COMMUNICATION AND PSYCHOLOGICAL TYPE IN A LATENT MATRIX ORGANIZATION: A CASE STUDY

THESIS

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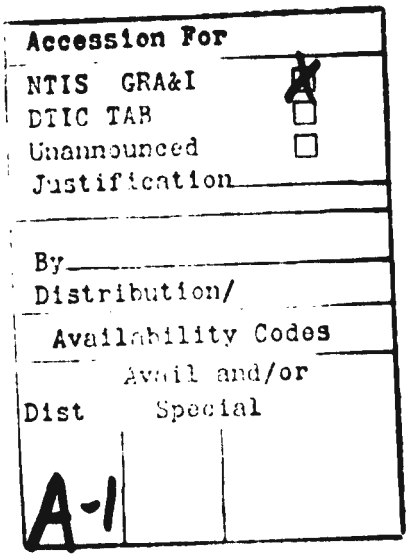

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Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degrees of

Master of Science in Logistics Management

and

Master of Science in Systems Management

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September 1985

Preface

We are most grateful to our thesis advisor, Dr. Terrance M. Skelton, and to our reader, Mr. Dennis Campbell, for their patience and guidance throughout this research effort. Their assistance and optimism helped us through many a bleak moment in this learning experience.

We also wish to thank the men and women of the organization about which this thesis is written, nameless though they are. It would have been impossible to do the research without their cooperation. Their willingness to assist us in obtaining our graduate degrees is deeply appreciated.

We also wish to thank our families and friends for putting up with us during the rough times, and for understanding when we could not be with them. We especially thank Wendy, who has been in the trenches with us every step of the way. Her support and encouragement have kept us going. She has been an integral part of this thesis effort, and has sacrificed much in helping us reach our goal. She has managed the roles of wife, mother, and thesis partner admirably, and we salute her. Thank you, Wendy, from both of us.

Last, but most important, we thank God for His many gifts and blessings, without which none of this would have been possible.

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Abstract

This research effort examined the relationship between organizational structure and written communication in an Air Force test organization which had experienced difficulty in meeting established time limits for producing its technical reports. An analysis of the organizational structure was performed. Organizational documentation, comments made by members of the organization during interviews, and the researchers' personal observations were compared with current literature on the matrix organizational structure. The test organization was found to function as a variant of a matrix organization.

To study the written communication process, the researchers interviewed selected individuals within the test organization and obtained their thoughts on the technical report preparation process. The interview responses were first analyzed for all the respondents as a group, and then by role groups and project teams. In general, the present technical report preparation process was considered to be adequate. Problems with the time requirements and the level of review and signature were noted, however.

The Myers-Briggs Type Indicator, based on Carl Jung's theory of psychological types, was used to assess the information gathering and information processing preferences of the individuals who participated in this research effort. The responses were analyzed first for all the respondents as a group and then by project teams. The group was found

to be primarily ISTJ--Introverted (I), with Sensing (S) as the preferred function for gathering information, and Thinking (T) as the preferred function for processing information. The preferred method of dealing with the external world was Judgment (J). Likewise, the teams were found to be mostly ISTJ. No relationship between preferences and timeliness of reports was seen.

While some problems with the report process were noted, no distinct relationship between the organization's operational structure and its difficulty in meeting the time limits was observed.

COMMUNICATION AND PSYCHOLOGICAL TYPE IN A LATENT MATRIX ORGANIZATION: A CASE STUDY

I. Introduction

General Issue

Organizational structures can vary considerably from a purely functional form, with direct lines of authority and communication within a specific discipline, to a purely project form with an orientation to the task or project. Between these two extremes lies the matrix structure in which individuals specializing in various functional areas are brought together to work on a specific project. Often organizations lie somewhere along a continuum between the purely functional and purely project forms (22:151), causing the interworkings of the organizations to be that much more complex.

Communication is key to the effective operation of any organization. It is especially important as organizational complexity increases, and its effectiveness becomes, in fact, more of a challenge. When an organization uses the matrix structure, or a variant of that structure, the need for and challenge to effective communication are often critical (3:533; 4:379; 42:242).

One important aspect of organizational communication is in the area of written communication or documentation. Written communication must be accurate and timely to be useful to individuals within and outside the organization. The degrees of accuracy and timeliness required will

depend on the needs of the user. Use of the document in immediate decision making, for example, requires a higher degree of timeliness than does use as a historical reference, while the degree of accuracy required might well be the same in both cases.

Problem Statement

Military organizations display degrees of structural complexity similar to those found in commercial enterprises. Especially in research and development areas, organizational structure varies to accommodate the nature of the work. This is seen in United States Air Force research and development organizations, where structure varies from project-oriented to matrix-structured or even variations of these structures.

Written communication is important in all research and development organizations and especially in those that test systems under development. Documenting a test--reporting its results--is a crucial part of a test organization's mission. One particular Air Force test organization determined that a problem existed with its production of written technical reports. The technical reports are this organization's chief written product and must be published within a specified period following completion of active testing. The organization was unable to consistently meet the specified time limits. It therefore requested assistance from the Air Force Institute of Technology (AFIT) in improving the quality and timeliness of the technical report preparation process.

In view of the critical role of communication in a complex organizational structure, the question of whether the test organization's structure affects the written communication surfaces. Officially, the

segment of the organization that conducts and reports the test is organized along functional lines. Operationally, however, with test or project teams, lateral communication and coordination, and consensus decision making at certain points, the organization appears to be structured as a variant of the matrix. In this particular Air Force test organization, is there a relationship between the organization's operational structure and the problem of meeting the technical report production time limit?

Background

This organization, with its operations oriented toward a specific test or project and with people from various functional areas involved in planning, conducting and reporting a test, exhibits characteristics that point to a form of the matrix organizational structure.

The matrix structure, in theory, can be defined as an organizational structure in which a project orientation has been superimposed on a traditional functional hierarchy (31:113-114). There are usually two lines of authority--one along functional lines and one along project lines. Members are responsible to functional supervisors as well as project managers.

Because of its complex nature, the matrix depends on good communication--the uninhibited flow of information--to achieve its goals (3:533; 4:379; 30:168; 42:242). However, two types of communication problems are common in matrix organizations. First, the nature of the matrix is such that people from different backgrounds who communicate based upon those differing perspectives may not always understand each other (4:384-385; 42:242). The test organization under study exhibits

lateral coordination and communication as well as vertical communication. Since the lateral coordination crosses functional lines, the potential for this first type of communication problem exists. Second, studies indicate that individuals may have different preferences for how they gather and process information, which can affect how they communicate (46:1-4; 48:2). If people possessing different preferences must work together to produce a document, as could be the case in this organization, this second type of communication problem may exist also. In short, both of the communication impediments possible in the pure matrix are also possible in this variation of the matrix.

Producing a technical report involves writing, revising and coordinating the document within a specified period of time after completion of active testing. In the test organization, technical reports historically have not been completed within established time limits. Approximately two years ago the organization's managers started to focus attention on this problem with written communication and requested assistance from AFIT. In an effort to shorten the time required to draft and edit the technical reports, an existing AFIT Professional Continuing Education course was tailored to improve the writing skills of individuals involved in the technical report process. The course has been presented several times to selected personnel involved in the technical report preparation process, receiving positive review from the requesting organization. Even with this course, however, room for improvement remains.

Research Objectives

The objectives of this research are threefold: to describe in detail how the organization functions in preparing, conducting, and

reporting tests; to describe and compare the participants' information gathering and processing preferences; and to describe and compare the participants' perceptions of the technical report preparation process.

Research Questions

The research objectives are met by addressing a series of research questions. Answers to these questions were developed from a combination of interview comments, observations made by the researchers, test organization documentation, and results of a psychometric questionnaire.

1. How does this test organization function as a variant of a matrix organization while planning, conducting, and reporting tests?
2. How can the information gathering and processing preferences of key participants in the technical report process be described?
3. How do these preferences of the key participants compare relative to their roles in the operational structure?
4. How can the perceptions of the technical report preparation process held by key participants in that process be described?
5. How do these perceptions held by key participants compare?

Assumptions

Three assumptions were made in conducting this research. First, the researchers assumed that a combination of interview responses and the researchers' personal observations would provide sufficient data with which to determine the organization's structure in its day-to-day functioning. Second, the researchers assumed that a guarantee of unit and individual confidentiality was necessary to obtain open and honest responses to the interviews and the psychometric questionnaire. Third, the researchers assumed that Carl Jung's theory of personality

preference types, as applied through the psychometric questionnaire, would provide an accurate assessment of the information gathering and information processing preferences of individuals involved in the technical report preparation process.

Limitations

Three major factors limited the conduct and documentation of this research effort. First, the amount of time available to conduct on-site research was limited by the test organization's location outside the state of Ohio and the amount of temporary duty and travel time permitted. Second, the population from which individuals were selected to participate in the research was small, due to the test organization's current mission requirements and the normal rotation of military personnel. When combined, these two factors kept the number of interviews and the psychometric questionnaire results too small to permit meaningful statistical analysis, and thus a qualitative approach was taken. Third, in honoring the guarantee of unit and individual confidentiality, the researchers have had to take certain liberties in citing individual interview responses as well as test organization documentation. While the citations and bibliographic entries have been made, they purposely omit any detail which might make possible identification of the unit or any individual.

II. Literature Review

This chapter presents a review of the literature concerning the matrix organizational structure, Carl Jung's theory of psychological type, and the Myers-Briggs Type Indicator. The matrix structure is defined and its use is reviewed from its development in the early 1960s to the present. Both functional and project-oriented organizations are discussed to facilitate better understanding of the matrix organization itself. The environmental conditions for which a matrix structure is best suited are presented, as are some of the positive and negative characteristics associated with such an organization. Variations of the matrix organizational form are then addressed, followed by an in-depth discussion of communication in the matrix organization.

Jung's theory of psychological type is then presented. Its role as the basis for the Myers-Briggs Type Indicator is reviewed, and development of the Indicator is discussed. Descriptions of the functional and attitudinal types are presented, with emphasis on their relationship to communication. The chapter concludes with a discussion of the Indicator's uses in research on communication problems.

Matrix Management Review

According to Donald R. Kingdon, twentieth-century man's large scale organizational structure traditionally followed a hierarchical pattern, stressing the superior-subordinate relationship, vertical chain of authority, and well-defined rules for communication and interaction (27:1-4,34). In the 1960s, however, another important type of organizational structure--the matrix--was recognized.

Kenneth Knight defines this matrix structure as "a 'mixed' organizational form in which the normal vertical hierarchy is 'overlayed' by some form of lateral authority, influence or communication" (31:113). Stanley M. Davis and Paul R. Lawrence believe that the best definition of the matrix structure highlights the structure's replacement of the traditional single line of authority with dual lines of command (9:3). Thus they define

> matrix as any organization that employs a multiple command system that includes not only a multiple command structure but also related support mechanisms and an associated organizational culture and behavior pattern. (9:3)

Linn C. Stuckenbruck defines the matrix organization as "a project organization, or some other type of organization, superimposed upon a conventional functional organization" (51:330). "There are usually two chains of command, one along functional lines and the other along . . . project lines . . . [thus] there is dual . . . managerial accountability and responsibility" (52:157). Knight comments that "the most typical and widespread view . . . sees the matrix as an evenly balanced compromise between functional and project organization, between grouping by process and by purpose" (31:114).

Kingdon writes that the matrix form developed in the 1960s as

> an outgrowth of an environmental requirement for a project management system which was imposed on the aerospace industry by the [United States] government as a condition of receiving consideration for research and development contracts. (27:19)

Companies interested in obtaining government contracts for the development of missiles and space vehicles found that governmental coordination and administrative requirements, combined with the complexity and volume of the research effort itself, made coordination and technical performance capabilities equally important factors in winning the

desired contracts as well as in actually performing the work (22:145). The complexity of the situation ultimately resulted in development of the matrix organization, which combined elements of both functional and project-oriented organizational structures, to achieve the high levels of coordination and technical performance required (22:145; 27:17-19). Neither the functional nor the project-oriented firms could both satisfy the government's requirements and adequately perform the research and development in their original organizational configurations (22:144-145).

The functionally oriented firms tended to be hierarchical in nature and were divided into functional subunits by technical specialty (63:46). While functional specialization fostered the desired development of high technology, it was not well suited for a complex environment requiring simultaneous work on many projects (22:144; 63:46-47). Problems encountered when using this type of organization for multiple projects included conflicts between functional and project goals, conflicts over project priorities, and lack of motivation (63:46-47), which often resulted in the projects falling behind schedule (22:145). Additionally,

> the functional structure . . . [did] not provide efficient and effective relationships between the performances of the various technical specialties nor . . . [did] it provide for the integration and coordination of these specialties into the intraorganizational effort required on projects and programs. (27:19)

Project-oriented firms were divided into subunits designed around the projects to be undertaken. According to Robert Youker, "all the resources necessary to obtain a specific objective . . . [were] separated from the regular functional structure and set up as a

self-contained unit" (63:47). The project manager had complete authority over all personnel assigned to the project for its duration (63:47). Jay R. Galbraith states that project organization facilitated

> coordination among specialties to achieve on-time completion and to meet budget targets. It . . . [allowed] a quick reaction capability to tackle problems that . . . [developed] in one specialty, thereby reducing the impact on other specialties. (22:146-147)

Problems associated with using the project organization included both inefficient use and expensive duplication of resources (63:48), and a decrease in the degree of development of the desired technologies (22:145).

The matrix organization was developed in an attempt to "maximize the strengths and minimize the weaknesses of both the project and the functional structures" (63:48). According to Kingdon,

> the matrix structure is an attempt to maintain the advantage of functional specialization [leading to good technical performance] while taking advantage also of the improved coordination offered by the concept of project management. It represents an innovative solution in adapting to a complex environment. (27:19)

In Knight's view

> The matrix organization [was] a compromise between two sets of needs: the customer's need for unified direction of the project to avoid having to negotiate with a series of separate functional managers, and the company's need for continuity as a viable, developing organisation building up its capability to handle future projects as well as current ones through the existence of strong specialist departments. (28:1)

David I. Cleland comments further on the objectives behind the matrix structure.

> The purpose of a matrix design is not only to get the best from its strong project and functional approaches but to complement these facets with a strong unity of command at the senior level and ensure that the balance of power is maintained in the organization. (7:26)

He emphasizes "the bipolarity of functional specialization and project integration" (7:26), leading to

> establishment of a bilateral design requiring:
> -Project managers, who are responsible for results, and
> -Functional managers, who are responsible for providing resources to attain results. (7:26)

Stuckenbruck comments that the "project manager is responsible for the what, when, why, and/or how much of the project, and the functional manager for the how, where, and who" (51:331).

Victor G. Majek also discusses the two types of managers. He characterizes the project manager as "responsible for achieving the performance cost and scheduling objectives of the project" (23:61), and the functional manager as "responsible for providing the resources required to meet the objectives of all projects in the matrix organization" (23:61). Harvey F. Kolodny points out that both the project and functional managers must learn new behaviors to complement their roles in the matrix organization.

> The product or program managers [must] become mini-general managers and must learn the functions of general management. Most of all they must learn to stop being their own specialists. The functional managers must learn an entirely new style of behavior: proactive rather than reactive. (32:21)

Two other parties play integral roles in the matrix organization. The individual at the very top of the organization--sometimes called the "chief executive officer" (32:21) or the "matrix executive" (23:60)--must now "learn to balance power between the dual orientations" (32:21). Finally, the other party consists of the "discipline supervisors, often referred to as 'two-boss managers'" (23:62). These individuals "must learn to live with ambiguity" (32:21) as they work simultaneously for the functional and project managers.

> Although assigned to a specific project team, the discipline supervisor is responsible to both the project and the functional manager. As a member of the project team, he or she is responsible to the project manager for meeting the objectives established for his or her area of effort. Also, the discipline supervisor is responsible to the functional manager for effective utilization of the assigned resources, maintaining smooth personnel relationships among the discipline team members and in general meeting the objectives of the second boss. (23:62)

Thus far the development of the matrix organization has been linked to the American aerospace industry of the 1960s. However, not all authors agree that the matrix organization had its beginnings there. Derek Sheane, for instance, emphatically remarks that emergence of the American aerospace industry was not the driving force behind evolution of the matrix structure, stating that there was evidence of matrix existence in the United Kingdom as early as 1947 (49:46).

Regardless of where or when matrix structure originated, it has become an accepted alternative to the traditional hierarchy. "From a restricted beginning . . . matrix applications have proliferated and now flourish in multinational corporations, financial institutions, hospitals . . . , and governmental and educational institutions" (22:543).

Various types of organizational structures are available for use in current organizational design. One must ask, then, under what circumstances should an organization adopt the matrix structure?

Davis and Lawrence believe that there are three separate conditions which must be simultaneously present for an organization to justify choosing the matrix structure (9:11). The first condition is described as "outside pressure for a dual focus" (9:11), or otherwise as a requirement for "multiple orientations" (32:28). This condition "recognizes that more than one orientation may be critical to managing an

organization given its particular environment" (32:18). That is, the organization's external environment may be such that the organization must focus its energies on more than one problem area at a time.

The second condition concerns "the requirement for high information-processing capacity among organizational members" (9:14). This condition results from "the increased amounts of information an organization must process when it tries to respond simultaneously to two critical sub-environments" (32:18).

The third condition has been identified as "pressure for shared resources" (32:18). It reflects pressure on the organization

> to achieve economies of scale in human terms and high performance in terms of both costs and benefits by fully utilizing scarce human resources and by meeting high-quality standards. (9:17)

Davis and Lawrence indicate that the presence of only one--or a combination of any two--of the three conditions is not sufficient reason to adopt the matrix structure (9:19). They argue that the matrix structure is very complex and its proper implementation exceedingly difficult, so much so that they recommend its consideration only in those situations where all three conditions are fully satisfied (9:18-20).

Knight discusses some of the positive aspects generally used to characterize matrix organizations, including

> efficient use of resources
> flexibility in conditions of change and uncertainty
> technical excellence
> ability to balance conflicting objectives
> freeing top management for long-range planning
> improving motivation and commitment
> giving opportunities for personal development. (31:118)

The efficient use of resources results from the sharing of these resources among various projects in lieu of resource duplication to

satisfy each project independently (31:118). Increased flexibility is made possible by development of horizontal communication links and improved information flow within the matrix (31:118-119). In the area of technical excellence, the matrix provides an atmosphere of "interdisciplinary stimulation and cross-fertilization . . . [as well as] the ongoing contact of specialists with members of their own discipline" (31:119). The requirement to balance conflicting objectives is met by the matrix organization's ability to "respond simultaneously to sectors of the environment that are critical to its success" (32:19). Upper levels of management are freed from involvement in routine operational activities through delegation and decentralization of decision making made possible by increased information processing at lower levels in the organization (31:119; 32:19). Thus top management has more time available for long term planning. Improved motivation and commitment result from the participative nature of the matrix structure, where even members at the bottom of the organization may have a significant input in decision making (31:119-120). Finally, the matrix structure provides employees with various opportunities for personal growth and development. It exposes them to situations in which they must consider issues beyond those of their own specialty, thus broadening their experience (31:120). It gives them more responsibility than they would ordinarily have in a strictly functional setting (31:120). Likewise, it gives them wider exposure and an opportunity to demonstrate their abilities and potential for advancement (31:120).

Cleland describes concensus decision making as one of the major characteristics of a matrix team: "Members of the matrix team actively contribute in defining a question or problem as well as in designing

courses of action to resolve problems and opportunities in the management of the effort" (7:28).

Youker identifies two additional benefits of the matrix organizations--"the coordination across functional departmental lines, and the visibility of the project objectives through the project coordinator's office" (63:48).

Knight also discusses several problems which can occur in matrix organizations, listing them in four categories:

> the conflicts that exist in them
> achieving balance between their parts
> the stresses on people in them
> administrative and communication costs. (31:122-123)

Conflicts are inherent in any organization, and the matrix is no exception. According to Knight,

> the matrix expresses a set of pre-existing conflicts between organizational needs and environmental pressures. It structures these conflicts, internalizes them within the organization, but does not remove them. (31:123)

One of the most important sources of potential conflict is the relationship between the functional and project managers as they compete for control of available resources (31:123). Conflicts are also fostered by factors such as

> diversity of disciplinary expertise
> lower power of project manager
> poor understanding of project objectives by team
> role ambiguity of team members
> lack of agreement on superordinate goals
> perception by functional staff that their roles are being usurped
> low perception of interdependence
> managerial level (more conflict at higher levels).
> (31:123-124)

The balancing of conflicting objectives and authority, considered to be one of the main advantages of the matrix organization, can also be

one of its biggest problems (31:122). It is not always easy to maintain a balance of power between the functional and project managers, nor between horizontal and vertical relationships (31:124-125). In Knight's view, finding the proper balance does not necessarily result in an equality of power between the two positions. Instead, the immediate situation must dictate who should hold the greater authority and control over resources. That is, the overall objectives to be achieved should determine the apportionment of power and resources between the two (30:162-163).

People working in a matrix organization may be subjected to stressful situations as a result of the organizational structure itself. Three particular sources of stress--role conflict, role ambiguity, and role overload--are common in a matrix (31:125). Role conflict can occur for the individual who works for two managers, if the two managers themselves are in conflict or fail to clearly delineate the individual's role (31:125). Role ambiguity can result when an individual is not certain of his or her authority, decision making ability, or accountability (31:125). "The increase in personal discretion and delegation which is typical of matrix structures is experienced as stressful by many" (31:125). Role overload results when too much is demanded from an individual (31:125). It occurs when the individual gains new responsibilities and needs more time for meetings and discussions because of the matrix structure, but retains all of the original operating responsibilities and requirements (31:125).

The fourth area of concern identified by Knight, that of communication in the matrix, is a central issue of this research effort. As such, it is addressed in detail later in this chapter.

Variations of the Matrix Structure

Cleland points out that today there is no one single form of organizational structure known as the matrix organization (6:48). Rather, there are many organizations which employ various versions of the matrix structure previously described. As Cleland comments,

> A kaleidoscope of matrix management systems is emerging in the theory and practice of management today. These systems appear to have one overriding characteristic--a departure from the classical model of management in favor of a multidimensional system of sharing decisions, results, and rewards in an organizational culture characterized by multiple authority-responsibility-accountability relationships. (6:48)

Both Galbraith and Youker discuss variations on matrix design (22; 63). They describe organizational structure as a continuum, with the functional organization at one end and the project organization at the other (22:151; 63:51). "The matrix form falls in between and includes a wide variety of structures, from a weak matrix near functional to a strong matrix near project" (63:51). A given organization's position on the continuum is determined by its authority structure, mechanisms for integration across functional lines, and formal information system (22:151).

Cleland comments that an organization employing matrix management concepts should be viewed and described not only by its systems--"all the properties of organizational structure, management processes and systems, interpersonal relationships and behavioral patterns" (6:49)--but also in terms of its operational context (6:49). He defines an operational description as one which

> relates the structure, processes, relationships, and patterns of the matrix management system to a number of observable criteria which, if satisfied, indicate that matrix management exists. (6:49)

Cleland hypothesizes that the presence of one or more particular system characteristics supports the existence of "the partial requirement for some type of matrix management" (6:49). Among the properties he mentions are the use of teams to accomplish organizational goals, the intentional sharing of important strategic and operational decisions, and practice of concensus decision making (6:49).

Kolodny emphasizes Galbraith's use of a continuum to discuss the "continuously increasing complexity in the coordination devices of organizations" (33:543). He remarks that the "matrix organization represents a range of possible structural arrangements and accompanying behaviors" (33:543), as discussed by Galbraith, but cautions against referring to all such structures merely as matrix organizations (33:544). He offers instead the term "'matrix-tending' organizations" (33:544) for those structures which find themselves between the fully functional and fully matrixed positions on the continuum (33:544).

In a recent research effort, Gano S. Evans analyzed the official organizational structure of a large federal research and development organization, as well as the behavior of certain managers therein (21:78). Evans concluded that the organization was operating effectively but in a manner not entirely consistent with its official line-staff designation (21:78,80). The study revealed that management placed a strong emphasis on the existing informal lines of communication, and considered such a network imperative to continued success in their field (21:80). Evans reconciled this coexistence of a formal hierarchical structure and a well-developed informal communication network in a concept he termed the "latent matrix" (21:78,80-81). He suggests that this concept is "an accurate description of the way the officially

designated line-staff organization operated" (21:80). It "describes a management process that better accounts for a strong emphasis on informal and cross-organizational interfaces to best achieve the research mission of the agency" (21:78).

Knight presents an in-depth discussion of matrix variants, stating: "According to the widest definition any organisation involving lateral groupings or relationships in addition to a vertical authority structure qualifies to be called a matrix" (28:5). He postulates three separate methods of matrix management, each with its own characteristic organizational structure and variations thereof. He named these three basic approaches the "co-ordination model, the overlay, and the secondment model" (29:142).

The co-ordination model appears to be the most common form of the matrix (29:142). This approach emphasizes not interfering with the organizational structure any more than is absolutely necessary, in particular avoiding conflicts or ambiguity in reporting relationships (29:142,155)

> Staff remain organistically and managerially members of their original departments, usually functional, but procedural arrangements . . . ensure cross-departmental . . . interaction towards the achievement of extra-departmental objectives. (29:142)

Variations of this type of matrix model range from "the collateral team, a team without a co-ordinator, to the customer-contractor role, a co-ordinator without a team" (29:155). In the customer-contractor model, the project manager

> negotiates for work to be done with the individual functional managers, whose relationship to him is a 'service-giving' one. The project manager is in control of the budget for the project and can therefore decide the allocation of project

> finance to the individual departments, stipulating in exchange completion dates and standards to be met. (29:145)

The overlay model approximates the classic pure matrix. Here, in an effort to balance accountability for resource utilization and the achievement of project objectives, personnel formally become members of two separate organizational groupings (29:142-147,155).

Knight's third approach to matrix management is the secondment model (29:142). In this approach members move back and forth between their specialist departments and project groups, but are assigned to only one or the other--not both--at any given time (29:142,150). This model "tends to be used where project objectives are paramount and the functional structure exists as a fall-back and a service to the project organisation" (29:155-156). One variant of the secondment model is the "project within function" (29:151). In this variation

> each project is firmly located in one discipline-based department which provides the main inputs to the project. The project manager reports to the department head, and inputs from other departments are provided either on a service-giving basis, or by occasional secondment of specialists from other disciplines. (29:151)

Communication in the Matrix

As with any organization, the success of the matrix is dependent upon its members' abilities to communicate effectively. According to Stuckenbruck, "the matrix organization has evolved to cope with the conflict inherent in any large organization--the need of specialization versus the the needs of coordination" (51:333). "[The organization's] successful operation, like that of any organization, depends almost entirely on the activities of the . . . people involved" (51:333). As Ivars Avots points out, "most managers will readily agree that

management information is the key to effective performance of the tasks and functional activities within the matrix organization" (3:533).

Avots emphasizes the critical nature of a matrix organization's information flow:

> It is important to note at the outset that project management information involves much more than what is represented by critical path networks, cost charts, and technical progress reports. An effective information system passes a large variety of data, ideas, and concepts in a manner that is clear and does not distort its meaning between the originator and the receiver. In the matrix environment the information system stands at the heart of the organization structure, its planning and decision processes, and all the elements constituting the so-called cultural ambiance. It is critical to the very success or failure of the matrix management system. (3:533)

Stephen E. Barndt states that "communication of information is essential to cooperative goal directed behavior in all organizations . . . however . . . in the matrix type organization . . . it is even more important" (4:379). Stuckenbruck agrees, emphasizing the critical nature of the human interfaces within the matrix. He describes these interfaces as communication links and their management as a problem in communication (51:335-337).

While development of lateral communication links and improved information flow are considered positive aspects of matrix organizations, at the same time the complex nature of the structure actually increases the requirement for time spent in communicating (31:126). John V. Murray and Frank A. Stickney address the need for increased communication as a result of adopting a matrix structure.

> The matrix structure significantly increases the required interactions of people and their communication networks because of the reciprocal interdependencies inherent in most matrix tasks. This increased communication often creates problems between the matrix [project] and functional personnel

> because of their differing orientations: the matrix [project] personnel define the issues from the perspective of the task, whereas the functional personnel define them from the perspective of the functional area of specialization...but both perspectives are required for organizational performance. (42:242)

George H. Labovitz also discusses communication as a potential problem in a matrix organization.

> Each of us speaks the language of our background and discipline. As we adopt the protective coloration of our functions, we become reluctant to share information, to let others know what we know (after all, 'knowledge is power'). Our communications tend to be self-serving, our views of other functions stereotyped. (34:601)

The importance of communication to the efficient operation of a matrix organization is obvious. However, experience has shown that communication problems do occur within matrix organizations despite the emphasis placed on avoiding such problems.

> The organisation gives rise to an increase in formal communications, through meetings and memos, many of which are concerned with trivialities or with individual managers' attempts to cover themselves against blame, by putting everything in writing. (30:168)

Thomas J. Peters describes the problems of one large multinational corporation--the "endless time spent in meetings and in building personal relationships, and in communications . . . " (47:17) keeps the organization from responding quickly in a "turbulent market . . . [where] . . . very short communications lines, quick decisions, [and] alertness" (47:17) are needed.

Another generally recognized communication problem is discussed by Barndt. "The encoding-decoding problem is the familiar but difficult one of semantics, or meanings that we attach to symbols, where one person's or group's meanings are not the same as another's" (4:384). According to Barndt,

> Two conditions likely to exist in the matrix organization heighten the possibility of encoding-decoding problems. First, the matrix team normally consists of a number of individuals from identifiably distinct occupational specialties. The specialized language or jargon that goes with each should be expected to cause problems, when messages from one specialist are interpreted by another. In addition, the loyalties to professions and the acquired values of various specialist group members are likely to result in group frames of reference that view such subjects as cost, time deadlines, and technical perfection in different ways. (4:385)

Murray and Stickney point out that "management in the matrix organization must stress the need for a free flow of communication based on fact and mutual trust" (42:250). However, as Knight comments,

> Blocks to the free information flow which matrix structures depend on can be created by managers who feel that the matrix constitutes a threat to their autonomy and power. They see the boundaries of their sphere of control overlaid by the new horizontal groupings and react defensively by withholding information and emphasizing formal communications channels. (30:166)

Stuckenbruck addresses how communication problems result in conflicts within the matrix.

> Poor communication, however, is certainly the basic cause of most misunderstandings and conflicts. This may be due either to the inability or reluctance of one or both persons to express themselves or to their inability to understand the situation or see the other side of the picture . . . . Such personal conflicts are much more likely to occur in a matrix organization, because of the diversity of the people involved and the number of contacts to be made. (51:339)

The importance of communication to the efficient working of a matrix organization is obvious. "Managers and researchers . . . agree that communication processes underlie most aspects of organizational functioning and are critical to organizational effectiveness" (50:461). Any problem which impedes communication, and thus information flow, impedes the matrix as a whole. Likewise, any effort which improves

communication also improves the flow of information and therefore the productivity of the matrix organization.

Communication and Psychological Type

Communication between people can be evaluated through application of Carl G. Jung's theory of psychological type. First published in the 1920s, Jung's theory was an attempt to explain variations in human behavior.

> The gist of the theory is that much apparently random variation in human behavior is actually quite orderly and consistent, being due to certain basic differences in the way people prefer to use perception and judgment. (46:1)

Perception is defined as the process of "becoming aware of things, people, occurrences, and ideas" (46:1), the "process of gathering information/data" (48:3). Judgment, on the other hand, is the "process by which we order, hierarchize, come to closure or conclusion on the data perceived" (48:1). Both are important aspects of communication.

Type Theory. Jung's theory is three-dimensional, consisting of a perception component, a judgment component, and an attitude component, all of which consist of polar opposites (8:973; 38:297). The perception component is divided into the dichotomous mental functions of Sensing (S) and Intuition (N) (38:299; 46:2).

> Sensing refers to perception of the observable by way of the senses. Sensing establishes what exists. Intuition refers to perception of possibilities, meanings, and relationships by way of insight. (38:299)

The judgment component is also divided into two mental functions, Thinking (T) and Feeling (F). Jung considered these functions to be the two basic methods of decision making (38:299-300; 46:3).

> Thinking is the term used to define a logical decision-making process, aimed at an impersonal finding. Feeling is a term

> for a process of appreciation, making judgments in terms of a system of subjective, personal values. (39:16)

The attitude component of Extraversion (E) and Introversion (I) represents an individual's "basic orientation to life" (39:17).

> In the extraverted attitude, attention seems to flow out--to be drawn out--to the objects and people of the environment. There is a desire to act on the environment, to affirm its importance, to increase its effect. In the introverted attitude, energy seems to flow from the object back to the subject, who conserves this energy by consolidating it within his own position. (38:297)

According to Jung's theory, all people have and use the four mental processes of Sensing (S), Intuition (N), Thinking (T), and Feeling (F). However, the four functions are not equally developed in all people, nor is their use equally preferred (38:299; 39:14). As an individual grows from childhood toward adulthood, one of the four functions "becomes dominant . . . , because of an inborn predisposition that, in the course of normal development, makes the activities of that function more interesting and rewarding" (38:300). Later, as normal development continues, the individual will develop an auxiliary function which complements the dominant function. If the dominant function is one of the perception components (Sensing or Intuition), the auxiliary function will be one of the judgment components (Thinking or Feeling). The reverse is likewise true (38:301-302; 46:12-13).

According to the theory, an individual needs both a well-developed dominant function and a well-developed auxiliary function. The dominant function guides and directs the individual, while the auxiliary provides needed balance from the non-dominant component (38:301-302; 46:10-13). At this point the individual's preferred attitude or orientation toward life becomes more important. "By definition, each type uses the

dominant function (S, N, T or F) in the preferred attitude (E or I)" (39:18). That is, an individual identified as an extravert will primarily use his or her dominant function in dealing with the outer world, and the auxiliary function in dealing with the inner world. Likewise, an individual who prefers the introverted attitude will use the dominant function in dealing with the inner world, and will therefore use the auxiliary function in dealing with the outer world. Thus the outside world may often see the well-developed dominant function of the extravert, but will rarely see the introvert's well-developed dominant function (38:301; 39:18; 46:12-15).

Based on his theory, Jung described eight combinations of attitude and mental function, four extraverted and four introverted. The mental function used in each type was the dominant function for that type, while the auxiliary function was not mentioned (38:301; 39:18; 46:17).

Development of the Indicator. In the twenty years before World War II, Isabel Briggs Myers and her mother Katherine C. Briggs compared their own considerable observations of human personality with Jung's theory and found numerous similarities (38:295-296). The advent of World War II and the human suffering which ensued led Myers to devise "an instrument that would bring Jung's theory into practical application" (38:296) and perhaps help prevent such suffering in the future.

Over the next twenty years Myers developed and refined the psychometric questionnaire now known as the Myers-Briggs Type Indicator (38:296). To the three dichotomous preferences already outlined in Jung's theory, Myers added a fourth index known as Judgment-Perception (38:302; 39:18). This index was designed to identify which of the functions was the dominant and which was the auxiliary, thus making

possible a more complete description of any given type (38:302; 39:18). "To assess fully an individual's type, we must identify his dominant attitude and his superior [dominant] and auxiliary functions" (8:973).

The Judgment and Perception dichotomy is therefore concerned with whether an individual uses judgment or perception in dealing with the outer world. The Judging (J) type uses a judging function (Thinking or Feeling) to handle the outer world and thus prefers things to be planned and controlled. The Perceptive (P) individual uses a perceptive process (Sensing or Intuition) to deal with the outer world and enjoys flexibility and spontaneity (43:6). "By definition, J [Judgment] and P [Perception] refer to the process used for extraverting; thus they point directly to the dominant function of extraverts and to the auxiliary function of introverts" (39:19).

People need both the Judgment and Perception attitudes, but they are not both used at the same time. When the Perceptive attitude is in use, the individual is gathering information through either the Sensing or Intuitive function, and the Judgment attitude is turned off. Likewise, when the Judgment attitude is being used, the individual is processing the information through either the Thinking or Feeling function, and the Perceptive attitude is subordinated. Regardless of the individual's preferred attitude toward interacting with the outer world, there is a need for development of the other attitude to provide balance (46:69-74).

By adding the Judgment-Perception index to the three existing indices, Myers had four scales available for use in determining an individual's type. She designed the Indicator as a self-report questionnaire which would allow the respondent to choose the

alternatives which he or she preferred, and thereby indicate the four preferred poles of the dichotomous pairs (38:302-303; 39:19). Since, by virtue of Jung's theory, people create their individual types by expressing their own preferences concerning perception and judgment, the type can thus be described by ascertaining what those preferences are (46:10). The Indicator is designed to do just that--identify, from the individual's responses, his or her preferences in the four categories and thus the appropriate psychological type.

Use of the Judgment-Perception index also made possible inclusion of the auxiliary function in the descriptions of type. Myers was thus able to double the number of type descriptions from 8 to 16 by specifying the attitude, dominant function, and auxiliary function (46:21). By convention, a different four-letter type formula is used for each of the 16 types. The first letter is either an E (Extraversion) or an I (Introversion) and represents the preferred attitude. The second letter is either an S (Sensing) or an N (Intuition) and represents the preferred perception process. The third letter is either a T (Thinking) or an F (Feeling) and represents the preferred judgment process. The fourth letter is either a J (Judgment) or a P (Perceptive), which indicates whether the Judgment or Perception process is being used to deal with the outer world. This in turn determines the dominant and auxiliary natures of the second and third letters (38; 39; 43; 46). In conjunction with development of the Indicator, Myers wrote detailed descriptions of the four functional types (S, N, T and F), the four combined functional types (ST, SF, NT and NF), the four attitudinal types (E, I, J and P), and the 16 complete four-letter types. The 16

four-letter types and their descriptions are found in Appendix A. Brief descriptions of the first three categories follow.

Functional Descriptions. Sensing (S) types prefer to gather data or information using the five physical senses. They are interested in facts, actualities, and the present, can easily adjust to step-by-step procedures, and are able to tolerate routine and details (45:51; 48:3).

> With good type development, the expertise in sensing can lead to a differentiated awareness of present experience, acute powers of observation, a memory for facts and detail, and a capacity for realism, for seeing the world as it is. Attitudes characteristically developed as a preference for sensing include a reliance on experience rather than theory, a trust of the conventional and customary way of doing things, a preference for beginning with what is known and real, and moving systematically and step-by-step, tying each new fact to past experience and testing it for its relevance in practical use. To most sensing types, 'real intelligence' is characterized as being sound, accurate and having common sense. (39:15)

Intuitive (N) types prefer to gather data or information through in-direct means such as a "sixth sense" or insight. They are interested in theories, ideas, patterns, possibilities, and relationships and tend to be future-oriented. They do not enjoy routine and repetitive activities, but instead prefer change and challenge (46:2; 48:3).

> With good type development, development of intuition can lead to insight into complexity, an ability to see abstract, symbolic, and theoretical relationships, and a capacity to see future possibilities, often creative ones.
>
> Attitudes characteristically developed as a result of a preference for intuition include a reliance on inspiration more than past experience, an interest in the new and untried, and a preference for learning new materials through an intuitive grasp of the meanings and relationships. To most intuitive types, 'real intelligence' is shown by insight in grasping complexities, and flashes of creativity. (39:15)

Thinking (T) types prefer to process information--to reach conclusions or make decisions--in a logical, analytical, and impersonal manner. Their impersonal approach may lead them to pay insufficient

attention to other people's inputs, they may hurt other people's feelings without knowing it, and likely do not handle emotion well, either their own or someone else's. They tend to be fair, impartial, and objective, and tend to be more interested in things than in people (46:3,68,163; 48:4).

> With good type development, expertise in thinking leads to powers of analysis and an ability to weigh facts objectively including consequences, unintended as well as intended. Attitudes typically developed from a preference for thinking include objectivity, impartiality, a sense of fairness and justice, and skill in applying logical analysis. (39:16)

Feeling (F) types prefer to process information in a subjective and personal manner. This type "comes to conclusion by an associative process, using feelings--by analogy and comparison with past experience, with attention to personal associations" (48:4). They find people to be more interesting than things, and display compassion, sensitivity, and a need for harmony (46:4,68,163; 48:4).

> With good type development, feeling leads to development of values and standards, and a knowledge of what matters most to themselves and other people. Attitudes typically resulting from a preference for feeling include an understanding of people and wish to affiliate with them, a desire for harmony, and a capacity for warmth, empathy and compassion. (39:16)

Combined Functional Descriptions. The four mental functions just described can be combined to form four two-letter types, with each of the combinations containing one perception (or information gathering) preference, and one judgment (or information processing) preference (ST, SF, NT and NF). Each of these combinations possesses the characteristics of the respective individual functions, which interact to give the two-letter combination its own particular set of qualities as well (46:4).

Sensing-Thinking (ST) types prefer to use their five senses to gather information, and a logical method to organize and process that information. They are interested in facts, which they address in an impersonal and analytical manner (43:3; 46:5). They are often viewed as "practical and matter-of-fact" (43:3; 46:5).

Sensing-Feeling (SF) types prefer to use their five senses to gather information, and a personal and subjective method to organize and process the information. They tend to be more interested in facts which relate to people than in facts which relate to things, and make their decisions in a warm and personal manner (43:3; 46:5-6). They are considered to be "sympathetic and friendly" (43:3).

Intuitive-Thinking (NT) types prefer to gather information indirectly through a "sixth sense" rather than directly through the five senses, and prefer to process that information in a logical, step-by-step manner. They are interested in theory, possibilities, and relationships rather than facts by themselves, but apply an impersonal analytical approach to that on which they have focused (43:3; 46:6). These types are often described as "logical and ingenious" (43:3).

Intuitive-Feeling (NF) types prefer to gather information indirectly through a "sixth sense" rather than directly through the five senses, and prefer to process that information in a personal and subjective manner. They are interested in theory, possibilities, and relationships rather than facts by themselves, but make their decisions with warmth and personal consideration (43:3; 46:6). They are often considered to be "enthusiastic and insightful" (43:3; 46:6).

Attitudinal Descriptions. Extraversion (E) refers to that attitude or orientation toward life and the world in which energy flows out from

the individual to the environment. Extraverts prefer to focus their attention on the external world of people and things. They enjoy variety, action, and the company of other people. They tend to dislike activities which are complicated, take a long time, or otherwise slow them down (39:17; 43:6; 46:7-8,53-56; 48:6).

> With mature type development, extraverts typically create a life with action, social contacts, and a wide circle of acquaintanceships. Characteristics typical of those who prefer the extraverted attitude are sociability, outspokenness, ease of communication, awareness of and reliance on the environment for stimulation and guidance, and an action-oriented, often impulsive way of meeting new events. (39:17)

Introversion (I) refers to that attitude or orientation toward life in which energy flows inward from the environment to the individual. Introverts prefer to focus their attention on the inner world of concepts and understanding. They prefer peace and quiet for concentration, do not mind being alone, and often appear detached or withdrawn. Long or detailed jobs do not bother them. They are private individuals who do not easily reveal themselves to others, and may experience difficulty in communicating (39:17; 43:6; 46:7-8,53-56; 48:6).

> Introverts typically create a life with time for contemplation, socializing with intimates and close friends. Characteristics typical of those who prefer the introverted attitude are a thoughtful contemplative detachment, interest in clear conceptualization of ideas, and a relative unawareness of changes in the outer situation, discounting their importances in any important decisions. Privacy and time to go into depth are important for introverts, who are postulated to have a greater capacity for sustained attention than extraverts. (39:17)

The Judging (J) type prefers to use one of the judging functions, either Thinking (T) or Feeling (F), in dealing with the outer world. Judging types "live in a planned, decided, orderly way, wanting to regulate life and control it" (43:6). They thrive on order and

structure, and thus work well with schedules and plans. They are compelled to reach a decision--to come to a conclusion--and may do so too soon, without fully considering all the pertinent facts (39:18; 43:6; 46:69-75; 48:5).

> A preference for the judging attitude leads to a desire for decisions, with a minimum of information-gathering. Judging types tend to prefer to organize and plan their lives, using their energies to control events more than in understanding them. When at their best, they are likely to be rated responsible, dependable and decisive. (39:18-19)

Perceptive (P) types prefer to use one of the perceptive functions, either Sensing (S) or Intuition (N), to deal with the outer world. They "live in a flexible, spontaneous way, wanting to understand life and adapt to it" (43:6). These types are characterized by spontaneity, open-mindedness, curiosity, and adaptability. They are not in a hurry to make decisions and may resist doing so (46:69-75).

> A preference for the perceptive attitude leads to an open, curious desire for understanding events with relatively little pressure to control them. When at their best, perceptive types are called receptive, under-tanding and flexible. (39:19)

Thus Myers developed the various type descriptions and the psychometric questionnaire known as the Myers-Briggs Type Indicator. Based on Jung's theory, the Indicator is a paper-and-pencil instrument which, when completed, reports the respondent's indicated preferences in four categories. The four areas include the preferred attitude or orientation toward life, represented by the Extraversion-Introversion (E-I) scale; the preferred method of perception or way of gathering information, represented by the Sensing-Intuition (S-N) scale; the pre-ferred method of judgment or way of processing information, represented by the Thinking-Feeling (T-F) scale; and the preferred way of dealing with

the outer world, represented by the Judgment-Perception (J-P) scale. When the preferences in all four categories are combined, the resulting four-letter type combination makes possible an understanding of the respondent's preferences concerning communication.

The Indicator and Communication. Myers believed that "much of the widespread difficulty in communication is due to type differences" (44:3). She argued that people must believe that what they are going to hear will be important or relevant before they will listen. In her view, the "trouble is that what is considered worth listening to varies from type to type" (44:4). Approaching this point in another way, Extraverts will generally use their dominant function as their chief mode of communication, while Introverts will generally use their auxiliary function. If two individuals are using different functions in their communication process, it is conceivable that some miscommunication could occur.

Flavil R. Yeakley, Jr. follows through on Myers' thoughts by discussing Jung's four mental processes--Sensing, Intuition, Thinking, and Feeling--as four communication styles. He states that each of the 16 psychological types has associated with it the four communication styles in a unique pattern from primary, or most preferred, to least preferred (61; 62).

The primary communication style is determined by whether an individual is an Extravert (E) or an Introvert (I), and whether the preferred process for dealing with the outside world is Judgment (J) or Perception (P). For Extraverts, the primary style is the dominant function as determined by the J-P preference. The secondary style is that of the auxiliary function. The terciary style is the opposite of the auxiliary function. The least preferred style is the opposite of the

dominant function. For Introverts, the primary style is that of the auxiliary function (because Introverts face the world with their auxiliary functions) as determined by the J-P function. The secondary style is the dominant function, while the tertiary style is the opposite of the auxiliary, and the least preferred style is the opposite of the dominant function. When individuals whose preferences are not the same try to communicate, one or both may have to adjust to one of the lesser preferred styles (62:32). The 16 possible communications style preferences are shown in Appendix B.

Yeakley goes on to use the unique communication style preferences in devising a numerical method of ranking the relative difficulty experienced in adjusting one- and two-way communication styles between any two psychological types (61; 62). The ranking uses an ordinal scale ranging from 1 to 24 for one-way dyads, and from 1 to 17 for two-way dyads. One is the lowest ranking and represents the least amount of similarity between two different psychological types and, therefore, the maximum probability of difficulty in adjusting communication styles. Seventeen and 24 are the highest scores and represent the maximum amount of similarity between two psychological types and thus the minimum possibility of difficulty in adjusting communication styles (62:34-36). With this ranking it is possible to use derived quantitative values in comparing various communication situations. The one-way and two-way rankings are shown in Appendix C.

In another example of communication research, George H. Jensen and John K. DiTiberio discuss ongoing studies involving the use of the Indicator to evaluate and improve the way people write (25). The Indicator has been used at the University of Illinois and Georgia State

University in thesis support groups, writing clinics, writing workshops, and a developmental writing program (25:287-288). "In all of these settings, students reported that knowledge of their personality type and how it relates to writing helped to reduce writing anxiety and overcome writing blocks" (25:288).

III. Methodology

The focus of this research was to describe the nature of communication in the operational structure of a particular Air Force test organization. The aspect of communication studied was written communication in the form of a technical report, an important product of this organization. The objectives, as noted in Chapter 1, were threefold: 1) to describe how the organization operates; 2) to describe and compare the information gathering and processing preferences of selected individuals; and 3) to describe and compare the perceptions of the technical report preparation process held by those individuals. Due to the limitations discussed in Chapter 1, this research effort was performed and documented as a case study. No attempt at statistical analyses was made.

To observe the effect of the organizational structure, the interaction of individuals in different roles in the structure had to be studied. The most logical approach to study this was to obtain information from individuals who had worked together on a specific technical report. Knowing the history of the technical report and whether it was completed on time could provide insight into the structure's effect on timeliness. Therefore, it was necessary to select technical reports such that the individuals who worked on them were available to be interviewed. Because of the reassignment of military personnel in particular, this requirement limited the number of useful reports and correspondingly the number of people who could be sampled. These

considerations limited the breadth of data collected and necessitated a case study approach to the research.

General Approach

The general approach in answering the five research questions began with a review of the organization's documentation already available at the Air Force Institute of Technology (AFIT) to understand as much as possible about the organization before visiting it. The next step was to visit the organization to learn about the organization firsthand, present a proposed plan for the research effort, and prepare for a second visit when the majority of the data would be collected. Data was initially collected through studying the organization's documentation and then through formally interviewing participants in the technical report preparation process and administering a psychometric instrument, the Myers-Briggs Type Indicator, to measure their preferences for information gathering and processing (8:973).

During the second visit the data collection procedure consisted of selecting the technical reports, identifying the individuals who were involved in their preparation, and then interviewing those identified. This was followed by administering the Indicator to measure the individuals' preferences.

The next step involved analyzing the data collected from the two visits to the organization. The organization's documentation and the interview results provided a basis for comparison with the matrix literature to answer the first research question. Scoring and assessing the results of the instrument for measuring preferences provided a means to answer the second research question. A combination of the results of

the Indicator and the team structures answered the third research question. Finally, the interviews provided the data for answering the fourth and fifth research questions.

Instrumentation

Two instruments were used for data collection: an interview guide and the Myers-Briggs Type Indicator as the means for measuring preferences of information gathering and processing.

The Interview Guide. The primary purpose of the interview was to determine the perceptions of the technical report preparation process held by key participants in that process. In addition, information from the interview would help define both the operational structure for technical report preparation and the role of the participants in that process.

The purpose of the interview was to question the respondents about opinions, attitudes and feelings; therefore, the interview was not rigidly structured (20:215). Open responses were desired so that the respondents' true perceptions of the technical report process could be discovered (20:216).

The questions addressed a number of areas as follows: the task of putting together the technical report, the roles of those being interviewed, the time requirements for technical report preparation, the use of the data, likes and dislikes in the job, and guidelines for the work done, as well as biographical/demographical data. Separate interview guides were developed for individuals fulfilling various roles in the technical report preparation process.

The questions were jointly developed by the researchers, beginning with the objectives of describing how the organization operates and determining the perceptions of the process, and then listing areas in which information was needed. The researchers then drafted the questions, attempting to make them as understandable as possible (24:4). The questions were then arranged to "follow each other naturally" (24:4). The questions were further refined through a process of joint and individual brainstorming.

The first twelve questions were essentially the same for all respondents, allowing direct comparison of answers among not only those with the same role in the process but also across roles. The additional questions in each interview guide were developed to further explore the interviewee's specific role in the process. The interview guides were then reviewed by two AFIT faculty members for comments and subsequent refining. Appendix D contains a complete set of interview guides.

The Myers-Briggs Type Indicator. The Indicator was used to determine the information gathering and processing preferences of key participants in the technical report preparation process. Information gathering and processing preferences are psychological characteristics and, therefore, require a psychological instrument to measure them.

The Indicator consists of a self-administered, non-threatening 126-item paper-and-pencil questionnaire (Form G) which could be completed in approximately one hour (41:321; 45:7; 53:323). The format is forced choice, in that the respondent must answer with one of the available choices rather than create an individual answer (41:321; 45:2,84; 53:323). The items include both phrase questions and word pairs

(38:309-310). A copy of this questionnaire is not included in this document.

Published by Isabel Briggs Myers in 1962 after almost 20 years of development and refinement, the Indicator has been used extensively in research. In particular, it has been used to study methods of learning and teaching, occupational career choices, interpersonal communication, and team building (38:295). More recently it has been used to study how individual differences affect the writing process (25:286), with the intent to "more effectively individualize writing instruction" (25:286).

The researchers decided to use the Indicator for a number of reasons. First, a single instrument was desired to limit the amount of time the respondents were involved in the research effort and thus were away from their work. Second, the instrument was easy to administer and did not pose a threat to the participants. Third, since it has been used for over 20 years, with an additional 20 years of development, revision, and refinement, it is a widely recognized and accepted psychometric instrument with a large volume of validity and reliability data available (38:315-331; 41:321-322; 45; 53:323-324). Finally, studies performed by other researchers, especially in the areas of teamwork and communication, demonstrate its applicability to this research effort (5; 25; 38:335-336; 61; 62).

Specific Procedure

Data Collection. Data was collected in two visits to the test organization. The first visit was for one day and the second was for five days.

First Visit. The first visit was arranged by telephone several weeks before the visit. Upon arriving in the organization, the researchers met with the deputate technical advisor, two division technical advisors, and a branch chief, and presented a proposed plan for the research in the unit. The technical advisors were key participants in the technical report preparation process, while the branch chief supervised editors who were also key participants in the process.

After the initial group meeting, the researchers met with these people individually to learn more about the various divisions and the editing branch, in addition to the overall perspective obtained from the deputate technical advisor. This individual was the highest ranking participant in the technical report preparation process with whom the researchers had contact. The two division technical advisors represented two of the four generic test divisions as well as the two basic types of testing. Each of the technical advisors discussed the applicable division and its operation in detail. In one of the divisions the researchers also met with two people who performed division-level editing functions on technical reports. The chief of the editing branch also arranged a meeting with the two chief editors, who provided additional information. Topics such as length of the work day and guidelines used in doing the job were identified during this first visit, and were subsequently included in the interviews to be conducted during the second visit.

During this visit, documentation, in the form of draft technical reports, copies of the Test Engineers' Handbook, copies of control forms used to trace the documents through the review and coordination cycle, regulations, operating instructions, various writing guidelines and

data on the timeliness of past reports, was given to the researchers for their use. This documentation was brought back to AFIT and was very valuable in analyzing the interworkings of this organization and in planning for further data collection through the interview process.

The copies of the control forms used to trace the documents were a primary source in identifying, for purposes of the interviews and administering the Indicator, the key positions of participants in the technical report preparation process. These forms substantiated a preliminary identification of the deputate technical advisor, the division technical advisor and the editor from the editing branch as key participants in the technical report preparation process. Others identified were the test engineer as the author and--in the division with the two additional editors--those individuals. Additionally, by noting the length of time involved in preparation of the data, the researchers determined that other key participants could affect the timeliness of the technical report. These people included the analysts and mathematicians who planned and performed the data reduction for the tests. Even though their expertise was not required for data reduction in all tests, in many cases their efforts had a significant impact on the report preparation. They were therefore included in the interviews and psychometric evaluation along with the deputate and division technical advisors, the editors, the division editors, and the test engineers.

The proposed plan for additional data collection on the second trip was accepted, and the second visit to formally interview participants and administer the Indicator was arranged.

In the interim between the two visits, the procedure for future data collection was finalized. The researchers decided to limit the

breadth of the study to the two division whose technical advisors they had met on the first visit. This decision was based upon the limited time period of the second visit and the depth of the study desired. The division with the additional editors was designated as Division A, while the other division was designated Division B. A simplified organizational chart is available in Appendix E.

Considering the timeliness problem with some technical reports, the decision was made to interview and administer the Indicator to participants involved in preparing two classes of technical reports: 1) a technical report that was signed within its time limit and 2) one that was beyond its time limit. This allowed the researchers to more completely describe the process by studying successful situations as well as those that were less successful. An additional criterion used to select the technical reports was the amount of data reduction support required during the test.

Second Visit. At the beginning of the second visit, the researchers began in Division A by identifying two technical reports, one which was not late and another which was late. Because the data collection would be through personal contact by interviews and administering the Indicator, the most important consideration in selecting a report was that the test engineer be available for interviewing. Other important considerations included selecting a report for which the other key participants were available, and selecting one in which the analysts or mathematicians in the data reduction unit had participated. The same considerations were used to identify technical reports in Division B, with one modification. While two technical reports were identified in Division A, three technical reports were identified in Division B. A

third technical report was needed in order to include a test which required a great deal of data reduction support. A total of five technical reports were chosen. For Division A, Team 1 had a late report while Team 2 had an on-time report. For Division B, Team 3 had an on-time report with a mathematician involved but no division technical advisor. Team 4 had a late report, and Team 5 had an on-time report with no data reduction involved.

After the reports and the associated test engineers were identified in each division, the interviews of all the participants for the technical reports in that division were started. Initial interviews in each division were with the test engineers. Each test engineer identified the editors and mathematicians or analysts that he or she had worked with throughout the technical report preparation process. The individuals so identified, including the test engineer, were considered a team. The composition of Teams 1 through 5 is shown in Appendix F. After the interviews with the test engineers, the editors, mathematicians, analysts, division technical advisors and deputate technical advisor were interviewed. After each interview, the interviewee was asked to complete the Indicator at his or her convenience.

The general procedure for each interview included a short introduction by the researchers and a brief synopsis of the purpose of the interview. Since the researchers desired to tape record each interview, they requested permission to record the interview, as suggested in the Interviewers Manual published by the Institute for Social Research at the University of Michigan (24:25). Tape recording the interviews, when permitted, allowed maximum collection of information from the interview and was important in getting a full picture of each interviewee's

perceptions. The tape recorder was placed between the interviewer and the respondent as suggested in the Manual (24:25). If the interviewee preferred not to be tape recorded, the interviewer recorded the responses by hand.

Interviews were conducted with both researchers present for maximum data collection. For consistency, the same researcher interviewed all respondents. The second researcher took backup notes by hand in case there was a problem with the tape recorder. The next step was asking the questions. Again, as cited in the Manual, questions were read slowly to the interviewee, they were asked in order, and they were repeated as necessary (24:12). The questions were open-ended to get "a full expression of opinion" (24:19).

The technique of probing, as described in the Interviewers Manual, was important in these interviews so that the responses would be as complete and as developed as possible. Types of probes used included "repeating the question," (24:15) waiting expectantly by pausing, and "repeating the respondent's reply" (24:15).

After the interview, the Myers-Briggs Type Indicator was briefly explained and the interviewee was asked if he or she would consent to answering this questionnaire at a convenient time. If the respondent consented, it was distributed to be completed and collected later.

Data Analysis. Data, in the form of documentation or literature; interview questions and responses, both on paper and cassette tape; and Indicator answer sheets, were collected during the second visit to the test organization.

To convert part of the data into usable forms for analysis, the interview questions and answers on the cassette tapes were transcribed

and the Indicator answer sheets were scored and the results tallied. In addition, if any of the respondents preferred not to be recorded, the hand-written responses had to be typed for analysis.

The analysis itself was carried out on a question-by-question basis. The researchers addressed each research question individually, first presenting the findings and then analyzing them.

Research Question 1, "How does this test organization function as a variant of a matrix organization while planning, conducting, and reporting tests?", was addressed as follows. The matrix management literature served as the framework with which data gathered by the researchers was compared. Data consisted of test organization documentation and interview responses.

Research Question 2, "How can the information gathering and processing preferences of key participants in the technical report process be described?", was evaluated by using the Myers-Briggs Type Indicator to assess the preferences. An authorized AFIT faculty member scored the questionnaires and assisted the researchers in interpreting the results. The participants' responses were collectively analyzed to obtain an assessment of the group as a whole.

Research Question 3, "How do these preferences of the key participants compare relative to their roles in the operational structure?", was answered on the basis of the Myers-Briggs Type Indicator results and the team structures identified in the early part of the interview process. Each team was examined in terms of the preferences given by each team member when they completed the Indicator.

Research Question 4, "How can the perceptions of the technical report preparation process held by key participants in that process be

described?", was answered through use of interviews. Responses to selected questions were collectively analyzed to provide an evaluation of the group as a whole.

Research Question 5, "How do these perceptions held by key participants compare?", was also answered through the use of an interview. The responses provided the data with which to answer this question. Building on the analysis performed in answering Research Question 4, the researchers evaluated the interview responses to the selected questions in terms of role groups and team membership.

Conclusions and Recommendations. Upon completion of the data analysis for the research questions, the researchers then evaluated the results of the analysis. Conclusions were drawn, and recommendations made.

IV. Findings and Analysis

This chapter presents answers to the research questions. Each question is discussed individually; thus the chapter is divided into five sections. Within each section, relevant data is presented, and discussion and analysis follow.

Research Question One

How does this test organization function as a variant of a matrix organization while planning, conducting, and reporting tests?

This question is answered in two parts. The first section describes the organization and the test process in which the organization is involved. To manage and report test results, units within the organization use local documentation which defines the policy and procedures for these functions. The researchers used these documents to describe the organization and the test process.

The second part of this answer shows why this organization can be classified as a matrix variant. To define this organizations' operational structure, the researchers used the matrix literature as a framework with which to compare organizational documentation and interview responses. The interviews included questions about the roles of people in various positions in the operational structure, as well as broad questions that allowed the interviewee to explain how the testing process worked. Probing encouraged the interviewees to amplify answers. As a result of these interview characteristics, the interview responses provided valuable information on the organization's structure.

The Organization and the Test Process. The Test Engineers' Handbook, published by the test organization, provides helpful background information, not only for the newly assigned test engineer but also for those seeking to understand the test process. The first portion of the following description is based upon this document.

This Air Force test organization "is responsible for the acceptance, coordination, and documentation of tests" (60:3) performed as part of the developmental test and evaluation of specific new systems being acquired by the Air Force. The purpose of developmental test and evaluation is to demonstrate that the "engineering design and development [of a system] are complete [and] that the system . . . meets specifications" (60:13).

The organization is composed of four divisions which manage tests from a wide variety of Air Force programs (60:3-4). The four divisions may be grouped into two general categories, one category having, typically, more technologically complex test items, or testing techniques, than the other. For the purpose of this research, one division was chosen from each category. The division representing the more complex tests was designated Division A, while the division representing the less complex tests was designated Division B. The four production divisions are assisted by a support division which provides various kinds of services to these test-managing divisions, including editing of the technical reports prepared after each test (60:4). In addition to this support division, the test organization depends strongly on other base organizations for support in most aspects of its testing (60:10). One such organization, a data reduction support unit, takes raw, unprocessed data from the tests and transforms it into a more useful form (60:24).

Analysts and mathematicians from this organization are assigned to each test, as required (60:24). Despite all the organizations involved, the responsibility for the management of the test program rests solely with the test engineer in the test organization.

Developmental testing, the mission of this organization, is "a very fluid and dynamic process" which is constantly changing. This makes "realistic" planning very important (60:17).

In the course of performing this mission, the test organization initially receives requests to conduct tests (60:17). Planning is accomplished through a series of meetings attended by experts from the various functional areas who will be involved in the test (60:18-19). Attendees include the test engineer and an analyst (and sometimes a mathematician) from the data reduction support organization (60:18-19). The test directive, "an official document which . . . orders the execution of a test program by . . . assigned personnel (60:25), is prepared as a result of these planning meetings (60:19-20). Additionally, a method of test annex is prepared by "a team of experts" (60:26) from various functional areas who will support the test. The method of test is a detailed document which contains the methodology and procedures for accomplishing each test objective identified in the test directive (60:26). In Division A, responsibility for preparing the method of test lies with the test engineer, while a test design engineer performs this function in Division B (60:19).

When the test directive is approved and signed, the active phase of testing begins. The test engineer is responsible for conducting the test, including all coordination, scheduling, monitoring, and reporting of results. The Test Engineers' Handbook describes the many

organizations that support the testing mission. Services provided range from instrumentation for collecting test data to standard administrative support. Depending upon whether the tests are airborne or on the ground, several organizations are involved in conducting the tests (60:27-29,4-5).

The formal reporting of the test results was the main subject of this research effort. The test organization has an operating instruction which outlines "the policy and procedures for preparing, coordinating, reviewing, distributing and disposing of technical reports" (10:1). This operating instruction was being revised during the time of data collection in this research effort, thus the most current draft was used for this description. It specifies that "Normally, TRs [technical reports] will be prepared for . . . signature within 60 work-days after the last test mission" (10:2). The operating instruction also specifies that for tests which are either very complex or which require complex support, the reporting cycle may be lengthened to 120 days or longer as specified in the test directive. It further states that, in very special cases, an extension may also be requested after the testing has started (10:2).

The operating instruction also describes the technical report preparation process. The test engineer is responsible for preparing the technical report and ensuring that it is both a high quality and timely document. The test engineer should coordinate the technical report's initial outline with various people including the branch chief, the division technical advisor, one of the technical editors in the support division, and others as applicable. For special data needs, including format, the test engineer should meet with the analyst or mathematician

from the data reduction support organization. Working with an editor is also important in satisfying format and display requirements. The test engineer is encouraged to begin writing during the planning phase of the test to be as far along as possible before the 60-day reporting phase starts (10:4-5). In addition to the editors in the support division, Division A has two editors in its technical support branch. The Division A editors, one of whom is the branch chief and the other a technical writer/editor, are referred to as division editors and support the initial writing of the technical report.

The operating instruction then specifies the procedure to be followed after the test engineer prepares the draft of the technical report. The draft is first coordinated with the division technical advisor. Upon approval of the draft, the test engineer schedules a coordination meeting which is chaired by the division technical advisor. Attendees include the test engineer, the branch chief, the editor, the test requester and others as applicable. Each attendee receives a copy of the technical report several days before the meeting to allow time for review. At the meeting, the technical report is reviewed collectively, both for technical content and for editorial considerations. Changes are agreed to by the attendees and are incorporated by the test engineer after the meeting. The revised draft is then approved by the division technical advisor and sent to the editor for final editing and illustrating work. A reproducible copy is also prepared at this time. This reproducible copy is reviewed once more by the division technical advisor and is then sent to the deputate level for review. After the deputate technical advisor reviews and approves it, the technical report goes up to the final level for signature (10:5-6). Appendix G shows a

simplified version of this process, from the initial drafting of the technical report through signature (10:4-6,19).

The Organization as a Matrix Variant. The operational characteristics of an organization often provide a more meaningful representation of its interworkings than does the official structure. The official structure of the test organization is functional, with a vertical chain of command and separate test divisions defined by types of systems tested (60:3-4). Operationally, however, the organization exhibits characteristics that suggest other structural forms. The fact that the test organization "relies heavily on other organizations . . . to provide support . . . in most phases of testing" (60:10) and the fact that the test engineer communicates laterally with these organizations in conducting and reporting tests imply that the organization may not be purely functional as it manages testing activities.

Four major characteristics which are discussed in the literature on the matrix structure are also seen in this test organization. These four characteristics include 1) project orientation, 2) use of teams, 3) consensus decision making, and 4) informal communication channels.

Project Orientation. The first characteristic is the project orientation of the organization. Characteristics of the project organizational form, which is at the opposite end of the spectrum from the functional form (22:151; 53:51), are seen in this functionally-structured organization. The United States Air Force Dictionary defines the word "project" as "a planned undertaking or assignment to accomplish something specific" (59:403). Each test which the organization plans, conducts, and reports is essentially a project, in which the test organization is trying "to demonstrate the program objectives and provide

data for recommendations and decisions to continue or increase the commitment of resources for acquisition" of a new system (60:13). This project orientation is also seen in the Test Engineers' Handbook, where the test engineer is tasked to maintain a "project file [for] each DT&E [development test and evaluation] project [which the organization has been] tasked to manage, support or monitor" (60:85).

This view of the test effort as a project was also substantiated in the interview responses of key participants in the technical report preparation process. One editor, for instance, freely used the term "project" in an answer. One test engineer used the term seven times in answering a question concerning who establishes work priorities. All of the mathematicians used the word "project" during their interviews, with two of them referring to their job title as "project mathematician." In addition, one used some form of the term "project" ten more times throughout the interview (35; 36; 37). All of these uses were in reference to the test effort. One mathematician repeatedly used the term "project officer" in referring to the test engineer. Others interviewed gave special note to the test engineer's role in this context. One division editor said, "The test engineer is the focal point. He's the only person . . . [whose] name has been assigned to a project" (14). An analyst agreed, saying "He is the prime focal point of the whole test" (2).

Use of Teams. The matrix management literature identifies other characteristics of these organizations which are applicable here. David I. Cleland, in discussing an organization's structure in terms of its operational context, mentioned several characteristics that indicate "some type of matrix management" (6:49) in operation. One

characteristic was the use of teams to accomplish organizational goals (6:49). The use of teams in conducting and reporting tests is seen in the planning meetings that occur when the test request is received. Likewise, the method of test is prepared by "a team of experts" (60:26). Teamwork is also seen later during the technical report preparation phase, as the attendees at the coordination meeting collectively review the technical report to ensure a technically accurate and editorially correct document (10:6).

Interviews with key participants also verified the presence of teams in the operational context. One analyst from the data reduction support organization, when discussing his roles in the technical report preparation task, said the analyst's job was "to sit down with the test engineer and/or other customers to try to come up with the data products that are needed to satisfy those objectives" (1). The individual later said, "And then from those products, we put our heads together collectively . . . " (1). These statements point to teamwork. Additionally, one test engineer, in responding to the same question about roles, remarked that one cannot have pride of authorship--that team effort yields the best product (54). One division editor, who attends the coordination meetings, also affirmed that the attendees function as a team (14). In stronger words, this same individual described the team effort saying, "I think that the engineers fail to grasp this, but writing a tech report is a group effort. As a group, we are the expert in getting out a tech report" (14).

Teamwork can also be seen as the test engineers work with editors and mathematicians. One editor expressed a philosophy toward working with the test engineers that demonstrates positive teamwork, saying that

"If you will work with them, and help them, rather than tell them about the negative, you know, kind of guide and push a little bit, they are very easy to work with" (19). One test engineer described the benefits of a good working relationship with the mathematician, saying "if you work with him close enough, he knows what you're trying to do, and you get a feel for what he's doing" (55). Finally, from the mathematician's perspective, an excellent example of teamwork with the test engineer is illustrated in this interview response.

> Normally we have coordination meetings, and he says what he wants, what he needs. . . . I try to present that to him in the best, most efficient way possible. If I can come in here and do this little thing over here at no additional expense or something, I'll suggest it, something like that. We really think about each other. (37)

Consensus Decision Making. In addition to the use of teams, Cleland included the practice of consensus decision making as a matrix characteristic (6:49). Consensus decision making implies group decision making and occurs in many of the activities mentioned in the previous discussion of teams. Interview response examples that described decision-making situations in the test effort illustrate this characteristic. One mathematician, for instance, when asked about interaction with the test engineer, responded, "We get together with the test engineer. . . . [If there are] any questions on what type of data products they need, we'll sort of iron these out" (35). This type of decision making occurs during the planning process. Later in the technical report preparation process, decisions on what the technical report should say must be made. One test engineer gives an example of this in working with the editors, saying, "Then you try and explain to them [the

editors] what you meant to say and then you come up with . . . a happy medium" (56).

There are often differing opinions held by those involved in group decision making. Someone needs to mediate these situations, as one division technical advisor related. In speaking of his role in the coordination meeting he said he would "conduct that meeting and help the guy [the test engineer] get comments incorporated . . . ; [I] sometimes arbitrate between different factions that are trying to write the report different ways" (15). A good example of how group members with differing opinions reach agreement is given by a test engineer when he recounts the following situation, saying:

> they had a couple of concerns about a couple of points. We talked about them. We didn't agree with their point, and they didn't agree with our point. So we . . . came to a compromise, and then we rewrote it. (57)

Consensus decision making often involves reaching a compromise. One of the division editors affirmed the fact that consensus decision making occurs at the coordination meeting, as the draft technical report is refined (14).

Informal Communication Channels. A fourth characteristic of a matrix variant organization is presented by Gano S. Evans. Evans refers to the existence of a well-developed informal communication network in a formal hierarchical structure. He describes the organization that met these criteria as a "latent matrix" (21:78,80-81). The presence of well-developed informal communication channels is consistent with the matrix concept of "coordination across functional departmental lines" (63:48), or lateral coordination, as Robert Youker puts it.

This test organization's vertical chain of command was noted earlier. The degree of development of the informal communication or lateral coordination in this organization can best be seen in the interview responses. For instance, the coordination which occurs between the test engineer and the editor in perfecting the technical report can be seen in two examples. One editor, in telling about editing the draft technical report, said, "we call in the engineer and say 'Here you have said this, and now you're saying this. What point draws them together?'" (18). Likewise, one test engineer spoke from the test engineer's perspective by saying that "if they have questions, the first thing they'll do is call you . . . and ask if you can come up" (58). This individual went on to say that the editors will "explain why they want it changed" (58) and that sometimes "you have to go up and justify . . . to them why it has to be that way" (58). The importance placed on informal communication by those in the organization is also illustrated by interview responses that show the displeasure of those involved when there is no communication or limited potential for communication. In the first case, one analyst revealed a problem stemming from non-communicative test engineers: "It seems like recently they are more concerned with scheduling missions, . . . and seeing that everything is working smoothly, than they are with what we are actually doing here" (2). An example of the limited potential for communication is explained by one editor in saying "I would like . . . them not to go on TDY [temporary duty] or on leave [vacation] the day they bring the report in and leave us stuck" (18).

Looking deeper at this organization's communication in comparison with the literature on matrix communication, the researchers saw one

problem in particular which was highlighted in the interview responses: the "encoding-decoding" problem as described by Stephen E. Barndt (4). Here the language of one occupational specialty, such as engineering, must be interpreted by someone of a different occupational specialty such as accounting. Barndt states that the interpretation is often not what was intended, thus problems result (4:385). This "encoding-decoding" problem was seen in several responses to interview questions. On the "encoding" side, one test engineer, in working with the editors on the technical report content, said, "Sometimes they'll change a sentence and give it an entirely new meaning . . . and in those cases, we just tell the editor . . . 'No, that's not what I meant to say'" (56). On the "decoding" side, one editor gave this perspective:

> I mark those spots that I do not understand, or [that] don't seem to be parallel, or [are] not congruent or whatever, and I bring those all up to the engineer. Even if I ask something that seems very stupid to him, very elementary, even if I have to ask that, I ask it. I don't try to make him think that I know more than I do about his field . . . I think you have to be that way because you could slight something and never know it. (18)

Another editor expressed a different view of the problem saying, "They have to remember that people like me are going to read this document, and if I can't understand it, their reader can't understand it" (17).

Summary. In synopsis, the project orientation of the key participants in the process, the use of teams in planning and reporting tests, the presence of consensus decision making in the operation, and the well-developed informal communication network all suggest a variant of the matrix structure in operation throughout the test effort. In this test organization, as one division editor stated, the test engineer is the only one whose "name has been assigned to a project" (14). There

is no formal project group formed with the test engineer as manager. The "two chains of command" that Linn C. Stuckenbruck (51) referred to in his definition of the matrix organization are not present in this test organization. However, although the organization is not a pure matrix, it does exhibit the characteristics of a matrix variant and meets the requirements of a "latent matrix" as described by Evans (21:78,80-81). In addition, Kenneth Knight's secondment model of matrix management is representative of this test organization (29:142). For instance, the editors remain assigned to their specialist departments rather than being formally assigned to a project group or test team. Because meeting the objectives of a test are all-important, the support division's technical reports branch with the editors exists only to facilitate the test effort. The "project within function" variant of the secondment model (29:151) closely parallels the test organization's structure with each test or project managed by a test engineer assigned to a specific functional division.

Research Question Two

How can the information gathering and processing preferences of key participants in the technical report process be described?

The Myers-Briggs Type Indicator was used to assess the information gathering and information processing preferences for each of the 18 individuals who took part in this research. All 18 voluntarily completed the Indicator questionnaire. The results are presented by participant in Table 1.

Due to limiting factors of time and personnel availability, the size of the sample population was too small to be used in meaningful

TABLE 1

Myers-Briggs Type Indicator Results

Individual	Preference Type	Attitude with Dominant and Auxiliary Functions
Test Engineer 1	INFJ	Introverted Intuition with Feeling
Test Engineer 2	ISTP	Introverted Thinking with Sensing
Test Engineer 3	ENTJ	Extraverted Thinking with Intuition
Test Engineer 4	ISTJ	Introverted Sensing with Thinking
Test Engineer 5	ISTP	Introverted Thinking with Sensing
Editor 1	ENTJ	Extraverted Thinking with Intuition
Editor 2	ISTJ	Introverted Sensing with Thinking
Editor 3	ESTP	Extraverted Sensing with Thinking
Division Editor 1	INFP	Introverted Feeling with Intuition
Division Editor 2	ISTJ	Introverted Sensing with Thinking
Mathematician 1	ESTJ	Extraverted Thinking with Sensing
Mathematician 2	ISTJ	Introverted Sensing with Thinking
Mathematician 3	ISTJ	Introverted Sensing with Thinking
Analyst 1	ISTJ	Introverted Sensing with Thinking
Analyst 2	ISTJ	Introverted Sensing with Thinking
Division Technical Advisor 1	INTJ	Introverted Intuition with Thinking
Division Technical Advisor 2	ISTJ	Introverted Sensing with Thinking
Deputate Technical Advisor	ISTJ	Introverted Sensing with Thinking

Note:

E = Extraversion
I = Introversion
S = Sensing
N = Intuitive
T = Thinking
F = Feeling
J = Judging
P = Perceiving

statistical analyses. Nevertheless, a qualitative analysis has been completed and some limited generalizations, albeit not statistically valid, have been made. This question is answered in general terms for the total population of 18. Research Question 3 addresses the various responses at a more detailed level. All numerical totals of various type combinations are based on the type table constructed for the 18 respondents.

Normative data based on studies done by Isabel Myers and others suggests the following frequencies of preferences in the general population: 75% Extraversion versus 25% Introversion, 75% Sensing versus 25% Intuition, 50% Thinking versus 50% Feeling, and 50% Judgment versus 50% Perception (26:25; 40:3; 45). These estimates do not take into account gender differences, which may be particularly apparent for the Thinking-Feeling preference (46:66), but are acceptable for this research due to the small sample size under study. For larger samples where separate analyses will be conducted by gender, the authors recommend the use of the distributions presented in Mary H. McCaulley's 1985 article "Estimated Frequencies of the MBTI Types" (40).

The expected distributions for the single letter (E, I, S, N, T, F, J, and P) types are obtained by multiplying the sample size by the appropriate percentage listed above. The expected distribution for the various combinations is obtained by first finding the product of those percentages which are associated with the preferences of interest, and then multiplying that product by the sample size. The actual and expected values are listed in Table 2.

The following analysis is based on two assumptions. First, the process of perceiving, as expressed by either the Sensing (S) or

TABLE 2

Type Table and Indicator Results Summaries

N=18

ISTJ 9 EV = .84	ISFJ 0 EV = .84	INFJ 1 EV = .28	INTJ 1 EV = .28
ISTP 2 EV = .84	ISFP 0 EV = .84	INFP 1 EV = .28	INTP 0 EV = .28
ESTP 1 EV = 2.53	ESFP 0 EV = 2.53	ENFP 0 EV = .84	ENTP 0 EV = .84
ESTJ 1 EV = 2.53	ESFJ 0 EV = 2.53	ENFJ 0 EV = .84	ENTJ 2 EV = .84

Comparisons of Dichotomous Pairs:

Actual Values				Expected Values			
E: 4	S:13	T:16	J:14	E:13.5	S:13.5	T:9	J:9
I:14	N: 5	F: 2	P: 4	I: 4.5	N: 4.5	F:9	P:9

Combinations of Perception and Judgment (columns):

Actual Values		Expected Values	
ST:13	NT: 3	ST:6.75	NT:2.25
SF: 0	NF: 2	SF:6.75	NF:2.25

Heaviest Concentration of Respondents, Excluding Attitude:

Actual Values	Expected Values
TJ:13	TJ:4.5
STJ:10	STJ:3.375
NTJ: 3	NTJ:3.375

Note: E = Extraversion
I = Introversion
S = Sensing
N = Intuitive
T = Thinking
F = Feeling
J = Judging
P = Perceiving
EV = Expected Value

Intuitive (N) function, is defined as the process by which an individual prefers to gather information and thus becomes aware of what is occurring in the world around him (48:2-3). Second, the process of judging, as expressed by either the Thinking (T) or Feeling (F) function, is defined as the method by which an individual prefers to process--to sort out, order, and reach a conclusion about--the information which has been gathered (48:2,4).

There are four possible combinations of the functions associated with these two processes--Sensing-Thinking (ST), Sensing-Feeling (SF), Intuition-Thinking (NT), and Intuition-Feeling (NF). These combinations are sometimes called the two-letter combinations and refer to the two letter abbreviations used for them as part of the Myers-Briggs type formula. The 16 four-letter preference types, as measured by the Myers-Briggs Type Indicator, are extensions of the 4 two-letter types. They additionally reflect a preferred orientation toward life by adding the Extraversion-Introversion (E-I) attitudes, and a preferred method of dealing with the outside or public world by adding the Judgment-Perception (J-P) attitudes (46; 48).

Eight of the possible 16 four-letter types were seen in this research. These results will first be analyzed at the level of the various single functions. With that analysis as a base, the discussion will then be extended to various two- and four-letter combinations.

Functional Preferences. An examination of the one-letter perception preferences revealed that the ratio of Sensing types to Intuitive types was 13 to 5. The ratio of expected distributions for a sample of 18 is 13.5 to 4.5. The sample population thus appears representative of the general population for this preference. The almost three-quarters

majority of the sample population preferred to gather its information in factual form through the five senses, while the minority preferred to gather information in the form of possibilities and relationships through insight or some "sixth sense." The two preferences complement one another and, if properly used, can provide well-balanced perception for the group.

For the one-letter judging preferences, the ratio of Thinking to Feeling was 16 to 2. The ratio of expected distributions for a sample of 18 is 9 to 9. The sample population is thus heavily skewed toward the Thinking function. An eight to one majority of the sample population preferred to process its information in a logical and analytical manner, while the minority preferred to process its information in a personal and subjective manner.

In examining the one-letter Judgment-Perception (J-P) attitude preferences, the ratio of Judging types to Perceiving types was 14 to 4. The ratio of expected distributions for a sample of 18 is 9 to 9. The sample population is thus skewed toward the Judging function. This indicates that a majority of the respondents prefer to live a planned and orderly existence. They should respond well to schedules and deadlines, but may find themselves trying to finish projects before they are really completed because of their inherent desire to reach closure.

For the one-letter Extraversion-Introversion (E-I) attitude preferences, the ratio of Extraverts to Introverts was 4 to 14. The ratio of expected distributions for a sample of 18 is 13.5 to 4.5. The sample population is almost a complete inverse of what would normally be expected. The majority of respondents have thus indicated a preference for a quiet, peaceful environment and sufficient time to do their job

properly. They may find it difficult to communicate, and are not inclined to seek out other people or to ask for assistance. Introverts have a tendency to self-generate concepts and ideas, while Extraverts prefer to interact with the outside world to gain experience and coordinate or collaborate on concepts and ideas.

Combined Functional Preferences. In looking at the combined perception and judgment function preferences, there were 13 Sensing-Thinking (ST) types, 0 Sensing-Feeling (SF) types, 3 Intuitive-Thinking (NT) types, and 2 Intuitive-Feeling (NF) types. The expected distributions for a population of 18 are 6.75 each for ST and SF, and 2.25 each for NT and NF. Thus, while the NTs and NFs number about as expected, there are twice as many STs as expected, and no SFs at all. The frequency of Sensing-Thinking types compared to the combined results for the other three two-letter types (13 to 5) indicates that the majority of the sample prefers to gather facts through the five senses (experience-based, realistic, practical, useful information), and--at the same time--prefers to analyze and process that information in a logical manner (objective, based upon principles, criterion, law or standards, and impersonal).

If the Judgment-Perception attitude preference is also considered, the heaviest concentration of preferences consists of 13 Thinking-Judging (TJ) types, composed of 10 Sensing-Thinking-Judging (STJ) types and 3 Intuitive-Thinking-Judging (NTJ) types. The expected distributions for a population of 18 are 4.5 for TJ and 3.375 each for STJ and NTJ. While the NTJs number about as expected, both the STJs and TJs number roughly three times the expected values. The Thinking-Judging types, which occupy the four corners of the type table, are Thinking

types with Judging as their preferred method of dealing with the outer world. They make decisions based upon logic and in an analytical manner, and enjoy a planned and orderly life. They are often considered to be the "tough-minded, executive" (45:68) types who can get the job done.

Four-letter Preferences. If all four indices of the Myers-Briggs Type Indicator are considered, the preferences are concentrated in the ISTJs, with 9 of the 18 respondents falling into this category. The other responses included two ISTPs, one ESTP, one ESTJ, one INFJ, one INFP, one INTJ, and two ENTJs. Brief descriptions of all 16 types are found in Appendix A. For a sample size of 18, one would expect to find .84 each for ISTJ, ISTP, ISFJ, ISFP, ENFP, ENFJ, ENTP, and ENTJ. One would expect to find .28 each for INFJ, INFP, INTJ, and INTP. One would also expect to find 2.53 each for ESTP, ESTJ, ESFP, and ESFJ. Comparing actual distributions to expected distributions, there are 10.7 times as many ISTJs as expected, 3.6 times as many INTJs as expected, but only .4 times the number of ESTPs and ESTJs as expected. The ISTJ is an Introverted Sensing type with Thinking as the auxiliary function and Judging as the preferred attitude for interaction with the outer world. This type is characterized by strong powers of concentration, a fascination with observable facts, noticeable logic and analytical abilities, and a high propensity for organization (38:305). Those who prefer this type must, however, guard against being too impersonal and making decisions too quickly before they have all the pertinent data.

Analysis. The 13 to 5 ratio of Sensing (S) to Intuition (N) suggests that this group is well-suited for dealing with factual matters, but has some Intuitive types available to be open to new possibilities. The preponderance of Thinking (T) over Feeling (F) (16 to 2)

suggests that the group's modal judgment function is based on logic and is analytical. The group probably appears cold and impersonal to the Feeling types who may feel uncomfortable, misunderstood, and out of place. The Thinking group is well-suited to perform the objective kinds of tests and evaluations which are its mission. The 14 to 4 ratio of Judging (J) to Perceiving (P) also favors the unit mission. The organized and systematic nature of the Judging type, and the ability to tolerate detailed procedures, is ideal for the test and evaluation mission. Judging types, however, do not adapt well to change, and must rely on the Perceiving types to provide balance when needed. Also, the Judging types tend to make decisions too quickly, thus good relationships with the Perceiving types would help to ensure that enough facts had been included in the decision. The preponderance of Introverts (I) in this group, 14 compared to 4 Extraverts (E), suggests a group capable of sustained concentration and attention to detail. Again, these characteristics favor the test and evaluation mission. However, the group may not communicate well, and must rely on the Extraverts to keep the communication channels open. It is likely that written forms of communication are used extensively, rather than meetings, telephone calls, or other forms of personal interactions.

The concentrations of Sensing-Thinking (ST) and Thinking-Judging (TJ) follow naturally from the preponderance of Sensing, Thinking, and Judging types in the sample. The characteristics of the separate functions are combined and enhance one another as the functions themselves are combined. The heaviest concentration of four-letter types is nine ISTJs. This group deals well with facts and details. They are tolerant of step-by-step procedures and do not mind long, drawn out tasks. They

are logical and carry out objective analyses. They may appear cold, impersonal, and withdrawn. This type may get so involved with the facts that they fail to see various possibilities and options open to them. They may also have difficulty adapting to changing situations. The group as a whole needs the balance of Intuitives (N) to help see the possibilities, Perceiving (P) types to deal with change, and Extraverts (E) to help keep communication flowing. They are, however, well-suited for the detailed, fact- and procedure-oriented test and evaluation mission with which they are faced.

Research Question Three

How do these preferences of the key participants compare relative to their roles in the operational structure?

This question is answered by describing and comparing the information gathering and processing preferences of the key participants in terms of their membership in one or more of five teams. As described in Chapter 3, each team consists of one test engineer and at least three other individuals. Membership in each of the teams is shown in Appendix F.

Each team is discussed and analyzed separately. Team composition is presented, followed by identification of individual information gathering and processing preferences. Applicable type characteristics are then discussed. Each section concludes with a discussion and analysis of the team's preferred communication styles. Each section contains a table which summarizes applicable data.

Eight of the 16 possible psychological types are represented within the 5 teams. Brief descriptions of those eight types follow. More detailed descriptions of all the types are found in Appendix A.

The ISTJ is an Introvert (I) with Sensing (S) as the dominant function and Thinking (T) as the auxiliary function. This type is characterized by an interest in the inner world of concepts and ideas, a reliance on observable facts, use of logic and an analytical way of decision making, and well-developed organizational abilities (38:305).

The ISTP type is an Introvert (I) with Thinking (T) as the dominant function and Sensing (S) as the auxiliary function. This type is characterized by an interest in an internal world of thought, a reliance on factual information, use of logic and analytical decision making techniques, and the ability to adapt to changing situations (38:305).

The ESTP type is an Extrovert (E) with Sensing (S) as the dominant function and Thinking (T) as the auxiliary function. This type is characterized by an interest in the external world of people and things, a reliance on observable facts, use of logic and analytical methods of making decisions, and an adaptability to change (38:305).

The ESTJ is an Extravert (E) with Thinking (T) as the dominant function and Sensing (S) as the auxiliary function. This type is characterized by an interest in the outer world of people and things, a fascination with observable facts, reliance on logic and analytical methods when making decisions, and a propensity for organization (38:305).

The INTJ is an Introvert (I) with Intuition (N) as the dominant function and Thinking (T) as the auxiliary function. This type is characterized by interest in the internal world of ideas, an ability to see the possibilities in a situation, reliance on logic and analytical ways of making decisions, and a talent for organization (38:305).

The INFP is an Introvert (I) with Feeling (F) as the dominant function and Intuition (N) as the auxiliary function. This type is characterized by an interest in the inner world of concepts, an ability to visualize the possibilities in a given situation, a subjective method of making decisions based on personal beliefs and values, and an ability to adapt to changing environments (38:305).

The INFJ type is an Introvert (I) with Intuition (N) as the dominant function and Feeling (F) as the auxiliary function. This type is characterized by an interest in the internal world of thought, openness to the possibilities in a given situation, a subjective way of making decisions based on personal values, and good organizational abilities (38:305).

The ENTJ is an Extravert (E) with Thinking (T) as the dominant function and Intuition (N) as the auxiliary. This type is characterized by an interest in the outer world of people and things, an ability to see the possibilities in a situation, use of logic and analytical methods to make decisions, and a flair for organization (38:305).

Team One. This team includes Test Engineer 1, Editor 1, Mathematician 1, Analyst 1, Division Editor 1, Division Editor 2, Division Technical Advisor 2, and the Deputate Technical Advisor. The test on which this team's composition is based was selected because its technical report exceeded the allowable time limit.

Test Engineer 1 is the team's focal point. The test engineer interacted with Mathematician 1 and Analyst 1 primarily during the active testing phase, while the interaction between Test Engineer 1 and Editor 1 occurred during the reporting phase. Interaction among the test engineer and the two division editors occurred throughout the test

TABLE 3

Team One

Member	Type	Preferred Communication Style (61:7)			
		1	2	3	4
Test Engineer 1	INFJ	F	N	T	S
Division Editor 1	INFP	N	F	S	T
Editor 1	ENTJ	T	N	S	F
Division Editor 2	ISTJ	T	S	F	N
Mathematician 1	ESTJ	T	S	N	F
Analyst 1	ISTJ	T	S	F	N
Division Technical Advisor 2	ISTJ	T	S	F	N
Deputate Technical Advisor	ISTJ	T	S	F	N

E:2	S:5	T:6	J:7
I:6	N:3	F:2	P:1

Note: In type, the underlined function is dominant.
Style 1 is most preferred.
Style 4 is least preferred.

cycle and was not restricted to any particular phase. While both Division Technical Advisor 2 and the Deputate Technical Advisor reviewed the technical report, neither was as intimately involved with the test engineer as were the two division editors. Table 3 shows team composition, Myers-Briggs Type Indicator preferences, and preferred communication styles.

In terms of Myers-Briggs Type Indicator preferences, Test Engineer 1 is an INFJ, Editor 1 is an ENTJ, Mathematician 1 is an ESTJ,

Analyst 1 is an ISTJ, Division Editor 1 is an INFP, Division Editor 2 is an ISTJ, Division Technical Advisor 2 is an ISTJ, and the Deputate Technical Advisor is an ISTJ.

The INFJ and INFP prefer to gather conceptual information in an Intuitive (N) manner through a "sixth sense," and process that information in a personal and subjective manner through the Feeling (F) function. The ENTJ prefers to gather conceptual information in an indirect, Intuitive (N) manner, but processes that information using logic and analytical techniques through the Thinking (T) function. The ESTJ and ISTJs prefer to gather factual information through the five senses, via the Sensing (S) function, and process that information through logic and analysis via the Thinking (T) function. More detailed descriptions of the five types are available in Appendix A.

As a group, this team has ratios of two Extraverts to six Introverts, five Sensing types to three Intuitive types, six Thinking types to two Feeling types, and seven Judging types to one Perceiving type. The Extraversion-Introversion (E-I) ratio suggests a team which is quiet and does not volunteer information. Communication may be slow and cautious. Even with two Extraverts on the team, the preponderance of Introversion makes this group somewhat difficult to penetrate. However, the power of concentration available in this team is full of potential if it can be harnessed and guided.

The Sensing-Intuition (S-N) ratio is the most closely balanced of the four preferences. This suggests a team with the potential to deal with facts as well as with theories, possibilities, and relationships. The Intuitive types are well-suited to do future planning, while the

Sensing types excel at the detail work needed to actually execute the plan in the present.

The Thinking-Feeling (T-F) ratio reveals a team which is analytical, logical, and businesslike. The group is procedure-oriented and may fail to stop to think about how their actions affect other people. The two Feeling types are outnumbered and may find the atmosphere somewhat cool and impersonal. This could affect the unit's work if the Feeling types let the Thinking types get to them and upset them. The Feeling types may likely withdraw from the team if life becomes too uncomfortable.

The Judging-Perceiving (J-P) ratio indicates a team which prefers an organized and structured way of doing things. The single Perceiving type probably misses some of the action, as the Judging types like to make decisions more quickly, while the Perceiving type is still thinking about it. This tendency to rush to closure could be a problem for the team. A single Perceiving type is unlikely to have much influence, and may not even be heard, especially since the P for this team is an Introvert.

The team and team members can also be analyzed in terms of their preferred communication styles. The communication style preferences contained in Appendix B are used to perform this analysis. The four styles are listed for each type, from most preferred to least preferred. The four INFJ preferences are F, N, T, and S. For the INFP, the four preferences are N, F, S, and T. For the ENTJ, the four preferences are T, N, S, and F. For the ESTJ, the communication preferences are T, S, N, and F. For the ISTJs, the four preferences are T, S, F, and N. These preferences are also listed in Table 3.

Examining these preferred communication styles shows that the INFJ primary or preferred style F is the secondary style for the INFP, with the reverse also true. The results also show that the preferred style for the other three types is T, with the STJ types having a secondary style of S and the NTJ a secondary style of N. This suggests that the INFJ and INFP will communicate with each other reasonably well, as adjustments would only have to be made between primary and secondary styles. However, their communication with other team members will probably encounter difficulties. The TJs in the group appear to communicate well among themselves, primarily because they share their primary preference of T.

The communication rank adjustment scores for two-way dyads presented in Appendix C can be used to compare the degree of communication style adjustment difficulty for any particular team dyad with any of the other team dyads. Possible scores range from 1 to 17, with 1 representing maximum difficulty and 17 representing minimum difficulty. For an INFP-ISTJ dialogue, the rank adjustment score is one, indicating the possibility of maximum adjustment difficulty. For an INFP-ESTJ dialogue, the rank adjustment score is three, which indicates the possibility of very severe adjustment difficulty. For an INFP-ENTJ dialogue, the rank adjustment score is six, which suggests serious adjustment difficulty. For an INFP-INFJ dialogue, the rank adjustment score is 11, which suggests moderate difficulty with adjustment. For an INFJ-ESTJ dialogue, the rank adjustment score is three, which indicates the possibility of very severe adjustment difficulty. For the INFJ-ENTJ dialogue, the rank adjustment score is four, which indicates the possibility of very severe adjustment problems. For an INFJ-ISTJ dialogue,

the rank score is five, indicating serious adjustment problems. For the ENTJ-ISTJ dialogue, the rank adjustment score is 14, suggesting very little difficulty with adjustment. For an ENTJ-ESTJ dialogue, the rank adjustment score is 15, indicating very little adjustment difficulty. Finally, for an ESTJ-ISTJ dialogue, the rank adjustment score is 16, indicating almost no adjustment difficulty. As previously suspected, the rank adjustment scores of 14, 15, and 16 for the TJ-TJ interactions, compared to the FP-TJ interaction scores of 1, 3, and 6, and the FJ-TJ interaction scores of 3, 4, and 5, supports the belief that communication among the TJs is less difficult than that between the FJs and TJs, and between the FPs and TJs.

Team Two. This team includes Test Engineer 2, Editor 3, Mathematician 2, Division Editor 1, Division Editor 2, Division Technical Advisor 2, and the Deputate Technical Advisor. The test on which this team's composition is based was selected because its technical report was the closest to being on time of all those in Division A which were suitable for this research effort.

Test Engineer 2 is the team's focal point. Most of the interaction between Test Engineer 2 and Mathematician 2 occurred during active testing, while the interaction between Test Engineer 2 and Editor 3 occurred during the reporting phase. Interaction among the test engineer and the two division editors occurred throughout the test cycle and was not restricted to any one phase. Both Division Technical Adivsor 2 and the Deputate Technical Advisor reviewed the technical report, but neither was as deeply involved with Test Engineer 2 as were the two division editors. Table 4 shows team composition, Myers-Briggs Type Indicator preferences, and preferred communication styles.

TABLE 4

Team Two

Member	Type	Preferred Communication Style (61:7)			
		1	2	3	4
Test Engineer 2	ISTP	S	T	N	F
Editor 3	ESTP	S	T	F	N
Division Editor 1	INFP	N	F	S	T
Division Editor 2	ISTJ	T	S	F	N
Mathematician 2	ISTJ	T	S	F	N
Division Technical Advisor 2	ISTJ	T	S	F	N
Deputate Technical Advisor	ISTJ	T	S	F	N

E:1	S:6	T:6	J:4
I:6	N:1	F:1	P:3

Note: In type, the underlined function is dominant.
Style 1 is most preferred.
Style 4 is least preferred.

In terms of Myers-Briggs Type Indicator preferences, Test Engineer 2 is an ISTP, Editor 3 is an ESTP, Division Editor 1 is an INFP, while the other four members are ISTJs. The ISTP, ESTP, and ISTJs prefer to gather factual information using the five senses (the Sensing function), and process that information based on logic and in an analytical manner (the Thinking function). Since six of the seven team members exhibit this ST combination, the group in general will function this way. The INFP prefers to gather conceptual information through an Intuitive or "sixth sense", and processes that information in a personal and

subjective manner. More detailed descriptions of the types are available in Appendix A.

As a group, the team has ratios of one Extravert to six Introverts, six Sensing types to one Intuitive type, six Thinking types to one Feeling type, and four Judging types to three Perceiving types. The Extraversion-Introversion (E-I) ratio indicates a team which is probably quiet and restrained. While Introversion brings strong powers of concentration to the group, it also brings a tendency to withdraw into the inner world. The tendency to communicate is slow, possibly guarded. The single Extravert may not do much to improve or influence overall communication, and probably feels out of place if more than a few of the group get together.

The Sensing-Intuition (S-N) ratio points to a group which is fact- and detail-oriented. The single Intuitive is definitely a minority in this group and, while personally open to theories, possibilities, and relationships, may have little effect on the team as it goes along its way.

Likewise, the Thinking-Feeling (T-F) ratio suggests a team which uses logic and analysis and is procedure-oriented. It is likely that little attention is given to people, and the general atmosphere is somewhat cool and impersonal. Again, the single Feeling type is a minority. This person makes decisions in a subjective manner based on personal feelings and values. Warm, considerate, and caring, the Feeling type is prone to withdraw inward if the Thinking types become overpowering.

The Judging-Perceiving (J-P) ratio is somewhat more balanced, which suggests a group that does not rush to closure quite as quickly as

groups with more Judging types are inclined to do. The group is slightly more Judging than Perceiving, but there is the chance for team enhancement if both types are encouraged to contribute to whatever task is at hand.

One can also analyze the team members in terms of their individual preferred communication styles, and can thus evaluate the team's ability as well. Communication style preferences are listed in Appendix B. From most preferred to least preferred, the four ISTP preferences are S, T, N and F. For the ESTP, the four communication preference styles are S, T, F, and N. For the ISTJ, the four preferred communication styles are T, S, F, and N. For the INFP, the four communication styles are N, F, S, and T. These preferences are also listed in Table 4.

Examination of the communication style preferences for the four types seen in this team shows that the primary or preferred style for the ISTP and ESTP is S, while their secondary style is T. Similarly, the primary style for the ISTJ is T and the secondary style is S. The primary style for the INFP, however, is N, with a secondary of F. These results suggest that, while the ISTP, ESTP, and ISTJs should not experience a great deal of trouble in communicating, the INFP may have to make major adjustments to compensate for the differences in preferred styles. The results further suggest that, due to the relationships among and positions given by the preferred styles for each type, the least difficult communication will likely occur between two ISTJs, followed by dialogue between the ISTP and ESTP, because of common perception and judgment functions. The most difficult communication patterns will probably occur between the INFP and the ISTJs. This assumes,

of course, that no one type is particularly forceful or domineering in team relations because of rank, status, or position.

The degree of communication adjustment difficulty for any dyad on the team can be compared to that of the other dyads on the team by using the communication rank adjustment scores for two-way dyads presented in Appendix C. A low score of 1 represents maximum difficulty, while a high score of 17 represents minimum difficulty. For an ISTP-ESTP dialogue, the rank adjustment score is 16, indicating very minor difficulty in adjusting. For an ISTP-ISTJ dialogue, the rank adjustment score is 11, suggesting moderate adjustment difficulty. For an ISTP-INFP dialogue, the rank adjustment score is five, suggesting the possibility of serious adjustment problems. For an ISTJ-INFP dialogue, the rank adjustment score is one, suggesting maximum adjustment difficulty. For an ISTJ-ISTJ dialogue, the rank adjustment score is 17, indicating the least possibility of adjustment difficulty. For an ESTP-ISTJ dialogue, the rank adjustment score is 12, indicating moderate adjustment problems. For an ESTP-INFP dialogue, the rank adjustment score is three, suggesting the possibility of serious adjustment problems.

The rank adjustment scores of 16, 11, 17, and 12 for the ST-ST interactions, compared to the scores of 5, 3, and 1 for the NF-ST interactions, supports the thought that communication among the STs may be less difficult than communication between them and the NF.

Team Three. This team includes Test Engineer 3, Editor 1, Analyst 2, and the Deputate Technical Advisor. The test on which this team's composition is based was selected because it generated a large amount of data and therefore required the support of the data reduction organization. Analyst 2 worked on the test and is thus considered a member of

TABLE 5

Team Three

Member	Type	Preferred Communication Style (61:7)			
		1	2	3	4
Test Engineer 3	ENTJ	T	N	S	F
Editor 1	ENTJ	T	N	S	F
Analyst 2	ISTJ	T	S	F	N
Deputate Technical Advisor	ISTJ	T	S	F	N

E:2	S:2	T:4	J:4
E:2	N:2	F:0	P:0

Note: In type, the underlined function is dominant.
Style 1 is most preferred.
Style 4 is least preferred.

the team. Additionally, there is no division technical advisor present on the team because the division did not have such a position when this test was in progress.

Test Engineer 3 is the team's focal point. This individual worked closely with Analyst 2 during the course of active testing and while data was being prepared after completion of the active phase. The engineer then interacted with Editor 1 and the Deputate Technical Advisor in the technical report preparation cycle. Since the analyst is not assigned to the test organization, there was no contact with either Editor 1 or the Deputate Technical Advisor. Table 5 shows team composition, Myers-Briggs Type Indicator preferences, and preferred communication styles.

In terms of Myers-Briggs Type Indicator preferences, both Test Engineer 3 and Editor 1 were described as ENTJs, while Analyst 2 and the Deputate Technical Advisor were both ISTJs. The ENTJ prefers to gather conceptual information through the use of the Intuitive function, and processes that information in a logical and analytical manner, using the Thinking function. The ISTJ prefers to gather factual information through use of the five senses as represented by the Sensing function, and then processes that data in using logical and analytical methods through the Thinking function. Both the ENTJ and ISTJ prefer to use a Judging (J) function to deal with the world. The ESTJ therefore faces the world with the dominant Thinking function, while the ISTJ reserves the dominant function (Sensing) for the inner world and thus faces the outer world with the auxiliary Thinking function. More detailed descriptions of both types can be found in Appendix A.

As a group, the team is evenly split on the Extraversion-Introversion (E-I) and Sensing-Intuition (S-N) preferences, with ratios of two to two on both. On the Thinking-Feeling (T-F) and Judging-Perceiving (J-P) preferences, however, the ratios are four to zero in both cases. Thus, while the team is balanced in the Extraversion-Introversion and Sensing-Intuition areas, it is entirely a Thinking and Judging, or TJ, team. Neither Feeling (F) nor Perceiving (P) is represented.

The balancing of the four members' Extraversion-Introversion preferences suggests that both types will be comfortable with the team. The two Extraverts may provide each other with the external stimulation and focus that each needs, but are not so many in number that they will overwhelm the two Introverts, who might rather be left alone. The

balancing of the Sensing-Intuition preference bodes well for the team's production of the technical report, particularly since the report's Intuitive author (Test Engineer 3) had the document reviewed by the Sensing Deputate Technical Advisor who would be inclined to ensure that all the necessary facts were present.

The imbalance in the Thinking-Feeling preference suggests that the team may use logic and be impersonal and businesslike. The members are not particularly concerned with how people feel, thus the team might appear cold in its businesslike approach. This should not be a problem, however, as all four team members are Thinking types and will not be bothered by the cool atmosphere. The logic and analytical abilities associated with the Thinking type are suited to the scientific and technical work encountered in the developmental test and evaluation area.

The imbalance in the Judging-Perception preference is both positive and negative. On the positive side, the Judging type prefers to live an ordered life and can easily handle details, step-by-step procedures, and routine. In an environment where these abilities are important, such as in conducting a test which must be done in a specified step-by-step manner, or in editing a document which must meet strict format requirements, an imbalance toward Judging types does not cause a problem. On the negative side, however, the Judging types feel impelled to reach a decision--and may do so too quickly. They feel a need to get finished with whatever they are doing, even if the task is not really finished. Here the team could benefit from the presence of a Perceiving type who could temper the Judging tendency to reach closure.

When the two types are examined in light of the communication style preferences shown in Appendix B, one is able to characterize each team member's communication style preferences and the interaction among them. The four communication styles for the ENTJs, listed from most preferred to least preferred, are T, N, S, and F. Likewise, the four communication styles for the ISTJs are T, S, F, and N. Thus both types in this team have the same preferred or primary communication style--Thinking. The team members are therefore expected to have minimal trouble in communicating with each other. Since all share the primary style, none must try to adapt to a style which is less preferred.

This observation is further substantiated by reference to the communication adjustment rank scores for two-way dyads in Appendix C. A score of 1 represents maximum difficulty while 17 represents minimum difficulty. For an ENTJ-ENTJ dialogue, the rank score is 17, which indicates minimum communication style adjustment difficulty. For an ENTJ-ISTJ dialogue, the rank score is 14, indicating very minor adjustment difficulty. For an ISTJ-ISTJ dialogue (unlikely though it may be in this team since the one ISTJ does not work with the other one), the rank score is 17, again indicating minimum adjustment difficulty. Thus the team shares a preferred communication style and should have little trouble in communicating with each other.

Team Four. This team includes Test Engineer 4, Editor 2, Mathematician 3, Division Technical Advisor 1, and the Deputate Technical Advisor. The test on which this team's compostion is based was selected because its technical report exceeded the allowable time limit.

TABLE 6

Team Four

Member	Type	Preferred Communication Style (61:7)			
		1	2	3	4
Test Engineer 4	ISTJ	T	S	F	N
Editor 2	ISTJ	T	S	F	N
Mathematician 3	ISTJ	T	S	F	N
Division Technical Advisor 1	INTJ	T	N	F	S
Deputate Technical Advisor	ISTJ	T	S	F	N

E:0	S:4	T:5	J:5
I:5	N:1	F:0	P:0

Note: In type, the underlined function is dominant.
Style 1 is most preferred.
Style 4 is least preferred.

Test Engineer 4 is the team's focal point. This individual interacted with Mathematician 3 during active testing and while the data was being reduced after completion of active testing. Test Engineer 4 then worked closely with Editor 2 and Division Technical Advisor 1 during the technical report preparation phase. The Deputate Technical Advisor reviewed the technical report but was not as intimately involved with the test engineer as were Editor 2 and Division Technical Advisor 1. Again, the mathematician worked primarily with Test Engineer 4 and had little interaction with the other team members. Table 6 shows team composition, Myers-Briggs Type Indicator preferences, and preferred communication styles.

In terms of Myers-Briggs Type Indicator preferences, all of the team members are ISTJ except Division Technical Advisor 1, who is an INTJ. The team is thus composed of four ISTJs and one INTJ. The ISTJ prefers to gather factual information through use of the Sensing function, and processes that information using logic and analytical methods through the Thinking function. The INTJ prefers to gather conceptual information through the Intuitive function, and processes that information using logic and analysis through the Thinking function. Both the ISTJ and INTJ prefer to use a Judging (J) function to deal with the outer world. The ISTJ reserves the dominant Sensing function for use in the internal world and thus faces the outer world with the auxiliary Thinking function. Similarly, the INTJ reserves the dominant Intuitive function for use in the inner world and faces the external world with the auxiliary Thinking function. More detailed descriptions of both types can be found in Appendix A.

This team is predominantly ISTJ, with four ISTJs and one INTJ. Extraversion (E), Feeling (F) and Perceiving (P) are not represented at all, and the ratio of Sensing to Intuition is four to one.

The predominance of Introverts (I) on this team suggests a quiet and reserved group. Communication is probably kept to a minimum, with conventional "chit-chat" non-existent. Information may not be volunteered, but might have to be actively sought if needed. These tendencies could negatively affect the flow of work, such as by delaying it or by causing some needed factor to be excluded. This team's powers of concentration, however, could be a very useful tool in accomplishing whatever task is set before it, especially if the communication skills have been developed through compensation.

The team is primarily Sensing (S) oriented in terms of how it gathers information. The group prefers to gather factual information through the five senses. It may therefore be closed to any possibilities or information which is theoretical rather than factual. The single Intuitive provides some balance in this area, particularly since the position of Division Technical Advisor 1 is higher in the authority structure than the test engineer, editor, and mathematician. Division Technical Advisor 1 is capable of long range planning because of the Intuitive function, and thus may be able to guide the group and keep them open to all forms of information.

The five to zero ratio of Thinking (T) to Feeling (F) suggests a team which uses logic and is businesslike and impersonal. The members may not be people-oriented, thus they may appear cool and impersonal in their approach. This likely is not a problem for any of the members, since they are all Thinking types and probably will not notice the impersonality. Their logic and analytical capabilities will be useful in performing the tehcnical tasks associated with developmental test and evaluation.

The five to zero ratio of Judging (J) to Perceiving (P) suggests a team which is procedure-oriented. Judging types are comfortable with structured activities and do not mind details and routine. In occupations where the tasks are structured and must be done a particular way, such as in formal testing or editing, the Judging type is a welcome addition. However, the Judging type also exhibits a strong desire to finish whatever task is being performed, to make whatever decision needs to be made, to reach closure--quickly. This team runs the risk of reaching closure too soon, and needs some Perceptive types to delay

closure and keep activities going a while longer, or a method to check its natural tendency toward speed and closure.

The two types can be examined in terms of communication styles, and the team's ability to communicate can be assessed accordingly. The communication style preferences detailed in Appendix B can be used to do this. The four ISTJ communication style preferences are T, S, F, and N, from most preferred to least preferred. The four INTJ communication style preferences are T, N, F, and S. Here the two types share the primary or most preferred communication style of Thinking. The team members are expected to have little difficulty in communicating since all prefer to use their Thinking function and thus none must adapt to a lesser preferred style.

The communication rank adjustment scores for two-way dyads presented in Appendix C can also be used to characterize the degree of communication style adjustment difficulty possible. A low score of 1 represents maximum difficulty, while a high score of 17 represents minimum difficulty. An ISTJ-ISTJ dialogue has a rank adjustment score of 17, which indicates minimal adjustment difficulty. Likewise, for an ISTJ-INTJ dialogue, the rank adjustment score is 13, which represents minor adjustment difficulty. Thus the team shares a preferred communication style and exhibits high rank adjustment scores--both indications of good communication climate.

Team Five. This team includes Test Engineer 5, Editor 1, Division Technical Advisor 1, and the Deputate Technical Advisor. The test on which this team's composition is based was selected because its technical report met the allowable time limit and was written when the division had a technical advisor. The test did not require any data

TABLE 7

Team Five

Member	Type	Preferred Communication Style (61:7)			
		1	2	3	4
Test Engineer 5	ISTP	S	T	N	F
Deputate Technical Advisor	ISTJ	T	S	F	N
Division Technical Advisor 1	INTJ	T	N	F	S
Editor 1	ENTJ	T	N	S	F

E:1	S:2	T:4	J:3
I:3	N:2	F:0	P:1

Note: In type, the underlined function is dominant.
Style 1 is most preferred.
Style 4 is least preferred.

reduction support. Therefore this team does not include a mathematician or analyst.

Test Engineer 5 is this team's focal point, managing the test through the active testing phase, then working with Editor 1 and the Division Technical Advisor during the reporting phase. The Deputate Technical Advisor reveiwed the technical report but was not as deeply involved in its preparation as were Editor 1 and the Division Technical Advisor. Table 7 shows team composition, Myers-Briggs Type Indicator preferences, and preferred communication styles.

In terms of Myers-Briggs Type Indicator preferences, four different types are represented. Test Engineer 5 is an ISTP, Editor 1 is an ENTJ,

Division Technical Advisor 1 is an INTJ, and the Deputate Technical Advisor is an ISTJ. The ISTP and ISTJ prefer to gather factual information through use of the five senses and the Sensing (S) function, and process that information through logic and analysis, using the Thinking (T) function. Both the ENTJ and INTJ prefer to gather data via a "sixth sense" and the Intuitive function, and process the information using logic and analytical methods through the Thinking (T) function. More detailed descriptions of all four types can be found in Appendix A.

As a group, the team contains one Extravert and three Introverts, two Sensing types and two Intuitive types, four Thinking types and zero Feeling types, and three Judging types to one Perceptive type. The one to three ratio of Extraverts (E) to Introverts (I) suggests a quiet and reserved group in which the Extravert may sometimes feel uncomfortable and somewhat lacking in stimulation. The Extravert can make a positive contribution to the team by drawing out information from the quiet Introverts.

The team exhibits a balance between the Sensing (S) types and Intuitive (N) types. The two types can complement each other if they are motivated to do so. The Sensing types can deal with the facts and details, while the Intuitive types can handle theory and suggest possibilities that the Sensing types otherwise may not see. Thus the information that this team gathers can be well-balanced between specific facts and broad relationships and possibilities.

The predominance of Thinking (T) types over Feeling (F) types suggests a logical, impersonal and businesslike group. The members may appear cool and detached in their dealings with others because they are not people-oriented. This may not bother the group members because they

are all Thinking types. Since their daily occupations do not require extensive or demanding interaction with other people, this Thinking-Feeling imbalance should not impact the team's ability to do the job.

The Judging-Perceiving (J-P) ratio of three to one suggests a procedure-oriented team whose drive for closure is somewhat tempered by the Perceiving type's presence. The team will tend to organize and structure its activities in spite of the Perceiving type's ability to adapt to change, thus the Perceiving type may sometimes feel rather restricted.

The team can also be analyzed in terms of the members' preferred communication styles by using the communication style preferences presented in Appendix B. The team's overall ability to communicate may be evaluated accordingly. The four ISTP preferences are S, T, N, and F, from most preferred to least preferred. For the ENTJ, the four communication style preferences are T, N, S, and F. For the INTJ, the four communication style preferences are T, N, F, and S. For the ISTJ, the four communication style preferences are T, S, F, and N. Thus the primary or most preferred style is S for the ISTP, and T for the other three individuals. This suggests that Editor 1, Division Technical Advisor 1, and the Deputate Technical Advisor may find it easier to communicate among themselves than with Test Engineer 5. Examining the secondary communication style preferences reveals a T for the ISTP, Ns for the ENTJ and INTJ, and an S for the ISTJ. The test engineer's primary preference (S) is the Deputate Technical Advisor's secondary preference, while the Deputate Technical Advisor's primary preference (T) is the test engineer's secondary preference. Since both parties could theoretically adjust the style in use between S and T, one expects

that Test Engineer 5 may find it easier to communicate with the Deputate Technical Advisor than with either of the other two. The test engineer might find it particularly frustrating if all three of the teammates must be addressed at one time.

The degree of communication style adjustment difficulty expected for any given dyad can be compared to that of the other dyads in the team by using the communication rank adjustment scores for two-way dyads presented in Appendix C. An ISTP-ENTJ dialogue has a rank adjustment score of 10, which is half-way between the low and high ends of the scale and suggests a moderate amount of adjustment difficulty. An ISTP-INTJ dialogue has a rank adjustment score of seven, which again indicates a more than desirable amount of adjustment difficulty. An ISTP-ISTJ dialogue has a rank adjustment score of 11, again suggesting a moderate amount of difficulty. This score is, however, the highest of the three associated with Test Engineer 5, and supports the suggestion that the Test Engineer 5-Deputate Technical Advisor dyad is likely to experience better communication than the other dyads in which the test engineer is involved. In an ENTJ-INTJ dialogue, the rank adjustment score is 16, which indicates very little communication style adjustment difficulty. In an ENTJ-ISTJ dialuge, the rank adjustment score is 14, which indicates minor adjustment difficulty. In an INTJ-ISTJ dialogue, the rank adjustment score is 13, again suggesting minor adjustment problems. These three scores are substantially higher than those of the dyads in which the test engineer was involved, and thus reinforce the thought that the other three team members communicate more easily among themselves than they do with the team leader.

Research Question Four

How can the perceptions of the technical report preparation process held by key participants in that process be described?

This research question will be answered by presentation and analysis of the research participants' responses to interview questions covering five aspects of the technical report and its preparation process. Each subject area is individually presented and analyzed. The five topics discussed are 1) the purpose of the technical report; 2) the intended audience; 3) the assigned time limits; 4) the development of the technical report, which includes the tasks involved therein, guidelines for preparation and review, and an evaluation of the process; and 5) suggested changes to the process.

Purpose of the Technical Report. All 18 participants were asked to answer the question, "What is the purpose of the technical report?" Interview Question 5 was used for the test engineers, editors, division editors, division technical advisors, and deputate technical advisor. Interview Question 7 was used for the mathematicians and analysts. Nine of the respondents gave a single answer, 7 respondents gave 2 answers, and 2 respondents gave 3 answers, for a total of 29 answers. Preliminary analysis revealed that each of the individual answers could be placed into one of four major categories of purpose: 1) historical documentation, 2) reporting findings/giving results, 3) support for decision making, and 4) providing information for future researchers. Table 8 shows the categorization of individual responses.

Ten individuals indicated that they believed the purpose of the technical report was to provide historical documentation of a given test. The 10 individuals included 4 test engineers, 2 editors, both

TABLE 8

Technical Report Purpose Responses

	Provide Information Only		Provide Information For Action	
	Cat 1	Cat 2	Cat 3	Cat 4
Test Engineer 1	X			X
Test Engineer 2	X	X		
Test Engineer 3	X			
Test Engineer 4	X	X		
Test Engineer 5		X		
Editor 1	X			X
Editor 2	X			
Editor 3		X		
Division Editor 1	X	X		
Division Editor 2	X		X	
Div Tech Adv 1	X		X	X
Div Tech Adv 2		X		
Dep Tech Adv	X		X	X
Mathematician 1			X	
Mathematician 2		X		
Mathematician 3			X	
Analyst 1		X	X	
Analyst 2		X		

Note: Cat 1 = Historical Documentation
Cat 2 = Reporting Results/Findings
Cat 3 = Decision Making
Cat 4 = Research Data
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

division editors, 1 division technical advisor, and the deputate technical advisor. Of these people, two gave "historical documentation" as their only answer, while the other eight mentioned at least one other purpose as well. Answers placed in this first category contained statements such as "For historical purposes. It just documents that a test was done here" (55), "It is a record of what has been done for posterity" (17), and "To document testing they've done" (56).

Nine respondents made statements which showed that they viewed the technical report as a means of reporting the findings/results of a test. The nine individuals included three test engineers, one editor, one division editor, one division technical advisor, one mathematician, and both analysts. Of these nine respondents, five saw "giving results/reporting findings" as the sole purpose of the technical report. Answers placed in this second category included comments such as "Just to get a summary of what the test has done" (13), "To give, I guess, the final results of the test--the real nuts and bolts of the test" (36), and "To give the people on the outside results of our tests. It is not supposed to give you any kind of answers" (58).

Six respondents indicated that the technical report was used by the test requester or other agencies as an aid in decision making. The six individuals included one division editor, one division technical advisor, the deputate technical advisor, two mathematicians, and one analyst. Of these six respondents, two gave decision making as the only purpose of the technical report. Answers placed in this third category included statements such as "to provide information based upon which decisions can be made concerning further development or procurement of that item for the Air Force inventory" (12) and "Supposedly it explains

the item that was being tested. Is it acceptable? Does it meet specs? It . . . [enables] someone to pass judgment--do we manufacture this, or do we improve it, or what" (37). One respondent said, "I feel like sometimes lots of money depends on a proper tech report. . . . the Air Force might make a decision to buy that system" (14), but the respondent then indicated that many people in the organization did not share that perspective. Another individual commented that, although the technical report was supposed to provide the test requester with information to aid in the decision making process, "usually those decisions are made long before the TR [technical report] is actually published" (15).

Four individuals said that the technical report was a source of information for other researchers. The four--one test engineer, one editor, one division technical advisor, and the deputate technical advisor--all gave answers of this type in addition to one or more of the three types previously discussed. Answers placed in this fourth category included comments such as "[It] is also used for information [and] research" (17), "The TR [technical report] should answer questions about how you did it, later on" (54), and "To prevent someone from repeating a test unnecessarily" (12). One respondent highlighted the belief that a technical report serves more than one purpose. "The . . . purpose of the TR [technical report] is to document the results for posterity, so it goes into a central data bank and it's always there for people to refer back to" (15).

To summarize thus far, 18 participants provided 29 answers which were grouped into 4 categories. Ten answers were placed in the category of historical documentation, nine were placed in the category of reporting findings/results, six were placed in the category of supporting

decision making, and four were placed in the category of information for other researchers.

In further analysis, the first two categories--historical documentation and reporting findings/results--can be combined into a larger category of simply "providing information." Likewise, the third and fourth categories--support for decision making and information for other researchers--can be combined into a second larger category of "providing information necessary for some action to occur." That is, the purpose of the technical report, as seen in the answers associated with the first two categories, is merely to provide information, with little if any thought given to whether or how the gaining organization will use that information. However, a second purpose of the technical report, as seen from the answers in the third and fourth categories, is to provide information on which some action will be based. If the numbers of responses are also combined, there are 19 responses in the "providing information" category, and 10 responses in the "providing information for action" category. Thus two patterns of thought concerning the technical report's purpose emerge.

These two thought patterns or purposes are important in light of the emphasis placed on producing the technical reports within the specified time limits after completion of active testing. For those individuals who believe that some action will occur as a result of the technical report, especially if the action involves a development or production decision in an Air Force acquisition program, the need to meet the established time limit has some meaning and is real. For those individuals who believe that no action will occur as a result of the technical report, the need to meet the deadline is artificial and has

little meaning. Likewise, the requirement for the technical report to be sufficiently detailed and as accurate as possible is viewed differently depending on which purpose one has in mind. If action is to occur based on the technical report, the requirement is logical and has meaning. If, however, no action will occur, the requirement tends to lose its logic and meaning.

Intended Audience. To ascertain the identity of the perceived audience, the 13 participants assigned to the test organization were asked who they were thinking about when they performed their particular tasks in the technical report preparation process. Interview Question 6 was posed to the test engineers, editors, division editors, division technical advisors, and the deputate technical advisor. Because of the differences in the tasks performed by each major role group, a slightly different version of the question was used for each group. The mathematicians and analysts were not included in this portion of the analysis because they do not participate in the actual writing of the technical report. They were asked a related question, however, and the results will be discussed later in this section.

Ten of the 13 respondents gave single answers, while 3 had 2 answers, for a total of 16 responses. Preliminary analysis allowed the responses to be grouped into five major categories of intended audience: 1) the customer, 2) upper management, 3) the scientific/testing community, 4) future researchers, and 5) the general public. Table 9 shows the categorization of individual responses, including those of the mathematicians and analysts.

Four individuals stated that their primary concern was the customer. These four respondents included two test engineers, one division

TABLE 9

Perceived Audience Responses

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Test Engineer 1		X			
Test Engineer 2		X			
Test Engineer 3	X				
Test Engineer 4	X				
Test Engineer 5			X		
Editor 1			X		
Editor 2			X		
Editor 3					X
Division Editor 1	X				
Division Editor 2		X		X	
Div Tech Adv 1				X	X
Div Tech Adv 2		X			
Dep Tech Adv	X		X		
Mathematician 1	X				
Mathematician 2	X				
Mathematician 3	X				
Analyst 1	X				
Analyst 2	X				

Note: Cat 1 = Customer
Cat 2 = Upper Management
Cat 3 = Scientific/Testing Community
Cat 4 = Researchers
Cat 5 = General Public
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

editor, and the deputate technical advisor. One of the test engineers and the division editor identified the test requester as the customer (13; 56). The second test engineer and the deputate technical advisor both identified the System Program Office as the customer, while the engineer also mentioned contractors involved in the effort (12; 57).

Four individuals stated that their foremost concern was upper management. The four included two test engineers, one division editor, and one division technical advisor. Both test engineers and the division editor identified the individual who ultimately signs the technical report as the person in management that they kept in mind while completing their writing and editing tasks (14; 56; 57). The division technical advisor was not quite as specific as the others, stating "the people we consider most when we're writing a TR [technical report] is whether our management will buy what we say" (16).

Four respondents identified the scientific and testing community as their audience. The four included one test engineer, two editors, and the deputate technical advisor. The engineer commented that "It's really for somebody who is involved in the testing. . . . It's not to educate the uneducated" (58). One editor identified "the scientific community" (17) as the audience, while the other editor said "They are written by engineers for engineers, and that's who I'm thinking of" (18). The deputate technical advisor referred to the technical report as a vehicle of information for the scientific community, saying "I'm thinking about all the developers and testers in the United States DOD [Department of Defense]" (12).

Two individuals, a division editor and a division technical advisor, identified future researchers one audience. Both individuals

remarked that the technical report is eventually entered into the Defense Logistics Agency's Defense Technical Information Center (DTIC) system (14; 15). The division editor commented "But I'm also looking for that reader, you know, when the DTIC library will pick it up one of these days. They may want to run a test on the same type of system, not knowing this one has already been run" (14). The division technical advisor stated: "I usually think about the guy that goes into DTIC three years later and pulls this report out, and he has very little background information, and doesn't know much about the testing technique" (15).

Two respondents, an editor and a division technical advisor, identified the general public as the audience. The editor equated the general public with laymen who had very little, if any, technical background. "I'm talking about people like me . . . [who] may have a basic knowledge of what they are talking about but . . . do not know the intricacies of it" (19). The division technical advisor, however, equated the general public with those interested individuals who had access to the DTIC system and an appropriate technical background which would enable them to read "a complete, concise, and non-ambiguous" (15) document with relative ease.

In synopsis, 13 participants provided 16 responses concerning the identity of the perceived audience. These responses have been grouped into five major categories, as follows: 1) the customer, 2) upper management, 3) the scientific/testing community, 4) future researchers, and 5) the general public. Four responses each were placed in Categories 1, 2, and 3, while two responses each were assigned to Categories 4 and 5.

Additional analysis reveals an interesting difference among the categories. The first, third, fourth, and fifth categories all carry with them the connotation of concern for the reader's ability to understand what is written in the technical report. All address, in varying degrees, the technical level at which the document should be written, as well as its completeness. The second category, however, does not show the same type of concern for the reader as do the other four. Here concern is instead focused on doing whatever must be done to get the document signed, which may or may not be what is necessary to insure reader understanding. Four of the 16 answers are found in Category 2, while the remaining 12 answers are spread across the other 4 categories. Thus the ratio of concern for getting the document signed versus concern for the reader is one to three. All four individuals who gave the Category 2 response are assigned to the same work unit within the test organization--a unit which has, in management's view, historically experienced difficulty in meeting established deadlines--thus their answers may reflect their reaction to external pressure to now meet the deadlines. As one individual stated "I guess ultimately around here you have to worry about who signs it, to get it out of here" (14).

While the mathematicians and analysts do not participate in the actual writing of the technical report, the data that they prepare for the test engineers has a significant impact on the technical report. The researchers therefore believed it was important to determine who the mathematicians and analysts were thinking about as they performed their tasks. Interview Question 8 was presented to both groups.

Two mathematicians and both analysts identified the test organization in general--and test engineers specifically--as their customers,

while one of the analysts also mentioned off-base agencies which task the test organization (1; 2; 35; 37). Additionally, one of the analysts identified other local agencies which sometimes used the data generated by the test organization (2). One of the mathematicians identified the Air Force at large as the customer (36).

The response of the mathematicians and analysts suggests that these two groups, which support the test engineer and the test organization throughout the entire test cycle, possess a well-defined understanding of their relationships with the test engineer and their roles in the cycle.

Time Limits. Air Force Regulation 80-14, Research and Development, Test and Evaluation, states that "unless otherwise specified, test reports are released for publication no later than 60 calendar days after the data is processed for evaluation (11:11). The test organization has modified that requirement to "60 workdays after the last test mission" (10:2). In instances where a test is particularly long or complex, the time limit may be lengthened to 120 calendar days. Extensions to the original time limit may be requested if necessary, but must be fully justified (10:2).

All 18 participants were asked to answer the question, "What do you think of the time requirements for the report?" Interview Question 11 was posed for the test engineers, editors, division editors, division technical advisors, and deputate technical advisor. Interview Question 15 was used for the mathematicians and analysts. Twelve of the respondents gave single answers, while 6 had 2 answers each, for a total of 24 responses. After initial analysis, the 24 answers were consolidated into 5 major categories. Category 1 includes those answers which

indicated that time limits should be determined on a case-by-case basis. Category 2 consists of those answers which characterized the time limits as unrealistic and arbitrary. Category 3 includes answers which stated that there was no problem with the existing time requirements. Category 4 is composed of those answers which related the time limits to the need for goals. Category 5 consists of responses which indicated that the time limits are satisfactory after one has gained some experience on the job. Table 10 shows the categorization of individual responses.

Seven individuals responded that the length of time allowed for the report process should be determined on a case-by-case basis. The seven respondents included three test engineers, one editor, one division editor, and both division technical advisors. Three of the participants gave this as their only answer, while four also had a second answer. All three of the engineers commented on the differences among tests and stated that variations in tests should be considered when the time requirements are established. Technical reports from tests performed on completely new items or in new areas of technology could be expected to take longer to write than those from standard types of tests or tests on items with existing data bases (56; 57; 58). One division technical advisor and the editor thought the length of the report cycle should include some consideration of the number of pages in the report (16; 17), with the editor describing variations in report size as "everything from Peter Rabbit to Sears Roebuck" (17). The division editor also mentioned the size of the report. "It should depend on the report itself. Some reports are so small that 60 days is plenty of time. Other reports are so complex and so large that 120 days isn't near enough" (13). The second division technical advisor remarked that it is

TABLE 10

Time Limit Responses

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Test Engineer 1		X		X	
Test Engineer 2					X
Test Engineer 3	X				
Test Engineer 4	X				X
Test Engineer 5	X				
Editor 1	X	X			
Editor 2				X	
Editor 3			X		
Division Editor 1	X				
Division Editor 2		X			
Div Tech Adv 1	X			X	
Div Tech Adv 2	X	X			
Dep Tech Adv		X			
Mathematician 1			X		
Mathematician 2			X		
Mathematician 3			X		
Analyst 1		X		X	
Analyst 2			X		

Note: Cat 1 = Case-By-Case Basis
Cat 2 = Unrealistic
Cat 3 = No Problems
Cat 4 = Goals
Cat 5 = Satisfactory With Experience
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

difficult to know, while in the planning stages of the test, how long it will take to write the report. Therefore, there should be room for adjustments on a case-by-case basis (15).

Six respondents stated that they thought the existing time requirements were unrealistic. The six individuals included one test engineer, one editor, one division editor, one division technical advisor, the deputate technical advisor, and one analyst. Of these six people, three gave "unreal/arbitrary" as their only response, while the other three also had a second answer. The division editor commented that the current 60-day limit is unrealistic because there is only one test engineer assigned to a test. The test engineer cannot humanly do everything that should be done every day--schedule resources, fly, attend meetings, analyze data, and write the draft technical report--by himself, thus the 60-day limit is not realistic. The division editor also remarked that the 60-day limit is attainable, but only if a test team concept is used and changes are made to the technical report review cycle (14). The division technical advisor agreed that 60 days is unrealistic: "I think 60 days is unreal--totally ridiculous. For one thing, to have 60 days for all reports, whether the report is 20 pages or 200 pages or even longer, is kind of silly" (16). The deputate technical advisor stated, "I think it's an arbitrary number--written down on a piece of paper by someone who had little knowledge of how long it took to write a report and what it took to write a report" (12). The analyst felt that the 60-day limit is unreasonable in light of the amount of data generated. Modern technology makes it possible to collect vast amounts of data. "When you have large instrumentation systems, they gather a tremendous amount of data, and you are trying to do

a lot of analysis" (1). The analyst also indicated that, at times, even 180 days were not long enough to properly analyze the data and write a technical report (1). The division technical advisor suggested 120 days as a more reasonable length of time for his division's reports, considering the complexity of the testing done. The deputate technical advisor, however, thought that 90 days would be a more appropriate length of time across the organization (12; 16).

Five individuals remarked that there was nothing wrong with the existing time requirements. All five respondents gave this as their only answer. The five included one editor, three mathematicians, and an analyst. The editor stated that there were no problems with the time limit (19). The mathematicians and analyst knew that a time limit existed, and thought it was either reasonable or had no problem with it (2; 35; 36; 37).

Four participants viewed the setting of time limits and deadlines as the establishment of goals. Respondents included one test engineer, one editor, one division technical advisor, and one analyst. This was the sole answer for one individual, but one of two answers for the other three people. The test engineer, who also thought the existing time limit was unrealistic, said the time limit "should set a goal for employees just out of their reach to keep them working at their potential" (54). The division technical advisor commented:

> It's just a matter of trying to do business as efficiently as possible, having goals and trying to meet them. It's just a goal, and if people will think about what goals mean, then they won't get real hung up on the 60-day thing. (15)

Both the editor and the analyst remarked on the need for deadlines, with the editor commenting: "I believe that maxim, your work fills up the time no matter how many days you have" (18).

Two individuals, both test engineers, commented that the existing time requirements are satsifactory, but each then qualified the remark. One respondent gave this as his only answer, while the other had a second answer. Both indicated that the time limit was satisfactory now, after they had gained some experience and had written several technical reports (55; 57). As one of them explained:

> Right now I'd say it's adequate, but when I first got here I thought it was inadequate. The longer you stay here, you learn the system and you know a lot of shortcuts you can take. You do your first tech report. It's pretty difficult because you never have done one and it's a new thing to you. But the more you do, the more confident you get. You know you can write something and know it's going to get chopped up, but the basic thought is going to stay there. So I think it's pretty realistic, after you've been here three years. It's tough on second lieutenants, though, first assignment. . . . (56)

To summarize the preliminary analysis, 18 participants gave 24 responses which have been grouped into 5 categories. The categories include 1) determining time limits on a case-by-case basis, 2) characterizing time limits as unrealistic and arbitrary, 3) evaluating time limits as presenting no problems, 4) characterizing time limits as goals, and 5) evaluating time limits as satisfactory, with a caveat. Seven responses were assigned to Category 1; six answers were placed in Category 2; five answers were put in Category 3; four responses were grouped in Category 4; and two answers were placed in Category 5.

Analysis of the responses by category reveals two points. First, the responses in Categories 1,2, and 5 all acknowledge, implicitly if not explicitly, that the current report cycle time limit leads to some

problems for the test organization. Twelve of the 18 respondents are represented by answers in these 3 categories. The commonly recommended solution, mentioned by seven participants, is the case-by-case determination of report cycle length, driven primarily by the type, complexity, and length of a given test.

Second, the responses in Category 3--that the time limit is not a problem--are at odds with the concept of the time limit as a problem developed from answers in Categories 1, 2, and 5. In the case of the mathematicians and analyst, this seemingly extreme difference of opinion can be explained by noting that they are not personally involved in writing the technical report; thus there would be little, if any, reason for them to be concerned with deadline problems. The editor, however, is deeply involved in the report preparation process, and could reasonably be expected to be affected by time limit problems if they existed. It is possible that the editor answered the question from the perspective of the time segment officially allotted for the editing process after the coordination meeting, rather than from the perspective of the 60 days allotted for the entire process.

Analysis thus shows that the majority of the respondents perceive the current time requirement as a problem for the organization. Several view it as unrealistic and arbitrary, while some see it as something which should be determined on an individual basis. Some see it as having positive potential if considered as a goal to strive for rather than a deadline to be met. A few see it as something which can be overcome with time and the gaining of experience. Overall, however, it is seen as a problem.

Development of the Technical Report. This section of the research question addresses the process by which the technical report is developed. The discussion is divided into three subsections, each of which covers a specific aspect of the development process. The first subsection is concerned with the respondents' perceptions of the tasks involved in the process. The second subsection considers the guidelines used to write and review the technical report. The third subsection presents the respondents' evaluation of how well the current process works. Each subsection presents only the interview responses and preliminary analysis for that subtopic. Each subsection is individually summarized for the reader's convenience. The larger topic of technical report development is then analyzed in light of the three preliminary analyses.

Tasks. The 18 participants were asked to describe what was involved in the task of developing a technical report. Interview Question 7 was posed to all the participants. Six of the respondents gave 2 answers each, while the remaining 12 individuals had 1 answer each, for a total of 24 responses. The responses were grouped into three categories of tasks: 1) collecting and compiling data, 2) developing formatted text, and 3) answering test objectives. A fourth category consisted of answers from individuals who responded that they knew nothing about the development of technical reports. Table 11 illustrates the categorization of individual responses.

Ten individuals addressed collecting and compiling data as the first task in developing a technical report. The 10 included 3 engineers, both division editors, both division technical advisors, the deputate technical advisor, 1 mathematician, and 1 analyst. Five of the

TABLE 11

Report Preparation Task Responses

	Cat 1	Cat 2	Cat 3	Cat 4
Test Engineer 1			X	
Test Engineer 2		X		
Test Engineer 3	X	X		
Test Engineer 4	X	X		
Test Engineer 5	X			
Editor 1		X		
Editor 2		X		
Editor 3		X		
Division Editor 1	X			
Division Editor 2	X	X		
Div Tech Adv 1	X		X	
Div Tech Adv 2	X			
Dep Tech Adv	X	X		
Mathematician 1				X
Mathematician 2	X			
Mathematician 3				X
Analyst 1	X		X	
Analyst 2				X

Note: Cat 1 = Collecting and Compiling Data
Cat 2 = Developing Formatted Text
Cat 3 = Answering Test Objectives
Cat 4 = Do Not Know
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

10 respondents also gave answers which were placed in other categories. All 10 participants remarked that the first step in developing a technical report included collecting and compiling the data (1; 12; 13; 14; 15; 16; 36; 56; 57; 58). One of the division editors commented: "It's just a matter of gathering all this data and putting it together into some kind of semblance that would look halfway legible, so that you can see what you are doing" (13). One of the division technical advisors pointed out a problem associated with the data.

> With our test reports, the major effort is put into data reduction, not the actual writing. Our biggest bottleneck is the problem of getting through all the data. It's not just the fact that the math lab is not getting it out to us. It's just that there's a lot of data we have to deal with. Some of the data we have to go through by hand to get it ready to give to them [the data reduction organization], and that is very time-consuming. (16)

One test engineer summarized this aspect of preparing a technical report, saying it amounted to "getting all of your data, . . . gleaning through that and taking the unnecessary data out of there, and having it compiled in a logical manner which a knowledgeable person can make some sense out of" (58).

Eight respondents identified development of formatted text as a critical step in drafting a technical report. The eight included three test engineers, the three editors, one division editor, and the deputate technical advisor. Four of these individuals had answers placed in other categories as well. The three editors emphasized the importance of following the guidelines on format while drafting the report's text (17; 18; 19). Two of the engineers indicated that they viewed drafting formatted text as the second step in development of the report, coming immediately after collection and compilation of data (56; 57). One of

the editors pointed out that the method of test provided a lot of the information which was required in the technical report format (17). The division editor also emphasized the importance of the method of test.

> If you can perfect your method of test, a lot of that stuff is transferable, almost directly, over to your tech report. They could spend more of their time writing on the . . . [latter sections] of the tech report, and not have to worry about what's up front in the instrumentation section, in the test item description, and in the preface. All of their time can be spent in analysis. (14)

Three individuals--one test engineer, one division technical advisor, and one analyst--included answering the test objectives as a task in developing a technical report. The engineer said one should "go back to the TD [test directive] and MOT [method of test], and answer the objectives by telling what you've accomplished" (54). The analyst tied together the data and the objectives, saying the task was "to consolidate all the data from all the sources, and come to a conclusion, objective by objective, . . . and to have enough statistical and/or data products available to prove your conclusion" (1). The division technical advisor underscored the importance of the test objectives.

> In the TR [technical report] he's obligated to answer the test objectives that are contained in the method of test . . . which, in essence, represents the contract between the . . . [test organization] and the test requester. (15)

Finally, three of the respondents--two mathematicians and one analyst--said that they were not familiar with how a technical report is prepared; thus they could not comment on the tasks involved (2; 35; 37).

In summary, 18 respondents provided 24 answers when asked to discuss the tasks involved in developing a technical report. The responses were grouped into four categories. Ten answers were placed in the first category, which addressed collection and compilation of data. Eight

responses were included in the second category, the development of formatted text. Three answers were put in the third category, which stressed the importance of answering the test objectives. Three individuals were unfamiliar with the development process and could not comment on the tasks therein; thus their responses formed the fourth category, labeled "Do Not Know".

Guidelines. The five test engineers were asked to answer Interview Question 17: "Are there any guidelines or requirements that you use in writing the report?" Each of the 5 engineers gave 2 responses, for a total of 10 answers. The 10 answers were grouped into 2 categories: 1) published guidelines and 2) published technical reports. Since there are only two categories, and all five engineers had answers in both, no visual categorization is presented for this response.

All five engineers said they used some form of published guidelines in preparing their technical reports. Four of them mentioned the test organization's operating instruction (55; 56; 57; 58), and one of those four also mentioned the Test Engineers' Handbook (58). The fifth engineer identified some division-level handouts which were derived from the published guidelines (54). All five engineers also remarked that they tried to find published technical reports written for tests similar to the tests in which they were involved (54; 55; 56; 57; 58). One individual commented that existing technical reports were particularly helpful if either the same item or a similar item was being tested, or if the same or a similar kind of test was being conducted (58). A second engineer pointed out that existing technical reports might not be

helpful, saying "Sometimes something written a year ago is not acceptable today" (55).

The editors, division editors, division technical advisors, and deputate technical advisor were then asked to answer their version of Interview Question 17: "What do you look for when you review a draft technical report?" The mathematicians and analysts were not included in this portion of the analysis because they are not involved in actually writing or reviewing the technical reports. One of the respondents gave four answers, three respondents each had three comments, another three individuals each gave two responses, and one individual gave one answer. The responses, which totalled 20, were grouped into 4 categories. Category 1 consisted of all answers which concerned the technical report format. Category 2 included those responses which identified the objectives outlined in the method of test. Category 3 is composed of answers which dealt with the editorial details of the report. Category 4 included responses which mentioned the report's technical content. Table 12 shows the categorization of individual responses.

Six of the respondents said that, as they reviewed a technical report, they focused on the report's format. Responses in this category were given by the three editors, one division editor, one division technical advisor, and the deputate technical advisor. All of these individuals had answers in other categories as well. The three editors all remarked that format was the first thing they examined in the review process. They indicated that there was little point in reviewing for grammar or other details until the format was acceptable (17; 18; 19). One editor identified the test organization's operating instruction and

TABLE 12

Review Guideline Responses

	Cat 1	Cat 2	Cat 3	Cat 4
Editor 1	X		X	
Editor 2	X	X	X	
Editor 3	X		X	
Division Editor 1	X	X	X	
Division Editor 2				X
Div Tech Adv 1	X	X	X	X
Div Tech Adv 2		X		X
Dep Tech Adv	X	X		X

Note: Cat 1 = Review for Format Requirements
Cat 2 = Review for Test Objective Tracking
Cat 3 = Review for Editorial Details
Cat 4 = Review for Data and Technical Content
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

Military Standard 847B, Format Requirements for Scientific and Technical Reports, as the basic guidelines for format requirements (18). The division editor also commented that format received first consideration in the review process. However, this individual focused on the applicable method of test as the driving force behind a given technical report's format (13). Both the division technical advisor and deputate technical advisor also identified format as a key area for attention in the review process, but neither mentioned any specific guidelines associated with the format (12; 15).

Five participants focused on the test objectives as outlined in the method of test. These respondents included one editor, one division editor, both division technical advisors, and the deputate technical advisor. Each of the five also had an answer in at least one other category. All five indicated that the test objectives were at the center of the test itself, and thus should be completely addressed in the technical report (12; 13; 15; 16; 18). The editor and deputate technical advisor remarked that they checked to see if each objective was tracked throughout the technical report (12; 18). One of the division technical advisors said that he looked to see whether the test objectives had been met (16). The division editor said the technical report was reviewed for conformance to the objectives in the method of test, commenting: "You do just whatever your objective states. You don't do more, and you don't do less. You have to do exactly as your MOT [method of test] states" (13).

Five of the participants remarked that they looked at details during the review process. The five respondents were the three editors, one division editor, and one technical advisor. All five had an answer in at least one other category as well. Two editors, the division editor, and the division technical advisor indicated that they looked at details such as grammar, punctuation, and spelling (13; 15; 17; 19). All three editors emphasized the necessity of checking the sequencing of all figures, tables, and appendices (17; 18; 19). One editor also pointed out the need to insure that administrative security practices and procedures were followed (17).

Four individuals said that they examined the reports for data and technical content. The four respondents included one division editor,

both division technical advisors, and the deputate technical advisor. One individual gave this as his only response, while the other three each had an answer in at least one other category. All four indicated that the amount and type of data included in a report, when combined with applicable technical explanations, must be sufficient to substantiate or justify the report's conclusions (12; 14; 15; 16).

In synopsis, five test engineers each gave two answers when asked what guidelines they used in writing a technical report. Each replied that he or she used both published guidelines and existing technical reports.

The other eight people assigned to the test organization were asked what guidelines they use when reviewing technical reports. The 8 respondents gave 20 answers, which were grouped into 4 categories. Category 1 addressed review for format requirements and included six responses. Category 2 covered the tracking of test objectives and included five answers. Category 3 comprised those answers dealing with review for editorial details, a total of five responses. Category 4 included four answers and addressed review for data and technical content.

Evaluation. The 13 individuals assigned to the test organization were asked to evaluate, from their own perspective, how well the technical report preparation process actually worked. Interview Question 14 was posed to the test engineers, editors, division editors, division technical advisors, and the deputate technical advisor. The mathematicians and analysts were not included in this part of the research since they do not participate in the actual writing of the technical report. The 13 participants each gave a single response

TABLE 13

Process Evaluation Responses

	Cat 1	Cat 2
Test Engineer 1	X	
Test Engineer 2	X	
Test Engineer 3	X	
Test Engineer 4	X	
Test Engineer 5	X	
Editor 1	X	
Editor 2	X	
Editor 3	X	
Division Editor 1	X	
Division Editor 2		X
Div Tech Adv 1	X	
Div Tech Adv 2		X
Dep Tech Adv	X	

Note: Cat 1 = Process Works Well
Cat 2 = Process Does Not Work Well
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

to the interview question; thus there was a total of 13 answers. The responses were grouped into two categories: 1) the process works well and 2) the process does not work well. Table 13 illustrates the categorization of the individual responses.

Eleven of the 13 respondents stated that the technical report preparation process worked well, with four individuals adding caveats to

their evaluations. The respondents in this category included all the test engineers, all the editors, one division editor, one division technical advisor, and the deputate technical advisor. The four respondents who qualified their answers included two test engineers, the division editor, and the deputate technical advisor. One of the test engineers said the process was effective in that the technical report got published, but remarked that the result was "not worth the hassle and personal stress" (54). The second engineer indicated that the process worked, but expressed a belief that the engineers should give more thought to how the technical report will be written while they are involved in active testing (57).

> I did learn one thing, though, especially in taking photographs and in some of my test procedures. I am going to think more about the TR [technical report] during the test--think more about what I want to do--and put--in that report, and what kind of information I need to gather and how to document it so that it's easy to find. (57)

The division editor remarked that the process accomplished its intended function, but re-emphasized an earlier comment. "Like I was saying before, I think you have to look at everything on a case-by-case basis" (13). The deputate technical advisor agreed that the process worked well. He pointed out, however, that he was viewing the process from the outside and could not be sure how well the process was working at the lower levels of the organization (12).

> But I'm not down in the bowels of the process. I'm sitting up above looking down. . . . I do know that from my viewpoint up here, the quality is good, timeliness is pretty good. So, from the measures of merit that I have, it looks pretty good. (12)

Three other respondents, two test engineers and one editor, agreed that the current process worked well, and added that they knew of no other

way to get such a document published (19; 55; 56). One of the engineers commented:

> It is so much more fun to continue doing tests than just to write TRs [technical reports]. I understand why we have to have a limit to it--otherwise we may never get any TRs published. We really do need to document what we have done. (56)

Three of the individuals, one engineer and two editors, did not elaborate on their responses. The division technical advisor said he thought the process worked amazingly well, considering the general lack of writing experience most young engineers exhibit coming straight from undergraduate school into the Air Force (15).

Two respondents--one division editor and one division technical advisor--indicated that the technical report preparation process did not work well. The division editor remarked that there were too many levels of review in the process, which caused it to be slower than necessary (14). The division technical advisor said that, although it was working better than it had, "It doesn't work well from the standpoint that the test engineer does not have the time to stay on top of it" (16).

In summary, 13 individuals were asked to evaluate whether the technical report preparation process worked well. The 13 participants each gave a single answer, for a total of 13 responses. The responses were grouped into two categories. Eleven responses which indicated that the process worked well were placed in Category 1, while two answers which indicated the process did not work well were put in Category 2.

Analysis. Examination of the categorization of task responses illustrated in Table 11 shows that the respondents perceive primarily two tasks involved in developing a technical report. Ten of the 18 individuals identify collecting and compiling data as one task, while 8 of

18 identify the writing of formatted text. Thus the development of the technical report is seen as more than simply the drafting of a document. Rather it is a process which requires that thought be given to the final product--the technical report--while the author is still in the active testing phase.

Analysis of the guideline responses shown in Table 12 reveals two points. First, all of the editors and one division editor mentioned reviewing for format as well as for editorial detail. Second, there is an obvious difference in how technical reports are handled by the two division technical advisors. Whereas Division Technical Advisor 2 reviews the report for the test objectives and technical content only, Division Technical Advisor 1 reviews the report for format, test objective tracking, editorial details, and data and technical content. This difference results from differences in the organizational structures of the two divisions. Appendix E provides a review of the organizational structure. The division to which Division Technical Advisor 2 is assigned is the same division to which the two division editors are assigned. The division editors are part of a technical support branch within Division A. Division Editor 1 performs technical writing and most of the editing for technical reports generated within the division, while Division Editor 2 assists the division technical advisor with reviews for data and technical content, and with the coordination meeting in the formal review process. Division Technical Advisor 1, however, has no such support staff and thus must handle all of the various details himself.

Examination of the evaluation responses illustrated in Table 13 suggests that the established process does, in fact, accomplish that

which it is designed to do. While respondents were not wildly enthusiastic about the process, the majority (11 to 2) did indicate that the process worked and got the technical report published.

Changes to the Process. The 13 participants assigned to the test organization were asked to answer the question, "If you could change one thing in the technical report process, what would you change, and why would you change it?" Interview Question 13 was used for the test engineers, editors, division editors, division technical advisors, and deputate technical advisor. The mathematicians and analysts were not asked this particular question because they are not directly involved in the technical report preparation process. They were asked a related question, however; those results will be discussed later in this section.

Eleven of the 13 respondents gave single answers while 2 each gave 2 answers, for a total of 15 responses. Preliminary analysis permitted the responses to be grouped into four categories. Category 1 includes all answers which suggested changes to the technical report review process. Category 2 consists of all responses which recommended changes to the way in which time limits were assigned. Category 3 is composed of those answers which suggested changes to the technical report writing process. Category 4 includes responses which recommended changes to workload scheduling. Table 14 shows the categorization of individual responses, excluding the mathematicians and analysts.

In the first category, eight individuals recommended four different changes to the review cycle. These individuals included three test engineers, one editor, both division editors, one division technical advisor, and the deputate technical advisor. One of the engineers and the editor also gave second answers which were placed in other

TABLE 14

Suggested Change Responses

	Cat 1	Cat 2	Cat 3	Cat 4
Test Engineer 1	X	X		
Test Engineer 2	X			
Test Engineer 3	X			
Test Engineer 4		X		
Test Engineer 5			X	
Editor 1		X		
Editor 2	X			X
Editor 3				X
Division Editor 1	X			
Division Editor 2	X			
Div Tech Adv 1			X	
Div Tech Adv 2	X			
Dep Tech Adv	X			

Note: Cat 1 = Changes to Review Process
Cat 2 = Changes to the Time Limit Assignments
Cat 3 = Changes to the Writing Process
Cat 4 = Changes to Workload Scheduling
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

categories. The review cycle under discussion is that review cycle which was presented in detail in Research Question 1. A simplified diagram of the review cycle is found in Appendix G.

In the first recommendation, four of the eight respondents indicated that changes should be made to the level of review currently

used. Two of the engineers and the deputate technical advisor said that the final review and signature level should be delegated to the test organization level (12; 54; 56). Another test engineer recommended removal of one of the intermediate levels of review, but did not state specifically who should sign the technical report (55). Second, the two division editors both suggested reducing the number of revisions which occurred. One of them commented that use of computers with word processing capabilities actually increased the typing workload and impeded the preparation process. Each review level thought it was easy to make changes and print new versions of the report, so changes which were not absolutely necessary were made (13). The other division editor recommended that all levels of review be sent the first draft and then be required to attend a single coordination meeting. "I think that, if all the technical advisors were to show up at one meeting, having already read the draft, we would only have one change, instead of as we do now" (14). All changes could then be incorporated at one time, and two revisions could be eliminated (14). The division technical advisor suggested a third change to the review process. This individual would acquire the personnel and equipment necessary to perform the artwork functions currently done by illustrators within the technical support division. He believes that, by adding the artwork capability to his existing division-level editing capability, technical reports from his division would remain under division control throughout the editing and review process. Thus he would be better able to ensure the reports' timeliness (16). Finally, the editor suggested that test engineers should not be sent on temporary duty, nor should they be given leave, immediately after the draft technical report was sent to the editors.

The editor remarked: "There's always someone you can ask questions to, but I do like the engineer that wrote the report because he knows better than anyone else" (18).

In the second category, three individuals suggested two changes to the test cycle planning process. The three included two test engineers and one editor. One of the test engineers also gave an answer in another category. All three respondents suggested that differences in the kinds of tests and in test situations should be considered when report time limits are assigned. The editor said, "I would change the rigid time schedule because what is realistic for one report is not realistic for another one" (17). One of the test engineers pointed out that the two divisions perform completely different kinds of tests and suggested that the established time limits should reflect consideration of those differences. Since the tests are not the same, the same time constraints should not be applied arbitrarily to all tests (54). The second engineer recounted an incident where an engineer had to write two different technical reports from one test, yet was given no additional time to complete the writing. The engineer commented, "I think they should have a little consideration" (57).

In the third category, two individuals--one test engineer and a division technical advisor--recommended two changes to the actual technical report writing process. The test engineer commented on the organization's usual policy of not making recommendations in the technical report.

> I think it would be kind of nice to be able to put in some--what I call real--conclusions. We really don't put conclusions in our conclusions. They are more of a rehash of the results. . . . I guess, basically, I'd like to use my engineering degree a little bit more than I do. I like to be able

> to use a little bit of engineering judgment sometimes, which I don't get to do. (58)

The division technical advisor remarked that he would change the timing of the emphasis which is placed on writing the technical report. Management says that the engineer should begin drafting the technical report as soon as active testing starts, and should continue to work on it throughout active testing so that there will be no problem meeting the deadline once testing is completed. However, no management emphasis or attention is given to the technical report until after the report phase begins. The division technical advisor commented that increased supervisory attention to the writing, earlier in the testing, might improve the overall technical report preparation process. "I think if people put a little more emphasis on it, in other words if they cared more and reflected that care in their supervision, it might make it all easier as the process goes along" (15).

In the last category, two editors had two different suggestions for changes in workload scheduling. One editor commented on a given test engineer's involvement in several tests at any particular time, suggesting that the engineer should be allowed to "completely finish one thing before he has to start the second thing" (18). The second editor remarked that better quality reports would result if there were some way to level out the flow of reports into the editing function. The work was described as "one of those types of businesses where you are either so swamped you can hardly see where you are going, . . . or you have nothing to do whatsoever" (19). The editor did not, however, think that such a smoothing of the incoming workload was possible.

The 15 responses given by the 13 participants have thus been grouped into four major categories of suggested changes. The four categories include 1) changes to the review process, 2) changes to the way time limits are assigned, 3) changes to the writing process, and 4) changes to workload scheduling. Eight responses were grouped in Category 1, three answers were placed in Category 2, and two responses each were assigned to Categories 3 and 4.

Further analysis of the categorized responses highlights Categories 1 and 2. Eight of the 15 responses were placed in Category 1. Six of those eight responses suggested some change in the level or number of reviews, either delegating final review to a lower level, deleting one intermediate level, or holding one review meeting attended by all levels of review. In all three instances, the suggestions would theoretically result in fewer revisions to a given draft and therefore less time spent in the report cycle.

Three responses were assigned to Category 2. These answers suggested that differences in tests and test situations should be considered when time limits are assigned. Those tests which are unusual or particularly complex would be more difficult and time consuming to document than would standard or less complex tests. If the time limits were adjusted accordingly, there would be fewer problems and complaints of unrealistic deadlines.

Although the mathematicians and analysts are not directly involved in writing and reviewing the technical report, the researchers were interested in their perspective of the technical report process. All five were asked Interview Question 17: "If you could change one thing in your interaction with the test engineer, what would you change, and

TABLE 15

Interaction Change Responses

	Cat 1	Cat 2	Cat 3	Cat 4
Mathematician 1				X
Mathematician 2	X			
Mathematician 3		X		
Analyst 1		X		
Analyst 2	X		X	

Note: Cat 1 = Test Engineer Inexperience
Cat 2 = Improved Coordination
Cat 3 = Improved Planning
Cat 4 = No Suggestion

why would you change it?" The five individuals gave a total of six answers. The six answers were grouped in four categories: 1) test engineer inexperience, 2) improved coordination, 3) improved planning, and 4) no suggestions. The categorization is shown in Table 15.

Two people, one mathematician and one analyst, remarked that the test engineers appeared to be less experienced now than they had been in the past (2; 36). The mathematician also commented on the turn-over of engineers: "When the project officer does get a little experience, he gets transferred to somewhere else" (36). Another mathematician and the second analyst suggested that coordination between them and the test engineer could be improved. The mathematician stated that sometimes things were overlooked or forgotten, while the analyst commented on getting information in a more timely manner (1; 37). One mathematician had no suggestions for change, stating that there were no problems in

that interaction process (35). One analyst suggested that more emphasis should be placed on the initial planning for a test.

> The one thing, I think, that is still lacking in all of this--and it would help the TR [technical report]--is more and better up front planning. That may mean more TDY [temporary duty] for people, more trips, more money spent up front to go to find out how a system works, so that you can do better design up front. It could be test engineers, folks from our organization, if instrumentation is required, folks from there, whatever the expertise is that's required. More up front design, more thought. (1)

While no particular trends are apparent in these responses, it is possible that there is a connection between the inexperience of the test engineers and the need for improved coordination. Engineers who are new to the career field as well as new to the military might be less likely to recognize situations requiring anything other than ordinary day-to-day coordination than would their more experienced counterparts.

Research Question Five.

How do these perceptions held by key participants compare?

Research Question 4 dealt with the general perceptions of the technical report process as seen by the key participants in that process. The overall perceptions of the process were described in answering that research question. This question is a follow-on to the broad question addressed by Research Question 4. This question is addressed from two perspectives: 1) comparing the perceptions based upon the roles of the participants, and 2) comparing the perceptions based upon the teams that these participants formed in developing the technical report. Because membership on a team is based upon each individual's role in the task, the comparison of perceptions based upon roles is discussed first. The aspects of the technical report process

addressed will be the same as those addressed in the Research Question 4 discussion including 1) the purpose of the technical report, 2) the intended audience as viewed by each participant, 3) the time limit requirements, 4) the development process itself, and 5) changes to the process.

Comparison By Role. Each of the five aspects of the process are examined sequentially for this comparison by role. The 18 key participants are divided into 4 role groups: 1) the test engineers, 2) the editors, including the division editors, 3) the technical advisors, including the division and deputate technical advisors, and 4) the mathematicians, including the analysts. The general perceptions held by each role group are compared for each of the five aspects of the process.

Purpose of the Technical Report. For this analysis, Table 8 is modified to separate the individuals in each role. The modified table is Table 16, with four groups determined by role. The first group is the test engineers; the second group, the editors; the third group, the technical advisors; and the fourth group, the mathematicians.

Beginning with the test engineers, there are eight answers identifying purposes of the technical report. Seven of the eight answers are in the broad area of providing information only, while one lies in the area of providing information for action, in the specific category of providing research data. Four of the five test engineers agree that one purpose of the technical report is historical documentation, and three of the five say that it reports results and findings. All of them agree that at least one overall purpose is to merely provide information. As pointed out in Research Question 4, at the test engineer level, the

TABLE 16

Technical Report Purpose Responses By Role Groups

	Provide Information Only		Provide Information For Action	
	Cat 1	Cat 2	Cat 3	Cat 4
Test Engineer 1	X			X
Test Engineer 2	X	X		
Test Engineer 3	X			
Test Engineer 4	X	X		
Test Engineer 5		X		
Editor 1	X			X
Editor 2	X			
Editor 3		X		
Division Editor 1	X	X		
Division Editor 2	X		X	
Div Tech Adv 1	X		X	X
Div Tech Adv 2		X		
Dep Tech Adv	X		X	X
Mathematician 1			X	
Mathematician 2		X		
Mathematician 3			X	
Analyst 1		X	X	
Analyst 2		X		

Note: Cat 1 = Historical Documentation
Cat 2 = Reporting Results/Findings
Cat 3 = Decision Making
Cat 4 = Research Data
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

general perception is that the technical report simply provides information and is not a basis for later action.

The second group in Table 16 contains the editors' responses by general area and category. Of their eight answers, six are in the area of providing information only. The other two responses are split between use as an aid in decision making and use in later research, in the area of providing information for action. Four of the five editors say, as did the test engineers, that at least one purpose is historical documentation. Two of the five say that the document reports results and findings. Each of the editors has at least one answer that falls in the area of providing information only. Therefore, the editors perceive that the technical report simply provides information and is not used for later action.

The third group in Table 16 includes the technical advisors, the two division technical advisors as well as the deputate technical advisor. These individuals are considered middle and upper management personnel within the test organization. They give a total of seven answers describing the purpose of the technical report. The answers are divided between providing information only and providing information for action. In the area of providing information only, two of the three technical advisors agree that one purpose is to provide historical documentation, while one says that another purpose is to report results and findings. The same two technical advisors who saw historical documentation as one purpose also said the report can be used as an aid in decision making and as data for later research. Therefore, these managers, in general, recognize the dual purposes of providing

information only and providing information for action in the technical report.

The mathematicians and analysts are combined in the last group in the table. Six answers were given by these five individuals. Three of the answers are in Category 2, reporting results and findings, in the area of providing information only. The other three responses are in Category 3, aiding decision making, in the area of providing information for action. No answers were given which fit into either Category 1 or Category 4. There is, therefore, less variation in the answers given by this group whose members are not assigned to the test organization. Each person sees the technical report as either reporting the results or as impacting decisions on the future of the system being tested. In addition, as a group the mathematicians and analysts see the technical report as both providing information only and providing information for decision making.

In comparing perceptions of the technical report's purpose by the roles of the participants, the researchers observe that the test engineers and editors in general agree that the technical report's purpose is to provide information. The report is not to be used later, as support for any action. The middle and upper management personnel, the technical advisors, however, have a broader perspective on the purpose of the technical report, seeing it both as providing information only and providing information for further action. The mathematicians and analysts as a group also hold this dual perspective. However, since they are not as thoroughly familiar with the technical report as are those in the test organization, their answers show less variation as

they do not mention the two options of historical documentation and data for later research.

Intended Audience. Table 9 shows the perceived audience responses categorized by interviewee. The table may be modified to form Table 17 by separating the individuals in each role group with a double line.

As was stated in Research Question 4, the mathematicians and analysts were not questioned as to the intended audience of the technical report. They were questioned instead concerning the audience for their data reduction efforts. Therefore, this group will not be compared with the other three groups; their response as a group will, however, be summarized.

For the test engineers in the first group of Table 17, there are a total of five answers, one given by each test engineer. Two of the engineers were thinking about the customer, either the test requester, System Program Office, or contractor involved. Two others saw the person in upper management who signs the technical report as the audience, and one other test engineer was thinking of the testing community in general. As was stated in the Research Question 4 discussion, Categories 1 and 3, among others, are more oriented toward concern for a reader's ability to understand what is written than is Category 2. Both test engineers whose answers were placed in Category 2 are in Division A, which has, in general, experienced more difficulty in meeting the time limits than has Division B where the other three test engineers work. The test engineers are the individuals responsible for preparing or writing technical reports. All of the people perceived as the audience by this group of technical report authors are individuals who

TABLE 17

Perceived Audience Responses By Role Groups

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Test Engineer 1		X			
Test Engineer 2		X			
Test Engineer 3	X				
Test Engineer 4	X				
Test Engineer 5			X		
Editor 1			X		
Editor 2			X		
Editor 3					X
Division Editor 1	X				
Division Editor 2		X		X	
Div Tech Adv 1				X	X
Div Tech Adv 2		X			
Dep Tech Adv	X		X		
Mathematician 1	X				
Mathematician 2	X				
Mathematician 3	X				
Analyst 1	X				
Analyst 2	X				

Note: Cat 1 = Customer
Cat 2 = Upper Management
Cat 3 = Scientific/Testing Community
Cat 4 = Researchers
Cat 5 = General Public
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

are knowledgeable about either the system tested or the field of testing itself. The test engineers do not consider the general public to be the audience.

The second group in Table 17, which includes the editors and division editors, contains six answers to the question of intended audience. The six answers are spread across the five categories while two answers given by two of the editors are placed in the category of the scientific community. As a group, these individuals saw a wide range of audiences for the technical report. The individuals who compose this group have experience levels in editing that range from less than a year to many years, and experience in the testing field that ranges from no direct experience to experience as an instrumentation engineer and test engineer, as evidenced by their responses to the initial questions in each interview (12; 13; 16; 17; 18). The varied experience levels of these editors may partially explain the variety of answers given within this group.

The technical advisors in the third group have a total of five answers among the three of them. Each of the five answers was placed in one of the five categories. Thus, this role group also sees a wide range of audiences, as did the editors. When the experience level of these individuals is ascertained in the initial questions in each interview, the researchers discover that each individual has several years of testing experience, but the experience in these particular positions varies from three months to five years (11; 14; 15). This variation in experience in these positions may be a reason for the different answers given by these technical advisors.

The last group in Table 17 is the mathematicians and analysts. Their perception of the audience for their work of reducing the data was unanimously the customer. Those identified in the responses varied from the "Air Force" (34) to the "test engineer" (2; 33; 35) and also included the test organization and other local agencies (1; 2). Again, as was stated in answering Research Question 4, those individuals in this role group understand well their relationship with the test organization and the test engineers in the testing process.

Comparing the first three groups reveals that the test engineers in the first group have a more specific audience in mind when they prepare the technical report than do the editors in the second group or the technical advisors in the third group. The test engineers are thinking about those who are knowledgeable about the testing field or the system tested, whereas both the editors and the technical advisors, in editing and reviewing the technical reports, are thinking about a variety of people from upper management to the general public. In the latter cases, the variations in answers could be explained by the differences in experience levels among the individuals in each role group. The editors interviewed vary not only in experience in their positions but also in testing background, whereas the technical advisors vary largely in experience in their positions.

Time Limits. Table 10 was modified to separate the four role groups as was done with the previous two aspects of the technical report preparation process. Table 18 is the resulting table.

The first group consists of the test engineers and contains seven answers for the five test engineers. The largest number of answers in any category is in Category 1, recommending the technical reports be

TABLE 18

Time Limit Responses By Role Groups

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Test Engineer 1		X		X	
Test Engineer 2					X
Test Engineer 3	X				
Test Engineer 4	X				X
Test Engineer 5	X				
Editor 1	X	X			
Editor 2				X	
Editor 3			X		
Division Editor 1	X				
Division Editor 2		X			
Div Tech Adv 1	X			X	
Div Tech Adv 2	X	X			
Dep Tech Adv		X			
Mathematician 1			X		
Mathematician 2			X		
Mathematician 3			X		
Analyst 1		X		X	
Analyst 2			X		

Note: Cat 1 = Case-By-Case Basis
Cat 2 = Unrealistic
Cat 3 = No Problems
Cat 4 = Goals
Cat 5 = Satisfactory With Experience
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

evaluated on a case-by-case basis. Two of the test engineers, including one who had advocated the case-by-case evaluation, felt the time limits were satisfactory now. They added the caveat, though, that experience helped them become more proficient in meeting the deadlines. In addition, one test engineer stated that the time limits were unrealistic but that there should be goals set for the test engineers "just out of their reach" (54). Since the test engineers officially have the responsibility for producing the technical reports in a timely fashion, none of them stated that there were no problems meeting the time limits. Having experience in putting together technical reports and learning from that experience is reflected in both Categories 1 and 5. This experience caused them either to see the need to set the time limit based upon the specific test, or to capitalize on lessons learned in preparing and coordinating the technical report.

The editors in the second group of Table 18 gave six answers to this question on the time limits. One editor and one division editor described the various sizes of reports that are prepared and either implied or stated the need for case-by-case evaluation of the time limits (13; 17). The same editor and the other division editor commented that the time limits were unrealistic (14; 17). The other two editors either had no problems with the time limits or felt they should be viewed as goals (18; 14). The fact that three out of the five editors had problems with the time limits shows that this role group in general is sensitive to the issue. Four out of six answers are in Categories 1 and 2 which have the strongest negative connotations. Two of the three individuals seeing the problems are division editors and

are, thus, operationally closer to the test engineers who are responsible for meeting the time limits.

The two division technical advisors and the deputate technical advisor compose the next group and gave a total of five answers. Both division technical advisors gave two answers. In each case one answer dealt with the idea that tests are different, implying the need for case-by-case determination of the time limit (15; 16). One division technical advisor then commented on the need to see the time limit as a goal, while the other agreed with the deputate technical advisor that the 60-day time limit is unrealistic (12; 15; 16). Since these technical advisors are, to some degree, involved with the later stages of the technical report preparation cycle, they are all sensitive to the time limit issue. They all see problems with the time limits, with two of the three stating that the time limit is unrealistic and the third technical advisor suggesting "adjustments . . . on a case-by-case basis" (15).

The last group consists of the mathematicians and analysts. They gave a total of six answers. All of the mathematicians and one analyst commented that they thought the time limit was reasonable or had no problems with it (2; 35; 36; 37). The other analyst felt the time limit was unrealistic but that the deadline provided incentive for people (1). The majority of this group, however, has no problem with the time limit. This opinion can be explained, as stated earlier in the Research Question 4 answer, by their lack of personal involvement in the preparation of the technical report.

In summary, the test engineers' responses are based primarily upon the effect of their experience in the process, enabling them to see the

need for case-by-case evaluation or to benefit from lessons learned. The editors' responses are varied, with the two division editors, who are closer to the responsible test engineers, commenting more on the problems than do the other editors. The technical advisors, who are involved primarily in the later stages of the technical report preparation cycle, see problems with the time limits, either that it is unrealistic or that it should be set on a case-by-case basis. The majority of the mathematicians and analysts, in contrast, see no problem with the time limit requirement. They are not, however, directly involved in preparing the technical report.

Development of the Technical Report. This aspect of the technical report process is divided into three subsections which include the following: 1) perceptions of the tasks involved, 2) guidelines used to write and review reports, and 3) evaluations of how well the process works. As developed in the Research Question 4 discussion, the results for the third subsection (evaluation) showed that 11 individuals indicated the process worked well and 2 indicated it did not work well. These two individuals included a division editor and a division technical advisor. In any comparison in this subsection, these individuals will stand out as being different from all the others, and there would be negligible contribution to the study in a further analysis of this subsection. Therefore, there will be no comparison by role for the evaluations subsection.

Tasks. Table 11 contains a summary of the report preparation task responses for all interviewees. The individuals and their responses may be separated by roles using a double line to form Table 19.

Beginning with the first group in the table, the test engineers, there are seven answers to the question of what is involved in the task. Three test engineers stated the task involved collecting and compiling data, while two of those and a fourth test engineer said the task involved developing formatted text (55; 56; 57; 58). The fifth engineer saw the task primarily as one of answering the test objectives (54). With three of the five test engineers perceiving the task as involving collecting and compiling data or developing formatted text, this role group, in general, saw a dual nature to the task of preparing a technical report (55; 56; 57; 58).

The next group in the table, the editors, gave a total of six responses. Four of the five editors said that the task involved developing formatted text (14; 17; 18; 19). One of those and the other editor stated that collecting and compiling data was the task (13; 14). However, the job of this group as a whole, and especially the editors in the support division, is to make sure the report conforms to certain standards. Format is a large part of the standards, explaining why the majority of the editors stated that the task involved developing formatted text (14; 17; 18; 19).

The third role group is the technical advisors, who gave five answers among the three of them. All of them said that the task involved collecting and compiling data (12; 15; 16). In addition, the deputate technical advisor added that the task involved developing formatted text, and one of the division technical advisors included answering the test objectives in describing the task (12; 15). But the unanimous choice of collecting and compiling data is the significant aspect of this group's response.

TABLE 19

Report Preparation Task Responses By Role Groups

	Cat 1	Cat 2	Cat 3	Cat 4
Test Engineer 1			X	
Test Engineer 2		X		
Test Engineer 3	X	X		
Test Engineer 4	X	X		
Test Engineer 5	X			
Editor 1		X		
Editor 2		X		
Editor 3		X		
Division Editor 1	X			
Division Editor 2	X	X		
Div Tech Adv 1	X		X	
Div Tech Adv 2	X			
Dep Tech Adv	X	X		
Mathematician 1				X
Mathematician 2	X			
Mathematician 3				X
Analyst 1	X		X	
Analyst 2				X

Note: Cat 1 = Collecting and Compiling Data
Cat 2 = Developing Formatted Text
Cat 3 = Answering Test Objectives
Cat 4 = Do Not Know
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

The final role group, the mathematicians, gave a total of six answers, which included three negative responses from those individuals who did not know what was involved in preparing the technical report. One of the mathematicians and an analyst saw the task as involving collecting and compiling data, and this analyst also included answering the objectives in the response. In summary, only two of the five individuals in this role group demonstrated knowledge of the task in their answers. This lack of knowledge is explained by the fact that these individuals are not in the test organization and not directly involved in preparing the technical report.

Looking at all four groups, the researchers found that the test engineers in general saw a dual nature to the task in collecting and compiling data and in developing formatted text, while a majority of the editors focused only on developing formatted text. The technical advisors, conversely, gave responses which were focused especially on collecting and compiling data. Finally, since they are not involved in preparing the technical report, more than half of the mathematicians and analysts interviewed did not know what was involved in the task of putting it together.

Guidelines. The test engineers, when asked what guidelines they used in writing the report, all gave two answers, which included published guidelines and published technical reports. Their responses were further described as a group in the discussion of Research Question 4. Since their question on guidelines was different than the other role groups, their responses as a group are not compared with the other groups' responses. The mathematician role group is also

not included in this subsection because these individuals, as stated before, are not involved in actually writing the technical reports.

Table 12 contains a summary of responses, for the remaining individuals interviewed, to the question of what they look for when they receive a technical report for review. This table is modified by separating the two role groups, the editors and technical advisors. The new table is Table 20.

The first group in Table 20 is the editors, including the division editors. The five editors gave eleven answers which fell into all four categories. Category 1, which contains responses focused on the format requirements, and Category 3, which contains responses that relate to editorial details, each received four answers. One editor and one division editor in addition mentioned that they checked the report to see if the test objectives tracked throughout the report and with the method of test (13; 18). The other division editor reviews technical reports for data and technical content which differs significantly from the viewpoint of the other editors (14). This individual has a technical background and considerable special experience which the editors do not have, explaining this variance in response to the interview question. Overall, though, this group sees format requirements and editorial details as the focus of their review.

The second group in Table 20 include the technical advisors. This group had nine answers to the question about what they look for in a draft technical report. All three advisors review the document in relationship to the test objectives and for data and technical content (12; 15; 16). In addition, the deputate technical advisor also looks at the format in these reports, and one division technical advisor checks

TABLE 20

Review Guideline Responses by Role Groups

	Cat 1	Cat 2	Cat 3	Cat 4
Editor 1	X		X	
Editor 2	X	X	X	
Editor 3	X		X	
Division Editor 1	X	X	X	
Division Editor 2				X
Div Tech Adv 1	X	X	X	X
Div Tech Adv 2		X		X
Dep Tech Adv	X	X		X

Note: Cat 1 = Review for Format Requirements
Cat 2 = Review for Test Objective Tracking
Cat 3 = Review for Editorial Details
Cat 4 = Review for Data and Technical Content
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

format and editorial details (12; 15). In summary, however, all of the technical advisors review for test objective tracking and for data and technical content (12; 15; 16).

Comparing the editors and technical advisors in terms of their review criteria, the editors review for format requirements and editorial details, in general, while the technical advisors look for test objective tracking and for data and technical content, as a group. Variations in each case include a division editor who looked at the data and technical content in the editor group and a division technical

advisor who reviewed technical reports against all indicated criteria (14; 15).

Changes to the Process. Table 14 was modified so that the test engineers were separated from the editors and division editors, who were separated from the division technical advisors and deputate technical advisor. This new table is Table 21. The mathematicians and analysts are not included in this portion of the analysis because they were not questioned concerning changes to the technical report preparation process. They were asked a related question, though, and their responses are discussed at the end of this section.

Beginning with the first group in Table 21, one can see the test engineers' six answers to the question of "What would you change?" in the technical report preparation process. Three of them stated they would change either the level of signature or the number of reviewers in the review process (54; 55; 56). Two test engineers suggested changes to the procedure for assigning time limits for the technical reports, in light of different testing and reporting situations (54: 57). The fifth test engineer suggested modifying the writing process to include "real conclusions" in the technical report (58). The agreement by three of the five test engineers on eliminating at least one level of review is probably the most significant point in this analysis. As the role group responsible for preparing technical reports, these test engineers must follow the documents through the coordination and review cycle. They thus have more first-hand experience with all the levels of review than does any other role group.

The editor group gave a total of six answers to the question of suggested changes. The two division editors each said that changes

TABLE 21

Suggested Change Responses By Role Groups

	Cat 1	Cat 2	Cat 3	Cat 4
Test Engineer 1	X	X		
Test Engineer 2	X			
Test Engineer 3	X			
Test Engineer 4		X		
Test Engineer 5			X	
Editor 1		X		
Editor 2	X			X
Editor 3				X
Division Editor 1	X			
Division Editor 2	X			
Div Tech Adv 1			X	
Div Tech Adv 2	X			
Dep Tech Adv	X			

Note: Cat 1 = Changes to Review Process
Cat 2 = Changes to Time Limit Assignments
Cat 3 = Changes to the Writing Process
Cat 4 = Changes to Workload Scheduling
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

should be made in the review process, including eliminating the large number of rewrites that occurred with the numerous reviews and with the increased word processing capabilities that computers provided (15; 16). One editor added that another problem which sometimes occurred in the review process was the unavailability of the test engineer to answer

questions about the technical report (18). Two editors mentioned workload scheduling as an area where changes could ease the pressure on both the test engineers and the editors (18; 19). Assignment of time limits was also mentioned by one editor (17). Five of the six answers by those in this role group relate to the review cycle, including the number of rewrites and the ease of getting the technical reports edited. This is the part of the process in which these individuals are most involved. Their responses reflect their concern in this area.

The group of technical advisors gave one answer each to the question of changes. Their three responses vary, with the two in Category 1 addressing, in the first case, an internal structure change and, in the second case, a policy change. The third answer suggests a change in emphasis during the writing process. Although two responses fit the category of changes to the review process, they are not closely related, revealing that these managers are most concerned about changes that directly affect the management of their specific units.

In comparing the test engineers, the editors, and the technical advisors, the researchers observe that, in each group, changes to the review cycle received more suggestions than any other area. In the group of test engineers, the interest was in the number of levels of review. The editors mentioned the number of rewrites, and the availability and workload scheduling of personnel during the review cycle. The technical advisors had varied answers, with one of them agreeing with the test engineers that there should be changes in the review level.

When the mathematicians and analysts were asked what they would change in their interaction with the test engineer, the areas of concern

mentioned more than once were the inexperience of the test engineers and occasional poor coordination. Table 15 shows the categories in which their answers were placed.

Comparison By Teams. In this section the analysis is performed in terms of the teams presented in Chapter 3. Individual perceptions of the five aspects of the technical report preparation process are organized in various tables according to the teams in which the individuals are members. Each team is analyzed separately. The responses for a given aspect are examined to determine if any consensus exists, and significant variations are presented.

Purpose of the Technical Report. The responses originally summarized in Table 8 are shown in two tables: one table containing the two teams whose tests were functionally managed in Division A, and the second table containing the three teams whose tests were functionally managed in Division B. Responses for the teams in Division A are summarized in Table 22, and responses for the teams in Division B are summarized in Table 23.

In Table 22, for Team 1, six of eight members gave multiple responses with each category being represented by at least three answers. In general, Team 1 saw more than one purpose for the technical report. There is a fairly equal division between the two major purposes of merely providing information and providing information for action. For those individuals assigned to the test organization, five of the six saw the technical report as historical documentation, this being the strongest answer for this team.

Team 2, in the same table, tended to see the technical report primarily as a document to provide information only, as evidenced by all

TABLE 22

Technical Report Purpose Responses By Division A Teams

	Provide Information Only		Provide Information For Action	
	Cat 1	Cat 2	Cat 3	Cat 4
Team 1:				
Test Engineer 1	X			X
Editor 1	X			X
Division Editor 1	X	X		
Division Editor 2	X		X	
Div Tech Adv 2		X		
Dep Tech Adv	X		X	X
Mathematician 1*			X	
Analyst 1*		X	X	
Team 2:				
Test Engineer 2	X	X		
Editor 3		X		
Division Editor 1	X	X		
Division Editor 2	X		X	
Div Tech Adv 2		X		
Dep Tech Adv	X		X	X
Mathematician 2*		X		

Note: Cat 1 = Historical Documentation
Cat 2 = Reporting Results/Findings
Cat 3 = Decision Making
Cat 4 = Research Data
* = Individual Not Formally Assigned to Test Organization
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

TABLE 23

Technical Report Purpose Responses By Division B Teams

	Provide Information Only		Provide Information For Action	
	Cat 1	Cat 2	Cat 3	Cat 4
Team 3:				
Test Engineer 3	X			
Editor 1	X			X
Dep Tech Adv	X		X	X
Analyst 2*		X		
Team 4:				
Test Engineer 4	X	X		
Editor 2	X			
Div Tech Adv 1	X		X	X
Dep Tech Adv	X		X	X
Mathematician 3*			X	
Team 5:				
Test Engineer 5		X		
Editor 1	X			X
Div Tech Adv 1	X		X	X
Dep Tech Adv	X		X	X

Note: Cat 1 = Historical Documentation
Cat 2 = Reporting Results/Findings
Cat 3 = Decision Making
Cat 4 = Research Data
* = Individual Not Formally Assigned tc Test Organization
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

of the team members giving answers that fell into Categories 1 and 2, with 9 of the 12 answers lying in the area of merely providing information. Division Editor 2 and the Deputate Technical Advisor are the only two members who saw the technical report's purpose as a decision-making aid, and in the case of the Deputate Technical Advisor, also a reference for later researchers. Five of the seven members of Team 2 saw the purpose of the document as reporting results and findings, revealing the general impression of the group.

In Table 23, showing the teams in Division B, Team 3 shows a slightly stronger preference for the technical report as a document to merely provide information. Within that broad area, the unanimous agreement by the test organization members was that the technical report's purpose is to provide historical documentation. Only Analyst 2 in Team 3 gave the purpose as "to describe the work and the results of the test" (2). From the standpoint of providing information for action, however, two of the four members stated that the technical report could be an aid in later research.

Team 4 responses also contain a unanimous statement among test organization team members that the technical reports's purpose is historical documentation. The only person in Team 4 who did not express this was Mathematician 3 who saw it solely providing the information a decision maker would need (37). Two of the other four members agreed with Mathematician 3 by also mentioning this purpose. There is an equal division in Team 4 between the purposes of merely providing information and providing information for action, with five responses in each area.

Team 5, with no members from the data reduction support organization, has nine answers from its four members. The team consensus is

that the technical report has multiple purposes. Three of the four members had more than one answer, with both technical advisors giving answers that fell into the same three categories. There is excellent agreement between them, and good agreement between them and Editor 1, on this question. Test Engineer 5, in contrast, merely sees it as reporting results to those "on the outside" (58).

Comparing the team responses, team members in Teams 1, 3, 4, and 5 are fairly equally divided between the technical report's purpose being to merely provide information and its purpose being to provide information for action. The consensus among Team 2 members is that its purpose is to merely provide information. Among the Team 3 and 4 team members assigned to the test organization, the responses all included historical documentation as a purpose of the technical report. Historical documentation was also the strongest answer in Team 1. Lastly, Test Engineer 5 is the only test engineer whose only answer was different from the other members of Team 5. Except for Team 2, the teams have a reasonably broad view of the purpose of the technical report. The Team 2 technical report was the most timely in its division; therefore, no correlation can be made with timeliness for this aspect of the technical report preparation process.

Intended Audience. Team responses concerning the perceived audience are shown in two tables. Table 24, for the Division A teams, and Table 25, for the Division B teams, were made based upon the summarized responses in Table 9. The mathematician and analyst team members are not represented in the tables or the analysis of this aspect of the process because they were not questioned regarding the audience for the technical report.

TABLE 24

Perceived Audience Responses By Division A Teams

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Team 1:					
Test Engineer 1		X			
Editor 1			X		
Division Editor 1	X				
Division Editor 2		X		X	
Div Tech Adv 2		X			
Dep Tech Adv	X		X		
Team 2:					
Test Engineer 2		X			
Editor 3					X
Division Editor 1	X				
Division Editor 2		X		X	
Div Tech Adv 2		X			
Dep Tech Adv	X		X		

Note: Cat 1 = Customer
Cat 2 = Upper Management
Cat 3 = Scientific/Testing Community
Cat 4 = Researchers
Cat 5 = General Public
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

TABLE 25

Perceived Audience Responses By Division B Teams

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Teams 3:					
Test Engineer 3	X				
Editor 1			X		
Dep Tech Adv	X		X		
Team 4:					
Test Engineer 4	X				
Editor 2			X		
Div Tech Adv 1				X	X
Dep Tech Adv	X		X		
Team 5:					
Test Engineer 5			X		
Editor 1			X		
Div Tech Adv 1				X	X
Dep Tech Adv	X		X		

Note: Cat 1 = Customer
Cat 2 = Upper Management
Cat 3 = Scientific/Testing Community
Cat 4 = Researchers
Cat 5 = General Public
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

For Team 1 in Table 24, seven of the eight answers are in Categories 1, 2, and 3. These categories all represent an audience which is either knowledgeable about the system being tested or the field of testing itself. Team 1, therefore, primarily saw knowledgeable people as the audience for their technical report. Within that general group, "upper management" was the answer given by half of the team members. These team members are all assigned to Division A. As indicated in the Research Question 4 discussion, Category 2 answers do not show a concern for the reader as much as a desire to do what is required to get the document signed. Division Editor 1, Editor 1, and the Deputate Technical Advisor all saw the customer and the scientific or testing community as the audience. Division Editor 2 was thinking of a researcher as well.

Team 2 in this table gave responses that appear to very similar to the Team 1 responses. Two of the members, who were also members of Team 1, and Test Engineer 2 were thinking of upper management when preparing the technical report. Editor 3 was thinking of the general public as the audience when working on the technical report. A segment of the Editor 3 answer illustrates how this answer varies from the general consensus: "You need to make it not so technical that a person with average intelligence could not understand or at least basically understand it" (19). Except for this editor and the test engineer, the members of this team were the same as those on Team 1, but the variation in perceived audience is greater because of the inclusion of the general public by one member.

The Division B teams' answers are shown in Table 25. The Team 3 answers were divided equally between the customer and the scientific or

testing community. Both of these categories are centered on those people interested in the test itself or testing in general. This team's responses illustrate a focused understanding of the audience for these reports.

The Team 4 responses were more varied than were the Team 3 responses. Similar to Team 3, however, Team 4 saw the customer and the scientific or testing community as the audience. Additionally, Division Technical Advisor 1 mentioned researchers and "the general reader" who might request the document through the Defense Technical Information Center (15). With four of the six answers relating to those people who are interested either in the system tested or the field of testing, the consensus is the same as for Team 3.

The perceived audience seen by the members of Team 5 are, with two exceptions, the scientific or testing community. One exception is the Division Technical Advisor 1 response which includes researchers and the general public (15). The second exception is the additional answer given by the Deputate Technical Advisor, who mentioned the test organization's customer (12).

The Division A teams stand out from the Division B teams by seeing, in general, the signer of the technical report as the audience for the document. The Division B teams, in contrast, saw those interested in the test or testing in general as the audience. Within Division A, there is variance between the two teams. Looking at the responses for Team 1, the overall consensus is knowledgeable people, which includes upper management, the customer, and the scientific and testing community. However, the Team 2 answers include those who are not knowledgeable as well as those who are. In Division B, Teams 4 and 5 vary

more than Team 3 because the Division Technical Advisor 1 answers include the general reader as well as those interested in research.

Time Limits. Table 10 contains the responses for all the interviewees when questioned about the time requirements. These responses are grouped by teams for tests functionally managed by Division A in Table 26, and for tests functionally managed by Division B in Table 27.

From Table 26, 6 of the 12 Team 1 responses are in Category 2, corresponding to a view of the time limits as unrealistic. Only two of the eight people on this team did not have an answer in this category. One of these two, Division Editor 1, did, however, state that the technical reports should be evaluated on a case-by-case basis, implying the existence of a problem (13). The other member of the team, Mathematician 1, saw no problems with the time limit (35). Further analysis reveals that this individual was the most junior mathematician, in terms of experience, of the mathematicians interviewed (35; 36; 37). Mathematician 1 also did not know what was involved in the task of putting together a technical report, as seen in the answer to another interview question (35). These considerations help to explain the Mathematician 1 response in light of every other member of Team 1 seeing problems with the time limits.

Team 2 had eight answers to the time limit question as summarized in Table 26. The answers vary across four of the five categories, with only three answers in a single category. With only four of the seven members of Team 2 commenting on the problems with the time limits, there is not a strong implication of problems by team members. Editor 3 and Mathematician 2 stated there were no problems from their perspectives

TABLE 26

Time Limit Responses By Division A Teams

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Team 1:					
Test Engineer 1		X		X	
Editor 1	X	X			
Division Editor 1	X				
Division Editor 2		X			
Div Tech Adv 2	X	X			
Dep Tech Adv		X			
Mathematician 1			X		
Analyst 1		X		X	
Team 2:					
Test Engineer 2					X
Editor 3			X		
Division Editor 1	X				
Division Editor 2		X			
Div Tech Adv 2	X	X			
Dep Tech Adv		X			
Mathematician 2			X		

Note: Cat 1 = Case-By-Case Basis
Cat 2 = Unrealistic
Cat 3 = No problems
Cat 4 = Goals
Cat 5 = Satisfactory With Experience
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

TABLE 27

Time Limit Responses By Division B Teams

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Team 3:					
Test Engineer 3	X				
Editor 1	X	X			
Dep Tech Adv		X			
Analyst 2			X		
Team 4:					
Test Engineer 4	X				X
Editor 2				X	
Div Tech Adv 1	X			X	
Dep Tech Adv		X			
Mathematician 3			X		
Team 5:					
Test Engineer 5	X				
Editor 1	X	X			
Div Tech Adv 1	X			X	
Dep Tech Adv		X			

Note: Cat 1 = Case-By-Case Basis
Cat 2 = Unrealistic
Cat 3 = No problems
Cat 4 = Goals
Cat 5 = Satisfactory With Experience
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

(19; 36), and Test Engineer 2 commented that "it's pretty realistic after you've been here three years" (55). Therefore, experience was an important factor in the individual's perspective. In summary, Team 2 varied in its members' perceptions, with a small majority who saw problems with the time limits.

In Table 27, the Team 3 responses suggest problems with the time limits, with one exception. Analyst 2 has no problems with the time limits, while the other three members either see the need for more evaluation of the technical reports on a case-by-case basis, or see the time limits as unrealistic (2; 12; 17; 56). The validity of the general consensus concerning problems with the time limits is more firmly established by the fact that the analysts are not directly involved in the preparation of the technical report.

Team 4 shows considerable variation in responses to this question. Seven answers cover all five categories, with a maximum of two answers in each of two categories. However, these two categories are not directly related since one seeks evaluation of time limits on a case-by-case basis, and the other emphasizes tying time limits to goals. Team 4 is therefore characterized by the variation in its members' perceptions, there being no general consensus.

The responses of the last team in Table 27, Team 5, show that the members see problems with time limits. Five of the six answers fall into the case-by-case evaluation category or the unrealistic characterization category. The single answer not in these categories is the Division Technical Advisor 1 answer relating time limits to goals (15). The other half of this individual's response included the need for "adjustments made on a case-by-case basis" (15). Therefore, with each

member alluding to at least one problem, the consensus is that there are problems with time limits.

Looking at all the teams together, the researchers see a variance in response, although the majority of individuals on each team saw problems with the time limits. The overall impression of Team 1 was that the time limits are unrealistic. The Team 2 responses were varied but with the most agreement that the time limits are unrealistic. The Team 3 members assigned to the test organization saw problems with the time limits and were divided between seeing the need for case-by-case analysis and stating that they were unrealistic. The Team 4 responses were the most varied of all the team responses. Even in the two instances where two answers fell in one category, those answers were not in agreement. In essence, Team 4 had no internal agreement. The Team 5 responses were similar to the Team 3 responses in that, in general, they varied closely between the need for case-by-case analysis and the statement that the time limits for the technical report were unrealistic. 3

Development of the Technical Report. The three subsections of this aspect of the technical report preparation process include: 1) tasks involved in the process, 2) guidelines used to write and review the report, and 3) evaluations of the process. The latter two areas will not be addressed in this analysis. In the guidelines section the test engineers were not asked the same question as were the other groups. The evaluation section was thoroughly covered in Research Question 4.

Table 11 contains the interviewees' responses to the question of what is involved in the task of preparing a technical report. The responses in this table are regrouped by team for each of the five teams

to construct Table 28 for Division A Teams and Table 29 for Division B Teams.

The Team 1 responses fall into all categories with five of the eight members seeing the task as involving collecting and compiling data (1; 12; 13; 14; 16). In addition, three of the eight individuals saw the task as developing formatted text, and two of the eight saw the task as answering the test objectives (1; 12; 14; 17; 54). The only two members in the test organization who did not mention collecting and compiling data as being involved in the task were the test engineer and the editor (17; 54). Of possible significance, though, is the fact that the test engineer, the primary author of the document, responded differently than did every other member in the test organization (54). These other members, however, reviewed the test engineer's writing, and this technical report was late getting signed and through the process. In general, though, there is no consensus for Team 1 on what is involved in the task.

The Team 2 responses are divided fairly equally between collecting and compiling data and developing formatted text, with five answers in Category 1 and four in Category 2. As with Team 1, the only two members who did not mention collecting and compiling data as part of the task were the test engineer and the editor (19; 55). The technical report prepared by this team was the most timely in getting through the process of any technical report for which the test engineer was available for interviewing. There is good balance between the two categories or perspectives on the technical report preparation task.

The Team 3 responses also fall into Categories 1 and 2, with the exception of the analyst who did not comment on what is involved in the

TABLE 28

Report Preparation Task Responses By Division A Teams

	Cat 1	Cat 2	Cat 3	Cat 4
Team 1				
Test Engineer 1			X	
Editor 1		X		
Division Editor 1	X			
Division Editor 2	X	X		
Div Tech Adv 2	X			
Dep Tech Adv	X	X		
Mathematician 1*				X
Analyst 1*	X		X	
Team 2				
Test Engineer 2		X		
Editor 3		X		
Division Editor 1	X			
Division Editor 2	X	X		
Div Tech Adv 2	X			
Dep Tech Adv	X	X		
Mathematician 2*	X			

Note: Cat 1 = Collecting and Compiling Data
Cat 2 = Developing Formatted Text
Cat 3 = Answering Test Objectives
Cat 4 = Do Not Know
* = Individual Not Formally Assigned to Test Organization
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

TABLE 29

Report Preparation Task Responses By Division B Teams

	Cat 1	Cat 2	Cat 3	Cat 4
Team 3				
Test Engineer 3	X	X		
Editor 1		X		
Dep Tech Adv	X	X		
Analyst 2*				X
Team 4				
Test Engineer 4	X	X		
Editor 2		X		
Div Tech Adv 1	X		X	
Dep Tech Adv	X	X		
Mathematician 3*				X
Team 5				
Test Engineer 5	X			
Editor 1		X		
Div Tech Adv 1	X		X	
Dep Tech Adv	X	X		

Note: Cat 1 = Collecting and Compiling Data
Cat 2 = Developing Formatted Text
Cat 3 = Answering Test Objectives
Cat 4 = Do Not Know
* = Individual Not Formally Assigned to Test Organization
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

task (2). There is consensus among all team members who are in the test organization that the task involves developing formatted text (12; 17; 56). Test Engineer 3 and the Deputate Technical Advisor also said the task involves collecting and compiling data, but there is consensus in this team which prepared and processed a technical report within the time limit (12; 56).

The responses for Team 4 are divided between Categories 1 and 2, with two exceptions. Division Technical Advisor 1 commented on the task including answering the test objectives and Mathematician 3 did not comment on what was involved in the task (15; 37). Answers by all the test organization personnel fall into either the area of collecting and compiling data or the area of developing formatted text, being divided equally for Team 4, which was late in getting its technical report through the process.

The Team 5 responses also fall into Categories 1 and 2, with one exception. The Division Technical Advisor 1 comment on including the test objectives is the exception. This team prepared and processed a technical report within time limits. Their answers are divided fairly equally between collecting and compiling data and developing formatted text.

In comparison, Teams 2, 3, and 5, whose reports were timely, had less deviation in responses among the four categories than did Teams 1 and 4, whose answers fell into all four categories. Most of the answers for all five teams fell into the areas of collecting and compiling data or developing formatted text, with all of the Team 2 responses falling into one of these areas. Except for Test Engineer 1, the test engineers' answers were in good agreement with the answers of their teams.

Changes to the Process. For this final aspect of the process, the individuals and their responses in Table 14 are grouped by teams and separated into two tables. Division A teams are shown in Table 30 and Division B teams are shown in Table 31. Table 14 and, correspondingly, Tables 30 and 31 do not include the mathematicians and analysts since they were not asked a question related to changes in the technical report process.

Team 1 wanted to see changes primarily in the review process for the technical report. Five of the six members suggested changes in that phase of the process, and one member, Editor 1, stated the need for change in the "rigid time schedule" for the reports (17). Although a consensus exists that changes in the review process are needed, the changes sought are varied. Test Engineer 1 and the Deputate Technical Advisor, two of the five suggesting changes here, wanted the level of signature on the technical report reduced. Two others, the division editors, suggested reducing the number of rewrites which occurred. All four of these suggestions relate to each other as general methods for reducing time spent in coordination in this organization. However, the fifth suggestion, by Division Technical Advisor 2, which would allow Division A to acquire illustrators for the division, is specific to Division A and would not benefit the organization as a whole. Overall, for Team 1, the general consensus is that the review process needs changing. Lowering the signature level and reducing rewrites are the changes that were most often mentioned.

From Table 30, the consensus for Team 2 is to change the review process. Only one member, Editor 3, answered the question suggesting a change not related to the review process. Editor 3 wanted a consistent

TABLE 30

Suggested Change Responses By Division A Teams

	Cat 1	Cat 2	Cat 3	Cat 4
Team 1:				
Test Engineer 1	X	X		
Editor 1		X		
Division Editor 1	X			
Division Editor 2	X			
Div Tech Adv 2	X			
Dep Tech Adv	X			
Team 2:				
Test Engineer 2	X			
Editor 3				X
Division Editor 1	X			
Division Editor 2	X			
Div Tech Adv 2	X			
Dep Tech Adv	X			

Note: Cat 1 = Changes to Review Process
Cat 2 = Changes to Time Limit Assignments
Cat 3 = Changes to the Writing Process
Cat 4 = Changes to Workload Scheduling
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

TABLE 31

Suggested Change Responses By Division B Teams

	Cat 1	Cat 2	Cat 3	Cat 4
Team 3:				
Test Engineer 3	X			
Editor 1		X		
Dep Tech Adv	X			
Team 4:				
Test Engineer 4		X		
Editor 2	X			X
Div Tech Adv 1			X	
Dep Tech Adv	X			
Team 5:				
Test Engineer 5			X	
Editor 1		X		
Div Tech Adv 1			X	
Dep Tech Adv	X			

Note: Cat 1 = Changes to Review Process
Cat 2 = Changes to Time Limit Assignments
Cat 3 = Changes to the Writing Process
Cat 4 = Changes to Workload Scheduling
Div Tech Adv = Division Technical Advisor
Dep Tech Adv = Deputate Technical Advisor

flow of technical reports into the editor, neither too many nor too few (19). The changes desired by those in the consensus varied, with one suggested change as different from the others as the Editor 3 answer was different from the consensus. The change that Division Technical Advisor 2 wanted (acquiring illustrators) was discussed in the Team 1 analysis of this question (16). The other four recommended changes relate to reducing the amount of coordination and, specifically, eliminating some of the upper management review. Changing the review process is the consensus view of the change needed; the most supported change is reducing the number of reviews.

The responses by the Team 3 agree for two of the three people. Not only do Test Engineer 3 and the Deputate Technical Advisor agree there should be a change in the review process, but they also agree the technical report should be signed at a lower level. Editor 1 differs from them in the change that is needed, seeing a need to modify how time limits are assigned (17). Therefore, the most significant point for Team 3 is that two of the three members agree exactly on the change that is needed.

The responses by the Team 4 members are varied across all four categories. Although the answers given by Editor 2 and the Deputate Technical Advisor fall in the same category, that of changing the review process, their proposals for change differ greatly. Editor 2 wanted the test engineer to always be available to answer questions during the review, while the Deputate Technical Advisor wanted the technical report signed at a lower level (12; 17). The other three answers are in different categories, showing that there is not a consensus for Team 4.

Team 5 is similar to Team 4 with varied answers. Test Engineer 5 and Division Technical Advisor 1 both have answers in Category 3 for changing the writing process, but their desired changes are different. Test Engineer 5 wanted the opportunity to have "real conclusions" in the document, while Division Technical Advisor 1 wanted changes made in the emphasis phases of the writing process received (10; 58). The other two answers fall into different categories. Therefore, Team 5 members' responses vary such that there is no consensus among them.

The comparison of these five teams reveals similarities and dissimilarities. The consensus for Teams 1 and 2 and for two of the three members of Team 3 was to change the review process (12; 56). Also, in Team 4, with their varied answers, the only two team members in the same category agreed the review process should change (12; 18). The change sought to the review cycle varied, with the change most often suggested being to reduce the number of reviews. Reducing the number of reviews is a general term which includes lowering the signature level for the technical report, eliminating excess rewrites, or reducing the number of reviewers. This characteristic was true in Teams 1 and 2 and for the two members of Team 3 who agreed. Teams 4 and 5, on the other hand, had a variety of areas in which changes were suggested. Two team members in Team 4 agreed on the category, as was mentioned above, and two members in Team 5 agreed the writing process should change (12; 18; 15; 58). However, in both cases, their suggested changes varied drastically.

V. Conclusions and Recommendations

This final chapter is divided into two parts. The first part summarizes the findings for each of the research questions and draws conclusions based upon those findings. The second part makes recommendations as a result of the conclusions.

Summary of Findings and Conclusions

In this section, each research question is stated individually, its findings are summarized, and conclusions are drawn.

Research Question One.

How does this test organization function as a variant of a matrix organization while planning, conducting, and reporting tests?

The matrix management literature describes characteristics of matrix organizations and, in a broader context, variants of matrix organizations. Characteristics of matrix organizations and variants thereof include a project orientation, the use of teams, the practice of consensus decision making, and informal communication channels. Although this test organization has a vertical chain of command and, officially, a functional structure, these matrix characteristics are present in its operational environment of planning, conducting, and reporting tests. This evidence came from descriptions in organizational documentation and from responses to interviews with 18 key participants in the technical report preparation process.

Based upon organizational documentation and interview responses, the operational structure in preparing the technical report includes a well-developed informal communication network in a traditional hier-

archical structure. The test organization thus qualifies as a "latent matrix," the term used by Gano S. Evans (21:78,80-81). The organization can be further classified as the "project within function" variation of Kenneth Knight's secondment model approach to matrix management (29:151).

The researchers conclude, therefore, that this test organization does function operationally as a matrix variant in the testing process.

Research Question Two.

How can the information gathering and processing preferences of key participants in the technical report process be described?

The information gathering and processing preferences for the 18 key participants in the technical report process were assess by using the Myers-Briggs Type Indicator, an instrument based on Carl Jung's theory of psychological types. Of the 16 unique four-letter types the Indicator identifies, 8 were seen among these 18 individuals. The most prominent four-letter type found among these participants was ISTJ, with nine individuals typed accordingly. The ISTJ is an Introvert (I) with Sensing (S) as the dominant function and Thinking (T) as the auxiliary function. Normative data based on the research of Isabel Myers and others suggests that, in a population of 18, one would expect a distribution of .84 ISTJs (26; 40; 45). The actual distribution of 9 is roughly 10.7 times as many as would be expected in a group representative of the population at large.

The researchers conclude, in this case, that the group of participants studied are primarily ISTJ. They may be characterized by their powers of concentration, their fascination with observable facts,

their use of logic and analysis, and their propensity to get things done (38:305). Conversely, this type may tend to make decisions too quickly before they have all the pertinent data, and may not be open to all the possibilities. They must also guard against being too impersonal and somewhat uncommunicative.

This group is not heterogeneous; therefore, decisions may not be as thoroughly considered as they should be. In this environment, they probably will not have as many problems as they might in another environment where more--or more intense--interpersonal interaction was required. If the organization contained more Extraverts, Intuitive types, Feeling types, and Perceiving types, more resources would be available from which to draw to balance out the strong ISTJ tendencies.

Research Question Three.

How do these preferences of the key participants compare relative to their roles in the operational structure?

This question was answered by describing and comparing the information gathering and processing preferences of the key participants in terms of their membership in one or more of five teams. There are four to eight members on each of the five teams, with the test engineer as the team's focal point. All five teams are composed largely of ISTJs.

Team 1 includes two Intuitive Feeling (NF) types, who may feel stressed in this environment, which is mostly Thinking Judging (TJ). There is a possibility of communication difficulty betwen the NFs and the TJs.

Team 2 includes one NF and is mostly Sensing Thinking (ST). The Judging-Perceiving (J-P) ratio is relatively equal. As with Team 1, the

NF may feel stressed or isolated in this environment. There is the possibility of communication difficulty between the NFs and STs.

All the members of Team 3 are TJs. Team 3 is well balanced in the Extraversion-Introversion (E-I) and Sensing-Intuition (S-N) preferences, but includes no Feeling types or Perceiving types. Team members may feel impelled to reach a decision--and may do so too quickly--but they should have minimal difficulty communicating.

As with Team 3, the Team 4 members are all TJs. Team 4 includes no Feeling types, no Perceiving types, no Extraverts, and one Intuitive type. This team could have significant problems with premature closure, or the tendency to reach a decision. Team 4 may also be short sighted and too inward looking.

Three of the four members of Team 5 are TJs, with one Sensing Thinking Judging type and two Intuitive Thinking Judging types. The team exhibits a balance between Sensing (S) types and Intuitive (N) types and all are Thinking (T) types. The test engineer, who is ISTP, may be uncomfortable with the Judging (J) types.

The researchers conclude that all the teams are almost entirely Thinking (T) types, predominantly TJ. Most teams may have closure problems. The teams are not heterogeneous; therefore, there are few other resources, such as Extraverts, Intuitive types, Feeling types or Perceiving types to draw on for augmentation if needed.

Research Question Four.

How can the perceptions of the technical report preparation process held by key participants in that process be described?

This question was answered by presentation and analysis of the key participants' responses to interview questions covering five aspects of

the technical report and its preparation process. The five aspects included 1) the purpose of the technical report; 2) the intended audience; 3) the assigned time limits; 4) the development of the technical report, including the tasks involved therein, guidelines for preparation and review, and an evaluation of the process; and 5) suggested changes to the process.

Purpose of the Technical Report. The 18 participants interviewed gave a total of 29 answers when asked the purpose of the technical report. These answers were divided into four categories including 1) historical documentation, with ten answers; 2) reporting results and findings, with nine answers; 3) support for decision making, with six answers; and 4) information for future researchers, with four answers. Two patterns of thought emerge when Categories 1 and 2 are combined into a larger category of simply "providing information," and Categories 3 and 4 are combined into a second larger category of "providing information for action to occur."

The researchers' first conclusion for this aspect of the technical report is that the participants are divided in their perception of the technical report's purpose. The second conclusion is that there may be a difference between the perspectives of management and workers in this area.

Intended Audience. The 13 participants assigned to the test organization were asked who they were thinking about when they performed their tasks in the technical report preparation process. They gave a total of 16 responses. These responses were divided into five categories including 1) the customer, with four answers; 2) upper management, with four answers; 3) the scientific or testing community, with

four answers; 4) future researchers, with two answers; and 5) the general public, with two answers. Further analysis revealed a division of the categories such that Categories 1, 3, 4, and 5 all carry with them the connotation of concern for the reader's ability to understand what is written, while Category 2 focuses on whatever must be done to get the document signed.

The mathematicians and analysts in the data reduction support organization were asked a different but related question in this area because they do not participate in the actual writing of the document. The five mathematicians and analysts all gave answers which fit into Category 1, the customer.

Conclusions include that a majority of the 13 participants is concerned about producing a document which the reader can understand, while a minority focuses on getting the report signed. This minority are all from the same work unit--a unit which has, in management's view, historically experienced difficulty in meeting established deadlines--thus their answers may reflect their reaction to external pressure to now meet the deadlines, or it could signal a potential problem area for management.

The mathematicians' and analysts' responses suggest that they have a clear idea of their role and relationship with the test organization.

Time Limits. All 18 participants were asked their views of the time requirements for the technical report. They gave 24 answers, which were divided into 5 categories including 1) the need for time limits to be determined on a case-by-case basis, with 7 answers; 2) the characterization of the time limits as unrealistic, with 6 answers; 3) the view that there were no problems with the existing requirements,

with 5 answers; 4) the relating of time limits to goals, with 4 answers; and 5) the view that the time limits are satisfactory after one has gained experience on the job, with 2 answers. Additional analysis revealed that Categories 1, 2, and 5 all acknowledge that the time limits are a problem. The solution offered most often was to implement a case-by-case determination of report cycle length, based upon the type, complexity and length of a given test. Category 3 answers are in opposition to those in Categories 1, 2, and 5.

The researchers conclude that, overall, the time limits are considered unsatisfactory. The participants interviewed believe that those who assign the limits do not know what is actually involved in the task of preparing a technical report.

Development of the Technical Report. Three subsections within this aspect of the process include 1) the tasks involved, 2) the guidelines used, and 3) evaluation of how well the current process works.

Tasks. When asked to describe what was involved in the task of developing a report, the 18 respondents gave 24 answers, which were divided into 4 categories. The categories included 1) collecting and compiling data, with 10 answers; 2) developing formatted text, with 8 answers; 3) answering test objectives, with 3 answers; and 4) do not know, with 3 answers. The two major tasks described in these responses include collecting and compiling data and drafting formatted text.

The conclusion from this subsection is that members realize that the development of the technical report is more than just writing a report and that thought must be given to the technical report throughout the testing process.

Guidelines. The five test engineers were questioned with regard to the guidelines used in writing a technical report. They gave 10 answers in total which fell into 2 categories: 1) published guidelines, with 5 answers and 2) old technical reports, with 5 answers.

The other eight participants assigned to the test organization were asked what they looked for in the technical report, when reviewing a draft copy. Their 20 answers were divided into 4 categories: 1) review for format requirements, with 6 answers; 2) review for test objective tracking, with 5 answers; 3) review for editorial details, with 5 answers; and 4) review for data and technical content, with 4 answers. Results showed the three editors and one division editor all answered with responses that fell into Categories 1 and 3. There was a noticeable difference in the review between Divisions A and B. The Division A technical advisor reviews the report for test objectives and technical content only, while the Division B technical advisor reviews the technical report in all four categories. The Division A technical advisor has a support staff who provide format and editorial support which the Division B technical advisor does not have.

Conclusions include the fact that upper management reviews the document for technical accuracy and test objective tracking, and the editors, including one of the division editors, review it primarily for format and detail.

Evaluation. The 13 participants in the test organization who are involved in the actual writing and reviewing of the technical report were asked to evaluate that process. They gave 13 answers which were divided into 2 categories: 1) the process works well, with 11 answers and 2) the process does not work well, with 2 answers.

The conclusion is that the majority of the participants evaluate the process as working well.

Changes to the Process. The 13 participants who are involved in writing and reviewing the technical report were asked what they would change in the process. They gave 15 responses, which could be split into 4 categories: 1) changes to the review process, with 8 answers; 2) changes to time limit assignments, with 3 answers; 3) changes to the writing process, with 2 answers; and 4) changes to workload scheduling, with 2 answers. A majority of the responses related to changes in the review cycle and suggested some change in the level or number of reviews, either delegating final review to a lower level, deleting an intermediate level, or holding one review meeting attended by all levels of review.

The mathematicians and analysts were questioned about what they would change in their interaction with the test engineer. The five individuals gave a total of six answers, which were grouped into four categories: 1) test engineer inexperience, with two answers; 2) improved coordination, with two answers; 3) improved planning, with one response; and 4) no suggestions, with one response.

The conclusion from the analysis of responses relating to changing the process is that the review cycle should be shortened. A conclusion from the responses of the mathematicians and analysts to their question is that there is no consensus of what should be changed, unless the test engineer inexperience relates to the poor coordination.

Research Question Five.

How do these perceptions held by key participants compare?

This question is a follow-on to Research Question 4 and is addressed from two perspectives: 1) comparing the perceptions based upon the roles of the participants and 2) comparing the perceptions based upon the teams formed. This question was answered for the five aspects of the technical report and its preparation process which were addressed in the Research Question 4 discussion.

Comparison By Role. The 18 key participants were divided into 4 role groups: 1) the test engineers; 2) the editors, including the division editors; 3) the technical advisors, including the division and deputate technical advisors; and 4) the mathematicians, including the analysts.

Purpose of the Technical Report. This analysis of the findings previously developed in Research Question 4 found that the test engineers and editors agree on the purpose being to merely provide information. The technical advisors and the mathematicians, on the other hand, saw the purpose as both providing information only and providing information for action.

The researchers conclude that those who are writers and editors, in the lower levels of the organization, see no purpose other than providing information, while those like the technical advisors and mathematicians have broader perspective.

Intended Audience. The analysis of this aspect of the process by role group revealed that the test engineers have a specific audience in mind when they are writing, whereas the editors and technical advisors are thinking about a variety of people. A reason for this variance among the editors could be that the editors interviewed vary in experience in the position and in testing background. The technical

advisors may vary in perception because they vary in experience in the positions they occupy.

The researchers conclude that a technical report will be modified more if people who have a variety of audiences in mind are reviewing it. The test engineers, as writers, have a more specific audience in mind than do the editors or technical advisors. In this situation, the technical report will be modified more, and it will take longer to coordinate, possibly resulting in its being late for signature.

Time Limits. All four groups' responses were analyzed for this aspect of the process. The test engineers' responses as a whole were seen to be based upon their experience, including their desire for case-by-case determination of time limits and the benefits of lessons learned. The editors varied in their responses but the division editors, who are closer to the test engineers in work environment, commented more on the same problems that the test engineers mentioned. The technical advisors see the time limits as unrealistic or express the need for case-by-case adjustments. The mathematicians, in general, see no problems with the time limits.

Conclusions include the idea that the more experience a test engineer gains, the more proficient the engineer becomes at getting the technical report through the cycle. In addition, if the editor's work location were closer to the engineers, the editors might be more sensitive to the test engineers' perspective. Finally, all the participants had negative feelings on the time limits in general, except for the mathematicians.

Development of the Technical Report. Analysis of this aspect of the technical report process includes the two subsections of

tasks involved and guidelines used to write and review technical reports.

In the first subsection, the test engineers saw the dual tasks of 1) collecting and compiling the data and 2) developing formatted text. In contrast, editors see, in general, only developing formatted text and technical advisors see only collecting and compiling data. The mathematicians, in general, are not aware of what is involved in the task.

The researchers conclude that each individual sees the technical report development task from the perspective of his or her own job.

In the second subsection of guidelines for writing or reviewing technical reports, the test engineers all use published guidelines as well as old technical reports when they write. The editors, when they edit a technical report, review for format requirements and focus on editorial details. The technical advisors look primarily for test objective tracking and data and technical content.

A conclusion in this subsection is that the individuals who are reviewing the technical report are not using old technical reports as guidelines, as are the test engineers.

Changes to the Process. For this aspect of the process, the category of changes to the review cycle received more suggestions than any other category. The test engineers wanted to change the number of levels of review. The editors wanted to change the number of rewrites and the workload of the participants, specifically the test engineer and the editor. The technical advisors gave varied answers.

The conclusion is, simply, the respondents are dissatisfied with the review cycle, which should be changed.

Comparison By Teams. The five teams are divided into Division A teams and Division B teams. Teams 1 and 2 had tests which were functionally managed in Division A, and Teams 3, 4, and 5 had tests which were functionally managed in Division B.

Purpose of the Technical Report. Team members in Teams 1, 3, 4 and 5 were about equally divided between the technical report's purpose being merely to provide information and its purpose being to provide information for action. The consensus among Team 2 nembers is that its purpose is to merely provide information.

The researchers conclude that, except for Team 2, the teams have a reasonably broad view of the technical report's purpose. The Team 2 technical report was the most timely in its division; therefore, no correlation can be made with timeliness for this aspect of the process.

Intended Audience. the Division A teams differed from the Division B teams in their perspectives of audience. Division A teams tended to see the audience as the signer of the technical report, whereas Division B teams saw the audience as those interested in the test or testing in general.

The researchers conclude that, since Division A has historically experienced dif iculty in meeting the established time limits, some of its personnel have responded by focusing their attention on pleasing upper management rather than meeting the needs of a reader outside the test organization.

Time Limits. The team responses for this aspect of the technical report process were varied. Teams 3 and 5 each had responses which indicate that time limits were unrealistic and that a need exists for case-by-case adjustments to the time limits. The general perception

held by Team 1 was that the time limits were unrealistic, as was also the case with Team 2. The Team 2 responses were, however, more varied. Finally, the Team 4 responses were the most varied, with no two answers the same.

The researchers conclude that there is no clear relationship between the timeliness of a report and its preparers' views on time limits.

Development of the Technical Report. Teams 2, 3, and 5, whose reports were more timely, had less deviation in responses to the question of what is involved in the task of preparing a technical report than did Teams 1 and 4. Most of the answers for all five teams fell into the areas of collecting and compiling data or developing formatted text. All of the Team 2 responses fell into one of these answers. In addition, except for Test Engineer 1, the test engineers' responses were in agreement with the answers of their teams.

Here the researchers conclude that the view of the task can possibly impact the timeliness of the report. The general consensus that the task involves collecting and compiling data and developing formatted text reveal the essence of the technical report preparation task. The teams with less deviation among their members on "What is the task?" focus so that they can complete it expeditiously. The fact that Test Engineer 1 did not mention either of these two basic aspects of the preparation task indicate that this individual may not be as focused on the same task as the other team members.

Changes to the Process. The consensus for Teams 1 and 2 and for two of the three members of Team 3 was to change the review process (12; 56). Teams 4 and 5 had a variety of areas in which changes

were sought. The change most often suggested by these teams was to reduce the number of reviews. This concept included lowering the signature level of the technical report, eliminating excess rewrites, and deleting intermediate reviewers.

The researchers conclude that the review cycle, within which the timeliness of the technical report is often determined, is recognized by those individuals with timely reports and those with late reports as one aspect of the process where change is needed.

Summary. The results of this research effort do not highlight any relationship between this organization's operational structure and the timeliness of its technical reports. The results do suggest, however, that there are other factors which may affect the report timeliness, such as the number of review levels, test engineer workload, and psychological type.

Recommendations

As a result of the five research question analyses performed in Chapter 4 and the conclusions discussed in the earlier portion of this chapter, the researchers offer the seven recommendations listed herein.

First, based upon the presence of a matrix variant structure in this organization's operational environment, the test organization's management should encourage the use of the team concept among those collectively involved in preparing the technical report.

Second, to combat the problem of inexperienced test engineers, new engineers should be brought in for longer tours of duty, perhaps four years as a minimum. For the first year and a half to two years, this engineer should serve as an assistant test engineer to learn as much as

possible from a more experienced lead engineer. This would also decrease the tremendous workload placed on a single test engineer during the active phase of testing. The researchers realize that individual test engineers are already responsible for several tests. They believe, however, that the negative aspects of having double the number of tests would be offset by several benefits if the system is properly managed. These benefits include sharing the workload during the busiest moments of active testing, providing more and better on-the-job training for new test engineers, and transferring experience based knowledge such as "lessons learned" from the more experienced engineer to the new engineer.

Third, the test organizaiton should determine the answers to the following two questions: 1) "How is the technical report used?" and 2) "Who is its audience?" The organization should then publish those answers so that everyone involved in the technical report preparation process would have the opportunity to work together under a common understanding of the report's use and audience. Their energies would thus be focused toward a common goal.

Fourth, the organization should consider and implement action to lessen the number of rewrites and to reduce the required level of signature.

Fifth, if sufficient documentation exists, the test organization should consider requesting a formal waiver to the 60-day time limit for technical reports. If the technical report does not serve as a basis for immediate action by the test requester, the 60-day limit may, in fact, be arbitrary.

Sixth, in the area of planning, the test organization should examine the test planning phase to determine whether sufficient emphasis is placed on developing a good method of test. A well developed method of test should result in a well-run test and, therefore, a more easily written technical report.

In connection with this recommendation, these researchers believe Division A should consider developing a cadre of experienced personnel, perhaps four individuals presently assigned to the unit, whose primary duty would be designing tests and preparing the method of test. If one or two individuals served as the heart of this cadre, test engineers could be rotated in and out of the group to give them experience in test design and to keep test design techniques from becoming outdated. Such an action would, however, require more supervisory attention in the long run.

Finally, to enhance team interaction and facilitate problem solving, management should consider having a qualified consultant conduct a Myers-Briggs Type Indicator on-site seminar to help the organization reach its potential. The Indicator has been used extensively in the commercial world, and in some areas within the military, to assist managers in assigning people to tasks, to improve teamwork, and to improve interpersonal communication. Recently the Indicator has been used to help individuals overcome writing blocks. It is possible that the Indicator can be used in conjunction with the AFIT Professional Continuing Education course which was modified for the test organization.

Appendix A: Psychological Type Descriptions (38:305; 43:7-8)

Introverted Sensing Types

ISTJ

Serious, quiet, earn success by concentration and thoroughness. Practical, orderly, matter-of-fact, logical, realistic and dependable. See to it that everything is well organized. Take responsibility. Make up their own minds as to what should be accomplished and work toward it steadily, regardless of protests or distractions.

I Depth of concentration
S Reliance on facts
T Logic and analysis
J Organization

ISFJ

Quiet, friendly, responsible and conscientious. Work devotedly to meet their obligations. Lend stability to any project or group. Thorough, painstaking, accurate. May need time to master technical subjects, as their interests are usually not technical. Patient with detail and routine. Loyal, considerate, concerned with how other people feel.

I Depth of concentration
S Reliance on facts
F Warmth and sympathy
J Organization

ISTP

Cool onlookers--quiet, reserved, observing and analyzing life with detached curiosity and unexpected flashes of original humor. Usually interested in impersonal principles, cause and effect, how and why mechanical things work. Exert themselves no more than they think necessary, because any waste of energy would be inefficient.

I Depth of concentration
S Reliance on facts
T Logic and analysis
P Adaptability

ISFP

Retiring, quietly friendly, sensitive, kind, modest about their abilities. Shun disagreements, do not force their opinions or values on others. Usually do not care to lead but are often loyal followers. Often relaxed about getting things done, because they enjoy the present moment and do not want to spoil it by undue haste or exertion.

I Depth of concentration
S Reliance on facts
F Warmth and sympathy
P Adaptability

Extraverted Sensing Types

ESTP

Matter-of-fact, do not worry or hurry, enjoy whatever comes along. Tend to like mechanical things and sports, with friends on the side. May be a bit blunt or insensitive. Adaptable, tolerant, generally conservative in values. Dislike long explanations. Are best with real things that can be worked, handled, taken apart or put together.

E Breadth of interests
S Reliance on facts
T Logic and analysis
P Adaptability

ESFP

Outgoing, easygoing, accepting, friendly, enjoy everything and make things more fun for others by their enjoyment. Like sports and making things. Know what's going on and join in eagerly. Find remembering facts easier than mastering theories. Are best in situations that need sound common sense and practical ability with people as well as with things.

E Breadth of interests
S Reliance on facts
F Warmth and sympathy
P Adaptability

ESTJ

Practical, realistic, matter-of-fact, with a natural head for business or mechanics. Not interested in subjects they see no use for, but can apply themselves when necessary. Like to organize and run activities. May make good administrators, especially if they remember to consider others' feelings and points of view.

E Breadth of interests
S Reliance on facts
T Logic and analysis
J Organization

ESFJ

Warm-hearted, talkative, popular, conscientious, born cooperators, active committee members. Need harmony and may be good at creating it. Always doing something nice for someone. Work best with encouragement and praise. Little interest in abstract thinking or technical subjects. Main interest is in things that directly and visibly affect people's lives.

E Breadth of interests
S Reliance on facts
F Warmth and sympathy
J Organization

Introverted Intuitive Types

INFJ

Succeed by perseverance, originality and desire to do whatever is needed or wanted. Put their best efforts into their work. Quietly forceful, conscientious, concerned for others. Respected for their firm principles. Likely to be honored and followed for their clear convictions as to how best to serve the common good.

I Depth of concentration
N Grasp of possibilities
F Warmth and sympathy
J Organization

INTJ

Usually have original minds and great drive for their own ideas and purposes. In fields that appeal to them, they have a fine power to organize a job and carry it through with or without help. Skeptical, critical, independent, determined, often stubborn. Must learn to yield less important points in order to win the most important.

I Depth of concentration
N Grasp of possibilities
T Logic and analysis
J Organization

INFP

Full of enthusiasms and loyalties, but seldom talk of these until they know you well. Care about learning, ideas, language, and independent projects of their own. Tend to undertake too much, then somehow get it done. Friendly, but often too absorbed in what they are doing to be sociable. Little concerned with possessions or physical surroundings.

I Depth of concentration
N Grasp of possibilities
F Warmth and sympathy
P Adaptability

INTP

Quiet, reserved, impersonal. Enjoy especially theoretical or scientific subjects. Logical to the point of hair-splitting. Usually interested mainly in ideas, with little liking for parties or small talk. Tend to have sharply defined interests. Need careers where some strong interest can be used and useful.

I Depth of concentration
N Grasp of possibilities
T Logic and analysis
P Adaptability

Extraverted Intuitive Types

ENFP

Warmly enthusiastic, high-spirited, ingenious, imaginative. Able to do almost anything that interests them. Quick with a solution for any difficulty and ready to help anyone with a problem. Often rely on their ability to improvise instead of preparing in advance. Can usually find compelling reasons for whatever they want.

E Breadth of interests
N Grasp of possibilities
F Warmth and sympathy
P Adaptability

ENTP

Quick, ingenious, good at many things. Stimulating company, alert and outspoken. May argue for fun on either side of a question. Resourceful in solving new and challenging problems, but may neglect routine assignments. Apt to turn to one new interest after another. Skillful in finding logical reasons for what they want.

E Breadth of interests
N Grasp of possibilities
T Logic and analysis
P Adaptability

ENFJ

Responsive and responsible. Generally feel real concern for what others think or want, and try to handle things with due regard for other person's feelings. Can present a proposal or lead a group discussion with ease and tact. Sociable, popular, sympathetic. Responsive to praise and criticism.

E Breadth of interests
N Grasp of possibilities
F Warmth and sympathy
J Organization

ENTJ

Hearty, frank, decisive, leaders in activities. Usually good in anything that requires reasoning and intelligent talk, such as public speaking. Are usually well-informed and enjoy adding to their fund of knowledge. May sometimes be more positive and confident than their experience in an area warrants.

E Breadth of interests
N Grasp of possibilities
T Logic and analysis
J Organization

Appendix B: Communication Style Preferences of the 16 Psychological Types (61:7)

TYPE[a]	CHOICE[b,c] 1 2 3 4	TYPE	CHOICE[b,d] 1 2 3 4
ISTJ	T S F N	ESTJ	T S N F
ISFJ	F S T N	ESFJ	F S N T
ISTP	S T N F	ESTP	S T F N
ISFP	S F N T	ESFP	S F T N
INFJ	F N T S	ENFJ	F N S T
INTJ	T N F S	ENTJ	T N S F
INFP	N F S T	ENFP	N F T S
INTP	N T S F	ENTP	N T F S

Note:

a
Dominant function is underlined.
Auxiliary function is the one of the middle two letters that is not underlined.

b
Choice 1 = primary communication style
Choice 2 = secondary communication style
Choice 3 = tertiary communication style
Choice 4 = least preferred communication style

c
For I's:
Primary communication style is the auxiliary.
Secondary communication style is the dominant.
Tertiary communication style is the opposite of the auxiliary.
Least preferred communication style is the opposite of the dominant.

d
For E's:
Primary communication style is the dominant.
Secondary communication style is the auxiliary.
Tertiary communication style is the opposite of the auxiliary.
Least preferred communication style is the opposite of the dominant.

Appendix C: Communication Adjustment Rank Scores for One-Way and Two-Way Dyads (61:8)

PERCEIVER'S PSYCHOLOGICAL TYPE	PSYCHOLOGICAL TYPE OF SENDER OR PERSON A															
	ESTJ	ESTP	ESFJ	ESFP	ENTJ	ENTP	ENFJ	ENFP	ISTJ	ISTP	ISFJ	ISFP	INTJ	INTP	INFJ	INFP
	24	17	3	11	22	14	1	8	23	18	9	5	20	16	7	2
ESTJ	17	11	2	9	15	9	1	5	16	12	4	6	14	10	3	3
	17	24	14	22	11	3	8	1	18	23	16	20	5	9	2	7
ESTP	11	17	9	15	9	2	5	1	12	16	10	14	6	4	3	3
	3	11	24	17	1	8	22	14	9	5	23	18	7	2	20	16
ESFJ	2	9	17	11	1	5	15	9	4	6	16	12	3	3	14	10
	14	22	17	24	8	1	11	3	16	20	18	23	2	7	5	9
ESFP	9	15	11	17	5	1	9	2	10	14	12	16	3	3	6	4
	22	14	1	8	24	17	3	11	20	16	7	2	23	18	9	5
ENTJ	15	9	1	5	17	11	2	9	14	10	3	3	16	12	4	6
	11	3	8	1	17	24	14	22	5	9	2	7	18	23	16	20
ENTP	9	2	5	1	11	17	9	13	6	4	3	3	12	16	10	14
	1	8	22	14	3	11	24	17	7	2	20	16	9	5	23	18
ENFJ	1	5	15	9	2	9	17	11	3	3	14	10	4	6	16	12
	8	1	11	3	14	22	17	24	2	7	5	9	16	20	18	23
ENFP	5	1	9	2	9	15	11	17	3	3	6	4	10	14	12	16
	23	18	4	12	21	13	2	7	24	17	10	6	19	15	8	1
ISTJ	16	12	4	10	14	6	3	3	17	11	8	7	13	7	5	1
	18	23	13	21	12	4	7	2	17	24	15	19	6	10	1	8
ISTP	12	16	6	14	10	4	3	3	11	17	7	13	7	8	1	5
	4	12	23	18	2	7	21	13	10	6	24	17	8	1	19	15
ISFJ	4	10	16	12	3	3	14	6	8	7	17	11	5	1	13	7
	13	21	18	23	7	2	12	4	15	19	17	24	1	8	6	10
ISFP	6	14	12	16	3	3	10	4	7	13	11	17	1	5	7	8
	21	13	2	7	23	18	4	12	19	15	8	1	24	17	10	6
INTJ	14	6	3	3	16	12	4	10	13	7	5	1	17	11	8	7
	12	4	7	2	18	23	13	21	6	10	1	8	17	24	15	19
INTP	10	4	3	3	12	16	6	14	7	8	1	5	11	17	7	13
	2	7	21	13	4	12	23	18	8	1	19	15	10	6	24	17
INFJ	3	3	14	6	4	10	16	12	5	1	13	7	8	7	17	11
	7	2	12	4	13	21	18	23	1	8	6	10	15	19	17	24
INFP	3	3	10	4	6	14	12	16	1	5	7	8	7	13	11	17

Note: Rank scores for one-way dyads are the top part of each row.
Rank scores for two-way dyads are the bottom part of each row.
In two-way dyads both A and B send and receive.
Higher numbers indicate greater similarity of communication styles and thus greater predicted ease and effectiveness of communication.

Appendix D: Interview Guides

Interview Questions for Test Engineer

1. How long have you been in (employed by) the Air Force?

2. Have you ever worked for other government agencies?

3. Have you ever worked in this type of job in industry?

4. Does your job require any particular training (or education)?

5. Now turning to the technical report process, what is the purpose of the technical report?

6. For whom is it written, i.e. who are you thinking about when you put it together?

7. From your understanding, what is involved in the task of putting together a technical report after a test?

8. What is your role in this task (functional/job description)?

9. From your understanding, what is the role of the:

   - editor?
   - mathematician?
   - Division Technical Advisor?
   - Deputate Technical Advisor?

10. How are the data used?

11. What do you think of the time requirements for the report? (This refers to the 60-day time limit.)

12. How do you feel about your role in the technical report process, i.e. what are your likes and dislikes?

13. If you could change one thing in the technical report process, what would you change, and why would you change it?

14. Does it work well from your perspective?

15. How many tests are you involved in at any particular time?

16. Who establishes your work priorities?

17. Are there any guidelines or requirements that you use in writing the report (for example, in terms of format, etc.)?

18. At what point in the test cycle do you start writing a technical report?

19. Have you ever asked for help? If so, was it available?

20. If you received your technical report back with changes/corrections annotated, have you been given an explanation concerning what is needed and why?

21. How many hours a week do you work?

22. Is that all here, or is some of it at home?

23. Could you give us an estimate for the percentage of time you work on a technical report?

Interview Questions
for Editor

1. How long have you been in (employed by) the Air Force?
   [By whom are you employed?]
   [How long have you been in this job as an editor?]

2. Have you ever worked for other government agencies?
   [Have you ever worked for the government?]

3. Have you ever worked in this type of job in industry?
   [Have you ever worked in this type of job with other companies?]

4. Does your job require any particular training (or education)?

5. Now turning to the technical report process, what is the purpose of the technical report?

6. For whom is it written, i.e. who are you thinking about when you edit it?

7. From your understanding, what is involved in the task of putting together a technical report after a test?

8. What is your role in this task (functional/job description)?

9. From your understanding, what is the role of the:

   - test engineer?
   - mathematician?
   - Division Technical Advisor?
   - Deputate Technical Advisor?

10. How are the data used?

11. What do you think of the time requirements for the report? (This refers to the 60-day time limit.)

12. How do you feel about your role in the technical report process, i.e. what are your likes and dislikes?

13. If you could change one thing in the technical report process, what would you change, and why would you change it?

14. Does it work well from your perspective?

15. How many technical reports are you involved in at any particular time?

16. Who establishes your work priorities?

17. What do you look for when you review a draft technical report?

18. Do the test engineers consult with you about changes to the technical report? (Do they ask you why something needs to be changed, or do they ask for help?)

19. How many hours a week do you work?

20. Is that all here, or is some of it at home?

Note:

One of the editors who was interviewed was employed by a company under contract to the Air Force. Questions #1, #2, and #3 were modified accordingly for that interview. The modified questions are those shown in brackets.

Interview Questions
for Mathematician

1. How long have you been in (employed by) the Air Force?

2. How long have you been working in this directorate? This particular job?

3. Have you ever worked for other government agencies?

4. Have you ever worked in this type of job in industry?

5. Does your job require any particular training (or education)?

6. What is your background in [functional area A]/[functional area B]?

7. Now turning to the technical report process, what is the purpose of the technical report?

8. Whose needs are you thinking about when you reduce the data?

9. From your understanding, what is involved in the task of putting together a technical report after a test?

10. What is your role in this task (functional/job description)?

11. Who do you interface with in the Test Organization when you're working on a test?

12. Would you describe your interaction with the test engineers for a given test?

13. From your understanding, what is the role of the:

    - test engineer?
    - editor?
    - Division Technical Advisor?
    - Deputate Technical Advisor?

14. How are the data used?

15. What do you think of the time requirements for the report? (This refers to the 60-day time limit.)

16. How do you feel about your role in the Test Organization's technical report preparation process, i.e. what are your likes and dislikes?

17. If you could change one thing in your interaction with the test engineer in the Test Organization's reporting process, what would you change, and why?

18. In your opinion, what, if anything, could be done to improve the usefulness of the data?

19. How many tests are you involved in at any particular time?

20. Who establishes your work priorities?

21. What are your guidelines or standards for your part in the process?

22. How many hours a week do you work?

Interview Questions
for Analyst

1. How long have you been in (employed by) the Air Force?

2. How long have you been working in this directorate? This particular job?

3. Have you ever worked for other government agencies?

4. Have you ever worked in this type of job in industry?

5. Does your job require any particular training (or education)?

6. What is your background in [functional area A]/[functional area B]?

7. Now turning to the technical report process, what is the purpose of the technical report?

8. Whose needs are you thinking about when you reduce the data?

9. From your understanding, what is involved in the task of putting together a technical report after a test?

10. What is your role in this task (functional job/description)?

11. Who do you interface with in the Test Organization when you're working on a test?

12. Would you describe your interaction with the test engineers for a given test?

13. From your understanding, what is the role of the:

    -test engineer?
    -editor?
    -Division Technical Advisor?
    -Deputate Technical Advisor?

    What is your role relative to the mathematician?

14. How are the data used?

15. What do you think of the time requirements for the report? (This refers to the 60-day time limit.)

16. How do you feel about your role in the Test Organization's technical report preparation process, i.e. what are your likes and dislikes?

17. If you could change one thing in your interaction with the test engineer in the Test Organization's reporting process, what would you change, and why?

18. In your opinion, what, if anything, could be done to improve the usefulness of the data?

19. How many tests are you involved in at any particular time?

20. Who establishes your work priorities?

21. What are your guidelines or standards for your part in the process?

22. How many hours a week do you work?

Interview Questions
for Division Technical Advisor

1. How long have you been in (employed by) the Air Force?

   How long have you worked in this organization?

   How long have you worked in this job?

2. Have you ever worked for other government agencies?

3. Have you ever worked in this type of job in industry?

4. Does your job require any particular training (or education)?

5. Now turning to the technical report process, what is the purpose of the technical report?

6. For whom is it written, i.e. who are you thinking about when you review it?

7. From your understanding, what is involved in the task of putting together a technical report after a test?

8. What is your role in this task (functional/job description)?

9. From your understanding, what is the role of the:

   - test engineer?
   - editor?
   - mathematician?
   - Deputate Technical Advisor?

10. How are the data used?

11. What do you think of the time requirements for the report? (This refers to the 60-day time limit.)

12. How do you feel about your role in the technical report process, i.e. what are your likes and dislikes?

13. If you could change one thing in the technical report process, what would you change, and why would you change it?

14. Does it work well from your perspective?

15. How many tests are you involved in at any particular time?

    How many tests is the division involved in at any particular time?

    How many tests do you have in the technical report process at any particular time?

16. Who establishes your work priorities?

17. What do you look for when you review a draft technical report?

18. Do the test engineers consult with you about changes to the technical report? (Do they ask you why something needs to be changed, or do they ask for help?)

19. How many hours a week do you work?

20. Is that all here, or is some of it at home?

21. Could you give us an estimate for the percentage of time you work on a technical report?

Interview Questions
for Deputate Technical Advisor

1. How long have you been in (employed by) the Air Force?

   How long have you worked in this organization?

   How long have you worked in this job?

2. Have you ever worked for other government agencies?

3. Have you ever worked in this type of job in industry?

4. Does your job require any particular training (or education)?

5. Now turning to the technical report process, what is the purpose of the technical report?

6. For whom is it written, i.e. who are you thinking about when you review it?

7. From your understanding, what is involved in the task of putting together a technical report after a test?

8. What is your role in this task (functional/job description)?

9. From your understanding, what is the role of the:

   - test engineer?
   - editor?
   - mathematician?
   - Division Technical Advisor?

10. How are the data used?

11. What do you think of the time requirements for the report? (This refers to the 60-day time limit.)

12. How do you feel about your role in the technical report process, i.e. what are your likes and dislikes?

13. If you could change one thing in the technical report process, what would you change, and why would you change it?

14. Does it work well from your perspective?

15. How many tests are you involved in at any particular time?

16. Who establishes your work priorities?

17. What do you look for when you review a draft technical report?

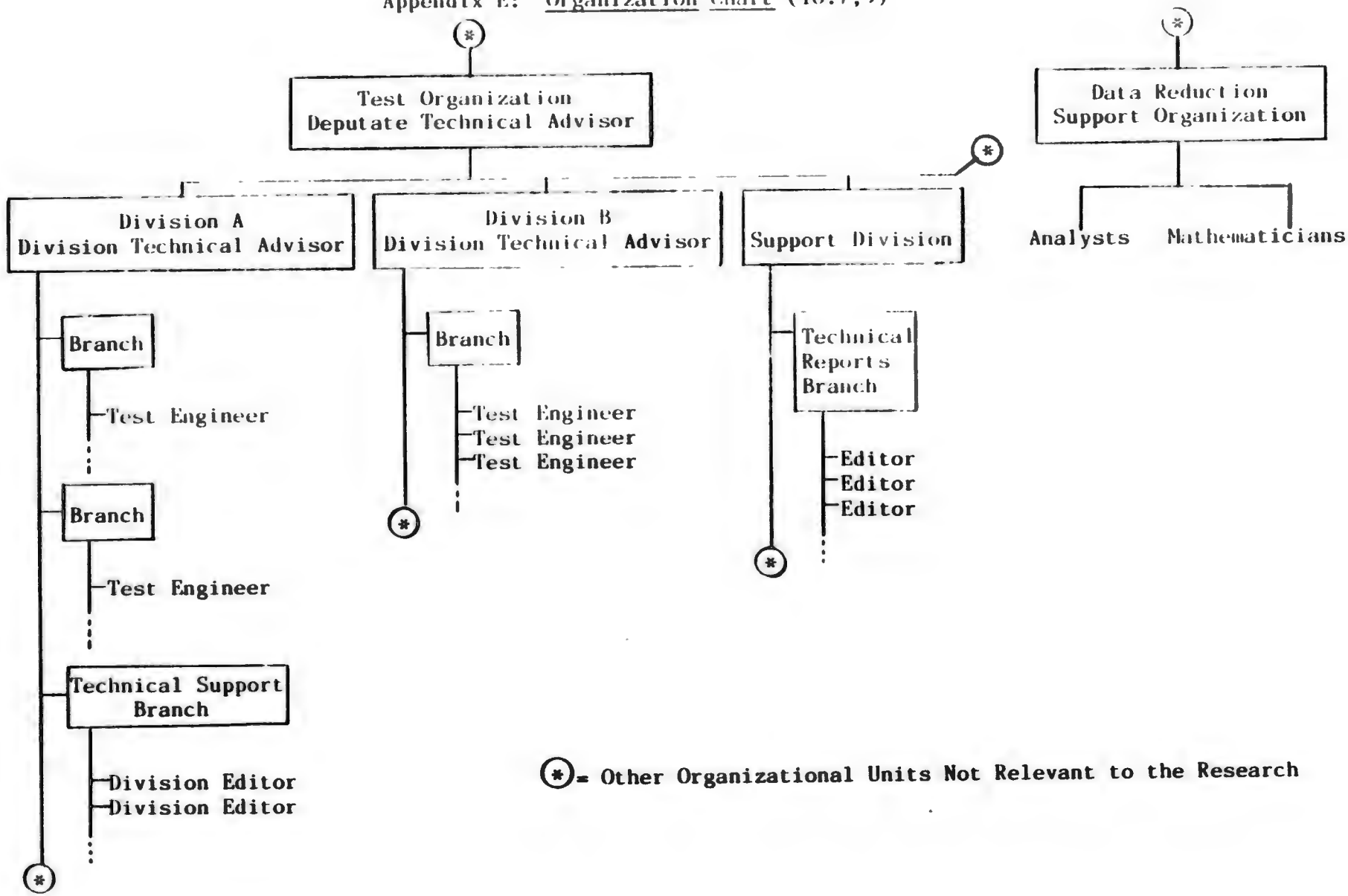
18. Do the test engineers consult with you about changes to the technical report? (Do they ask you why something needs to be changed, or do they ask for help?)

19. How many hours a week do you work?

20. Is that all here, or is some of it at home?

21. Could you give us an estimate for the percentage of time you work on a technical report?

Appendix E: Organization Chart (10:7,9)



Appendix F: Project Teams

Team One

Test Engineer 1

Editor 1

Division Editor 1

Division Editor 2

Mathematician 1

Analyst 1

Division Technical Advisor 2

Deputate Technical Advisor

Team Two

Test Engineer 2

Editor 3

Division Editor 1

Division Editor 2

Mathematician 2

Division Technical Advisor 2

Deputate Technical Advisor

Team Three

Test Engineer 3

Editor 1

Analyst 2

Deputate Technical Advisor

Team Four

Test Engineer 4

Editor 2

Mathematician 3

Division Technical Advisor 1

Deputate Technical Advisor

Team Five

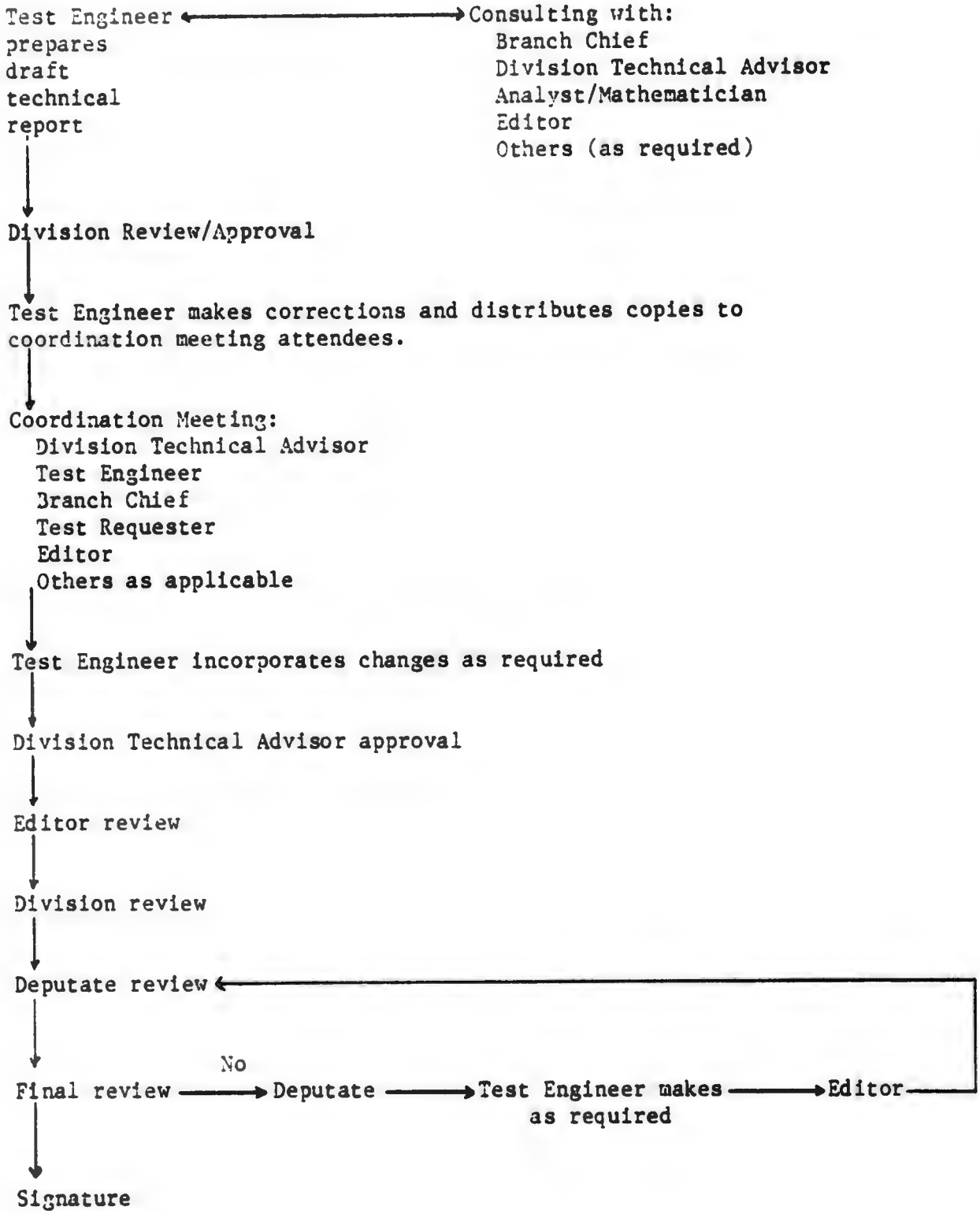
Test Engineer 5

Editor 1

Division Technical Advisor 1

Deputate Technical Advisor

Appendix G: Technical Report Preparation Cycle (10:19)



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SECURITY CLASSIFICATION OF THIS PAGE

AD-A161188

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): AFIT/GLM/LSM/85S-5	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: School of Systems and Logistics; 6b. OFFICE SYMBOL (If applicable): AFIT/LS	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code): Air Force Institute of Technology, Wright-Patterson AFB OH 45433-6583	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS. — PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification): See Box 19	
12. PERSONAL AUTHOR(S): Frances P. Belford, B.A., Capt, USAF; Dorsey E. Higdon, Jr., B.S., Maj, USAF	
13a. TYPE OF REPORT: MS Thesis; 13b. TIME COVERED: FROM _____ TO _____; 14. DATE OF REPORT (Yr., Mo., Day): 1985 September; 15. PAGE COUNT: 230	
16. SUPPLEMENTARY NOTATION	

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	Matrix, Organizations, Personality Tests, Reports, Technical Writing, Test and Evaluation
05	01		
05	10		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Title: COMMUNICATION AND PSYCHOLOGICAL TYPE IN A LATENT MATRIX ORGANIZATION: A CASE STUDY

Thesis Advisor: Terrance M. Skelton
Associate Professor of Technical Communication

Approved for public release: IAW AFR 190-1.
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Dean for Research and Professional Development
Air Force Institute of Technology (AFSC)
Wright-Patterson AFB OH 45433

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code)	22c. OFFICE SYMBOL
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DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE.

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This research effort examined the relationship between organizational structure and written communication in an Air Force test organization which had experienced difficulty in meeting established time limits for producing its technical reports. An analysis of the organizational structure was performed. Organizational documentation, comments made by members of the organization during interviews, and the researchers' personal observations were compared to current literature on the matrix organizational structure. The test organization was found to operate as a variant of a matrix organization.

To study the written communication process, the researchers interviewed selected individuals within the test organization and obtained their thoughts on the technical report preparation process. The interview responses were first analyzed for all the respondents as a group, and then by role groups and project teams. In general, the present technical report preparation process was considered to be adequate. Problems with the time requirements and the level of review and signature were noted, however.

The Myers-Briggs Type Indicator, based on Carl Jung's theory of psychological types, was used to assess the information gathering and information processing preferences of the individuals who participated in this research effort. The responses were first analyzed for all the respondents as a group, and then by project teams. The group was found to be primarily ISTJ--Introverted (I), with Sensing (S) as the preferred function for gathering information, and Thinking (T) as the preferred function for processing information. The preferred method of dealing with the external world was Judgment (J). Likewise, the teams were found to be mostly ISTJ. No relationship between communication style preferences and timeliness of reports was seen.

While some problems with the report process were noted, no distinct relationship between the organization's operational structure and its difficulty in meeting the time limits was observed.