A SURVEY OF RESEARCH DOCUMENTATION SYSTEMS IN SELECTED GOVERNMENT AGENCIES

By

GEORGE CURTIS BUCHER
Bachelor of Science
Washington University
St. Louis, Missouri
1950

Master of Science
University of Alabama
Tuscaloosa, Alabama
1960

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Thesis Approved:

Paul E. Ferguson
Thesis Adviser

W. J. Bentley

B. A. Kinsey

John E. Susky

Lloyd A. [illegible]

J. H. Boggs
Dean of the Graduate College

PREFACE

Managers of research organizations need to know about the progress and results of research so they can perform their managerial functions most efficiently. They learn about research through some form of documentation. Research documentation systems in different organizations vary in many respects; frequently these documentation systems are established without advantage being taken of the experience gained in other organizations.

The writer is an employee of the Marshall Space Flight Center of the National Aeronautics and Space Administration, and is an assistant to Dr. E. Stuhlinger, the manager of the center's over-all research program. In considering a thesis topic, Dr. Stuhlinger urged that a subject be selected so that the results of the study would be of practical benefit to many persons involved in research management, and desirably, of specific benefit to the National Aeronautics and Space Administration (NASA) and to the Marshall Space Flight Center. He recognized the need for improved research documentation systems, and suggested that a study be undertaken to determine the types of research documentation in use, and their adequacy, in selected government agencies. Accordingly, the writer proposed the suggested study to his Advisory Committee, and the Committee found it acceptable. The study was begun in 1964 and completed in 1966.

The study is divided into two parts: a literature review and a field survey of nine NASA Field Centers. The results of the study are presented in this thesis. The thesis consists of five chapters. For the reader with limited time who is unable to read the complete thesis, the final chapter, Summary and Implications, will provide a brief, yet comprehensive, picture of the over-all study.

Chapter I, The Problem, is intended to present to the reader the need for undertaking a study of research documentation systems, with the results being applicable to the improvement of existing systems. This chapter also defines the limitations of the study, so the reader will recognize its scope. It explains why research documentation is needed by managers of research and why government research managers are obligated to promote the betterment of research documentation.

Chapter II, Review of the Literature, presents the results of the literature review. It describes the kinds of research documentation used and the desirable characteristics of documentation. This chapter establishes a classification system for types of research documentation so that they can be uniformly categorized throughout the study.

Chapter III, Field Survey, describes the materials used in the field survey of the nine NASA Field Centers, the procedures used in the survey, and the data obtained from the survey.

Chapter IV, Interpretation of Survey Results, presents an analysis of the data collected in the field survey and the conclusions drawn from the analysis. The differences between documentation systems in the NASA Field Centers and the adequacies of the systems are analyzed.

Chapter V, Summary and Implications, is intended to summarize the entire study, and to identify its implications.

The writer acknowledges, with sincere appreciation, the efforts and interest of members of his Advisory Committee: Prof. W. J. Bentley and Dr. P. E. Torgersen, School of Industrial Engineering and Management; Dr. C. A. Dunn, Director of the Engineering Research and Experiment Station; Dr. B. A. Kinsey, Department of Sociology and Rural Life; and Dr. J. E. Susky, Department of Philosophy. All, through individual discussions and committee meetings, gave valuable guidance and assistance to the writer in the formulation and accomplishment of this study. The writer is particularly indebted to Dr. Torgersen, Thesis Adviser, who continually encouraged and directed the writer in this endeavor. The writer acknowledges, with deep appreciation, the guidance and encouragement provided by his supervisor, Dr. Stuhlinger, whose indulgence from the start permitted the writer to undertake this study. The writer is also indebted to all persons, too numerous to name, in the field centers of the National Aeronautics and Space Administration, who provided the source data during the field survey.

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CHAPTER I

THE PROBLEM

Statement of the Problem

Many agencies of the United States Government perform research. In some agencies, research work is their primary mission; in others, development, or possibly hardware production, may be the primary mission. Whatever the primary mission may be, if research work is performed there is a need to document that work so that it can become known to persons interested in it. One of the most important groups of persons interested in the progress and results of research work is the management group. This group consists primarily of top and middle management and staff personnel in the agency where the research is performed, and in the headquarters offices of the agency, which may be located elsewhere. These persons need to know about the progress and results of research so that they can perform their managerial functions most efficiently.

Managers learn about research through some form of documentation. There is a wide variation in the kinds of research documentation used in government agencies, and some agencies have better systems than others. There is always a need for improved systems of documentation. Thus, there is a need to look at those systems now being used.

The purpose of this study is to conduct a review of the literature and a field survey of selected government agencies for the purpose of determining the types of research documentation in use, and to determine their adequacy as seen by managers actually served by them. The results are expected to be applicable to the improvement of research documentation systems in the agencies surveyed, and in other government and non-government organizations.

Limitations of the Study

This investigation has been limited to a study of documentation systems used to keep management groups informed of the progress and results of research work. Relatively little work has been done in this area when compared to efforts in the area of research documentation for other research workers, commonly called "scientific and technological information documentation and retrieval." Many publications already describe the problems caused by the increased output of scientific information, mechanisms for storing and retrieving the information, information clearinghouses, and related topics. Therefore, this thesis investigation has been restricted to research documentation systems to serve management. However, documentation in the form most suitable for management is also valuable for dissemination outside of a government agency, such as to members of Congress and to the general public.

This investigation was limited to a survey of nine field centers of the National Aeronautics and Space Administration (NASA), all of which perform research work. This limitation was imposed by the fact that the writer is an employee of NASA, by the desire to keep the survey to a manageable size, and by the fact that the nine NASA Field Centers have common characteristics which facilitate a meaningful comparison between them.

Need for Documentation

The Federal Government of the United States is the largest single supporter of research and development activity in this country. This research and development work is not only performed in government laboratories; it is performed throughout the country in universities, non-profit institutions, and profit institutions. The obligation of the government to provide adequate information about the research and development work that it supports is well recognized by persons within the government as well as by those outside. The President's Science Advisory Committee (1) studied the scientific information transfer problem, and had this to say about the government's role:

> Moreover, since good communication [documentation] is a necessary tool of good management, the Federal Government, as the largest manager of research and development, has a strong stake in maintaining effective communication [documentation].
>
> Another reason for the Federal Government's interest in maintaining the health of our scientific communication [documentation] systems has to do with the validity of our science. Modern science and technology cost our society dearly, and our society if justified in demanding its money's worth. Much of the return from science and technology is tangible and obvious: better defense, better food,

> more abundant energy. But the many technical activities that do not directly lead to tangible gains must also justify their existence to the society that supports them.

These statements illustrate that documentation, which is termed "communication" in the report just quoted, is necessary in the government not only as a requisite of good research management, but to inform the public of the achievements of research.

Essentially everyone concerned with research, whether he is a manager or a researcher, recognizes that documentation is an accepted part of the research activities. Some persons, however, put more emphasis on the documentation efforts than others. The President's Science Advisory Committee (1) states that the emphasis upon documentation should be equivalent to the emphasis upon the research work itself:

> ......we come to perhaps the most essential attribute of the information process: *the information process is an integral part of research and development.* Research and development cannot be envisaged without communication of the results of research and development; moreover, such communication involves in an intimate way all segments of the technical community, not only the documentalists. The attitudes and practices toward information of all those connected with research and development must become indistinguishable from their attitudes and practices toward research and development itself. This is the central theme of our report.

Thus, research managers should give as much support to the research documentation system as they give to the research work itself.

As previously stated, good communication (documentation) is recognized as a necessary tool of good management. Even though poor management can and does occur with the best of communication systems, poor communication almost always leads to bad management (1). It should be emphasized, however, that even if poor communication systems are improved, it does not automatically follow that management will be improved. It should be clearly recognized that a good communication system provides for the flow of communications in both directions. Not only must the research manager receive information about the research program prior to, during, and after the research work, but he must initiate and transmit directives, guidance, and information to the research workers during all phases of the program.

Research managers in the Federal Government have a need for many kinds of information about research, including the results of research; actual technical research data; and data on funds, manpower, schedules, organizations, equipment, and facilities (2). This information is used by managers to formulate research objectives, to plan for and to allocate funding and personnel, to direct ongoing research, to defend and to justify the research, and to show what was accomplished with the expenditure of research dollars. A task force established by Dr. J. B. Wiesner, Special Assistant to the President for Science and Technology, for the purpose of making a detailed study of scientific and technological information activities operating within the Federal Government, had this to say about the need for documentation (2):

> Therefore, the conclusion is inescapable that an important R&D management function in Government is the maintenance of an adequate information system oriented toward both broad and specific aspects of the agency missions for both their own needs and those of the performing scientists and engineers.

The needs of research managers in the Federal Government are similar in many respects to the needs of industrial research managers, although government managers are not usually concerned with the profit motives of research. Heyel (3) states that top management in industrial research can make proper decisions on the support of research only if the management is well informed on certain aspects of the research program. Some of the aspects of the research program named by Heyel can be modified to the following form to make them applicable to research programs in the Federal Government. Accordingly, government research managers should be informed on:

(1) The correspondence between research objectives and the technical needs of the agency.

(2) The necessary size of the research effort.

(3) The evaluation of progress in research and the research time table.

(4) The evaluation of the output of research.

(5) Evidence of the effective management of the research program.

It is apparent that government research managers should be aware of all the above factors if they are to effectively manage their programs.

When government research managers have the necessary information about their research programs, they use it for a number of managerial activities. These activities are similar in many government agencies. As an example, some of the management tasks in Air Force research and development programs are (4) :

(1) Present and future research needs, and their relative importance, must be determined.

(2) Estimates must be made of the capability to fulfill these needs.

(3) Responsibility and authority for research projects must be assigned, and schedules must be established.

(4) Necessary resources must be allocated to the projects.

(5) The work on all related projects must be coordinated to assure mutual compatability.

(6) The work must be continually monitored.

(7) It must be determined whether the objectives of the research have been satisfactorily attained.

These management tasks are common to all organizations where research is conducted. The tasks represent, in a summarized form, the realm of research management responsibilities.

In addition to their obligations to promote communications to more effectively manage ongoing research programs, the managers of research have an obligation to promote communications so that the entire body of science and technology can grow. Communication has been termed a key element in a number of the positive and negative factors that determine the rate of growth of science and technology (2). Some of these factors are:

(1) The results of research provide the means by which further research can be conducted. These results may be in the form of instruments, materials, or techniques.

(2) The results of research disclose new problems to be solved by additional research.

(3) Information generated from research can interact in innumerable ways with other research information to produce further valuable results.

(4) Difficulties in communicating the results of research are increasing as the body of scientific and technological knowledge grows, and as the number of persons working in research grows.

(5) The probability of unwitting duplication of effort grows as communication difficulties grow.

(6) Communication difficulties adversely influence the effectiveness of manpower utilization, and the productivity of the individual scientist, engineer, or manager.

These factors illustrate the great influence which research communications have upon the entire field of science and technology. The research manager should realize that his needs for adequate communications are but a part of the over-all needs for good communications. When a government research manager improves the documentation system in his own agency, the benefits extend far beyond the agency boundaries.

The kind of information needed by the research manager is the same in some respects as that of the scientist and the technologist, because they all must have technical information. Yet the manager needs his technical information in a somewhat different form; the manager must sacrifice detail in order to keep abreast of the whole picture. This fact is in keeping with the knowledge that modern management methods require that the responsibility for detail be progressively delegated to subordinate levels within the organization (3). Not only does this factor pertain to technical information, it also pertains to information concerning manpower, funding, equipment, and other resources.

Generally speaking, the research manager must be concerned with both the quality and the quantity of information confronting him. From a managerial view, the quality of information increases as details of minor interest are eliminated. The optimum quantity of information for a research manager is determined by the capability of the manager himself to assimilate and digest the information.

One of the reasons for the increasing communication problems in the government research and development activities is the growing involvement of the Federal Government in science and technology (2). Prior to 1940, the bulk of research and development support was derived from private sources. In 1940, the Federal Government budgeted $100 million for research and development; in 1963, this amount had grown to $12 billion. This represents more than a hundred-fold increase in a little over twenty years. In 1962, Federal expenditures accounted for more than two-thirds of all the research and development funds in the United States. The forecast for the future shows no diminution of the role of the Federal Government; there will be continuing expansions in the fields of national defense, space exploration, and health sciences.

The discussions in this section have illustrated that the Federal Government has an obligation to play a strong role in research and development documentation systems, that research managers need information about research work in order to properly perform their management functions, that adequate research documentation advances and promotes the growth of science and technology, and that the kind of information research managers need is different from the kind of information needed by the scientific and technical workers themselves.

CHAPTER II

REVIEW OF THE LITERATURE

Kinds of Documentation

Documentation for research can be classified into two broad general categories: Oral and Visual documentation and Written documentation. These categories can be divided into two subcategories: Formal documentation and Informal documentation. Specific types of documentation can be classified within these categories and subcategories, as shown in Table I. The types of documentation listed in this table are the most important ones utilized in the performance and management of research work.

The term "documentation" is not consistently used throughout the literature. Some authors use the term "communication" and others use the term "information" to refer to the specific types of documentation listed in Table I. When material from another author is quoted or referenced, the terminology used by that author will generally be followed. Therefore, the terms "documentation," "communication," and "information" will often be used interchangeably; they all refer to the types of documentation shown in Table I.

When the two broad, general documentation categories of Oral and Visual documentation and Written documentation are considered, it

TABLE I

TYPES OF RESEARCH DOCUMENTATION

ORAL AND VISUAL DOCUMENTATION

Formal	Informal
Symposia	Briefings (Informal Reviews)
Technical Meetings	Person-to-Person Conversations
Reviews	Telephone Conversations
Conferences	
Displays and Exhibits	
Motion Pictures	

WRITTEN DOCUMENTATION

Formal	Informal
Management Reports	Memoranda
Technical Reports	Informal Reports
Journal Articles	Personal Letters

is seen that there are advantages and disadvantages to each. Oral documentation has the advantage of speed of transmission, which is often important in research (5). In addition, oral and visual documentation has the advantage that it usually commands the exclusive attention of the recipient; it can create a greater impact and more lasting impression; it may have a psychological advantage if the recipient is required to leave his desk; and oral documentation provides a personal two-way communication channel with the opportunity for immediate resolution of questions (3). On the other hand, oral documentation has the disadvantages of often becoming distorted in transmission, and of lacking the quality of exact reproducibility (5). These disadvantages of oral documentation reflect some of the advantages of written documentation: it does not become distorted in transmission, and it has the quality of exact reproducibility. Furthermore, written documentation has the advantage of historical permanency, and it is the accepted standard for achieving and maintaining stature in many scientific and technical fields. Also, some types of informal written documentation have the advantage of speed of transmission. Some of the disadvantages of written documentation are that it must compete with the staggering volume of other written matter for the attention of the recipient; it is impersonal; it is a one-way communication channel; and it is often less appealing to the eye than some types of visual documentation (3). With all of their advantages and disadvantages, there is still a definite place and a need for oral and visual documentation, as well as written documentation, in the management and performance of research. It will be seen later that the types of documentation listed in Table I are used in the NASA Field Centers visited during the survey.

Some of the most important types of documentation will be discussed briefly. The oral and visual types will be covered first, and the written types thereafter.

A research symposium is generally a conference organized for the discussion of some particular research subject. The material covered is mostly technical in nature, and is usually presented by speakers in formal addresses. Symposia are accepted as an important type of documentation effort. They are largely successful because they create favorable attitudes among scientists and engineers (4). They promote the professional status of the participants and they stimulate a feeling of scientific freedom. In addition, they provide the opportunity for scientists and engineers to make personal contacts with others in their fields of work. Often, two or more attendants meet to discuss many aspects of the subjects presented. Thus, symposia promote the exchange of information in several ways. For the research manager, symposia are important because he can learn the technical details of research and because he can exchange information and ideas with other persons in attendance.

Technical meetings are quite similar to symposia, and the names are frequently used interchangeably, but often the scope of the subjects discussed in technical meetings is broader. Large technical meetings, such as the annual ones sponsored by many engineering and scientific societies, frequently run for several days and have simultaneous sessions covering all subjects of interest to members of the society. There are smaller technical meetings also, however, and many times their coverage is limited to one or two subjects. These are often called "specialist meetings"; most attendants are specialists in the technical or scientific areas which are covered. As with symposia, formal presentations are given by speakers. Technical meetings also provide the opportunity for personal contacts and exchange of information. Research managers often find the large technical meetings, especially, to be of considerable benefit, because they can hear about the technical aspects of many subjects in a short span of time, and because they can exchange information and establish valuable communication channels with other research managers who attend.

Research reviews are customarily held for the purpose of presenting the research progress and accomplishments since a prior review, or to present the current status of research programs. Reviews can be formal or informal. Informal reviews may also be called briefings. Formal reviews usually follow a planned program, and speakers customarily have their presentations well prepared and often use visual aids such as slides or charts for support. The audience is usually aware of the program topics prior to the review, and persons attend because they are directly involved or because the subject matter is of interest to them. Informal reviews are similar, but the presentations are not formal and the size of the audience is usually smaller. The informal reviews, or briefings, do not have planned agenda, and the speakers present their material in a more casual fashion. Questions and answers commonly arise during informal reviews. Informal reviews can occur when members of management call for them, when researchers request them, or on other occasions. They are often convened on short notice. A semi-formal review is a cross between a formal review and an informal review. The semi-formal review may be pre-arranged, and the agendum items may be established, but presentations are made in the same manner as those in informal reviews. Speakers present their material without benefit of the extensive preparations of formal presentations. Reviews are an important type of research documentation, and are frequently used in the management of government research.

Conferences are formal meetings of a number of people for discussions or consultations. Conferences are customarily chaired by one person and an agendum is frequently used. Important uses of conferences are to exchange information, to obtain decisions, or to solve problems, among others. Managers, especially those in government, usually attend many conferences, and it is said that as a manager moves up in the organizational ladder, conferences occur more and more often (6). The number of conference attendants can be large or small, depending upon the scope, the nature, and the importance of the subject. If conferences are run efficiently and are called only as needed, they are among the most important documentation tools available to managers of research.

Displays and exhibits are useful to convey research information that might be difficult, or even impossible, to communicate by written or spoken words alone. Large-scale displays and exhibits are widely used at technical meetings and at symposia, and may be attended or unattended. Smaller-scale displays and exhibits are often used for illustration by speakers giving formal presentations. Displays and exhibits may consist of charts, photographs, drawings, research equipment, working models, and similar items. They are useful for conveying information to technical and scientific people, to management personnel, and to non-technical people. One author believes that the use of a working model is the most effective type of communication between research workers and managers (3):

> There is nothing so effective in research-management communication as a working model of a new device or system that is placed in the hands of a company executive by his research organization. This transcends all other reports of progress and status and is *the* exhibit that is sought after by top management. Whenever actual laboratory units are suited to easy portability, these can be pressed into service as ready-made exhibits; where this treatment is not feasible, models that illustrate the principles in a realistic way will serve as excellent substitutes. Regardless of the character

> of the exhibit, it is mandatory that it be self-explanatory, self-contained, and not overly detailed.

Motion pictures are often used to relay information about research. They may be used alone or they may be used as a supporting aid by a speaker. If properly prepared, motion pictures can tell a complete story, or can illustrate a technique, device, or event which is difficult to describe otherwise. The use of slow motion, time lapse, animation, and other specialized photographic techniques may be used to show otherwise obscure or complex phenomena (3). Research managers usually consider motion pictures to be appealing. The biggest drawback to their use is the difficulty in producing them so they effectively tell the desired story.

Person-to-person conversations and telephone conversations fall into the subcategory of informal oral and visual documentation. Information transmitted by these means is most often of temporary importance, although written documents of the conversations are sometimes made for record purposes or to further transmit the information to other persons. These conversations are informal in the sense that a person's words are not carefully prepared beforehand. The research manager usually spends a considerable part of each day talking to others, in person or on the telephone, and the volume of information received and transmitted can be very large. These conversation methods are among the most efficient documentation devices that a manager has at his disposal.

The first type of written documentation to be discussed is the research management report. This report usually is a summary of research information over a given time period, written in a language and prepared in a form that makes it readily understandable and interesting to managers. The report may contain technical information, or data on funding, manpower, schedules, equipment, or other factors. It is an important documentation medium for managers, mainly because it is written especially for them. In any organization, after managers express their desires and needs for specific kinds of information, the management reports can be written to include such information, and thereby become more efficient. Management reports are widely used in government research. The United States Air Force uses a variety of management reports to aid managers of their research and development projects, and these reports are described as follows (4):

> The management reports.....do not contain complete technical information on projects since they are not intended to be technical reports. Nonetheless, they often contain valuable technical information which is not reported in technical reports until a later date. Furthermore, they are the most complete source of requirement, planning and guidance information. Also, those documents which contain summaries, ..., are a useful tool for screening projects to find where data pertinent to a particular problem may be found.

Management reports can also take the form of summaries of full-length reports, and can be attached to, or combined with, the full-length reports as indexes to them (3). A manager receiving the reports can scan the summaries for general information and then can use them to find the location, by page, of detailed information in the full report. Another form of the management report is sometimes called the highlight report; this might consist of a single page containing a concise statement of a significant development, discovery, breakthrough, or other event, together with an idea of its meaning in relation to the organization's interests, and possibly with a photograph attached (3).

Technical reports, sometimes called research reports, play a significant role in research documentation. They first became a major communication tool for general research and development activity during World War II when rapid communication between research groups was needed (2). They were valuable as informal media which could be subjected to close security classification and control in order to protect sensitive information. The interesting thing about technical reports is that there has been an increase in their use since World War II, rather than a decrease. About 100,000 technical government reports, of which about 75,000 are unclassified, were produced annually in the United States around 1963, as compared to about 450,000 papers in standard American technical journals (1). Some of the reasons for the wide use of technical reports are discussed by Dr. Wiesner's task force (2):

> One reason for their continued existence in unclassified areas is their currency. Information can be distributed to both performers and administrators more rapidly in this form than through

> more formal publications channels. There is an even more significant reason resulting from their value to development efforts; the technical report is a primary recording medium for applied R&D work. It is revealing that most of the criticism of this communication tool comes from the research scientists who are accustomed to the conventional scientific journals; the strongest defense for reports, on the other hand, comes from the technological community for which adequate alternative media are not available..... The technical report, whatever its shortcomings, is likely to remain an important element in the technological communication network.

The quality of government technical reports varies, depending upon the author and upon the reviews required by the agency publishing the reports. Some agencies, such as the older NASA laboratories or the National Bureau of Standards, that visualize their missions to be the creation of information, have careful review systems, and have maintained the highest standards for their technical reports (1). Other agencies do not have such thorough review procedures, and the quality of some of their reports may reflect this. Technical reports appear in a variety of forms, such as the laboratory experiment report, project progress report, project final report, program progress report, or program final report. Progress reports are usually issued at periodic intervals during the life of an experiment, project, or program to report progress made since the last report, problems encountered, results of tests or studies, and possibly some facts on schedules, costs, and manpower (7). The interval at which progress reports are issued is largely dependent upon the nature and importance of the project or program. Research projects, which by their nature are less adaptable to schedules and milestones than development projects, usually require progress reports at less frequent intervals than development projects. Progress reports are often submitted at quarterly intervals for research projects, unless the project is large enough and important enough to warrant them more frequently, such as monthly. Final technical reports differ from progress reports, which are issued throughout the life of a project, in that they are issued only at the termination of the project and in that they are broader in scope and more conclusive. In effect, the final technical report tells the story of the project from beginning to end, and it contains the conclusions and recommendations of the persons performing the research. The final technical report is intended for management as well as for other research workers. Therefore, it should be written in a manner so the contents are readily understandable and the recommendations forcefully presented. Hertz (5) has this to say about final reports:

> It is not sufficient in such a report that the facts and conclusions be presented in a clear, concise manner.... examples of their utility and recommendations as to how best to use them should also be included .... This is the report ending the research group's work and presenting it to the remainder of the enterprise. Clarity and usability would be the keynotes here.

Final technical reports are often voluminous and filled with technical details, which makes it difficult for managers to read them in their entirety. It has already been mentioned that full-length reports, such as final technical reports, can be sent to managers with a summary and index attached. It is obvious that all managers of research must recognize that the technical report is an important documentation medium which they can profitably utilize. The large number of technical reports each year and the permanent place which they have attained in the literature field assures that they will be a continuing source of management information in the future.

Journal articles have long been the accepted method of formal scientific documentation, especially in the basic sciences. They are carefully and accurately prepared; they are usually formally refereed; their quality is uniformly high. Journal articles are the route by which scientists and researchers may attain and maintain their professional standing. Consequently, most scientists and researchers are anxious to publish in journals. As mentioned previously, about 450, 000 articles were written yearly around 1963 for publication in American technical journals. From the standpoint of the manager, journal articles are an important documentation tool if he is interested in, and has time to read, the technical details provided. Even if he does not read the entire article, the manager can read the abstract which is usually placed at the start of the article, and become aware of the major points covered. On a broader basis, the manager can scan the titles of a given journal, read the abstracts of articles which are of interest, and thus obtain a feeling for the scope of all the work reported in the journal.

The first type of informal written documentation to be discussed is the memorandum. Memoranda are generally distinguished from reports by their informality (5). A memorandum may be described as a written substitute for oral communication and often is phrased in much the same manner. The memorandum can be used to request, or to transmit, information within an organization. It is also used to request or grant authority for some activity, and to transmit brief technical or administrative material for information or reference. With respect to timing, memoranda should be written when their appearance is most desirable, and they should be issued promptly. Memoranda should be distributed to those persons who have a need to know, but not to others. Memoranda are important documentation channels for managers because the manager can receive and transmit timely, pertinent, and to-the-point information by them.

Informal reports are usually similar to technical reports but the contents are of a more preliminary nature and the distribution is quite limited. Informal reports are commonly used to transmit recently developed technical or management-type information quickly to those persons who should know about it. The contents are often designated as preliminary and subject to further verification and sophistication. Informal reports are distributed only to those persons known to be interested in the subject of the report; they are rarely distributed outside of the originating organization. Because of their informality, they are not prepared with the time and care given to formal reports. However, informal reports are often rewritten as formal reports after more work is done and the contents can be refined into a form suitable for a permanent document. Informal reports are not usually acceptable for historical purposes. Informal reports can be an important type of documentation for the manager when he is interested in receiving timely information in a preliminary state.

Personal letters are another type of informal written documentation. The contents are usually restricted to a single topic, and the message is of primary importance to the sender and the receiver, although copies can be distributed to other interested persons for informational purposes. Personal letters are usually used for communication between persons in different organizations. This is the distinction between letters and memoranda: memoranda are transmitted inside an organization, while letters are transmitted outside the organization. In other respects, personal letters are similar to memoranda. Managers, with their wide range of contacts, find that personal letters are a valuable and much-used type of documentation.

The discussions in this section have shown that there are two broad, general categories of documentation. These are oral and visual documentation, and written documentation. Within these categories, specific types of documentation can be formal or informal. Symposia and technical meetings are valuable for the research manager because he can learn of the technical details of research work and can exchange information with other attendants. Reviews are valuable because he can learn of the progress, accomplishments, and problems of research since the previous review. Conferences enable the manager to exchange information and to take action as necessary on the research program. The research management report is valuable to the manager because it is written especially for him in an easy-to-read style and because it contains only information intended to be valuable to him. Technical reports and journal articles are valuable to the research manager if he desires detailed scientific and technical information. Memoranda are used by the manager to transmit and receive information in a fast and informal manner within his own organization, and personal letters are used for the same purpose with persons outside of his organization. Since all these types of documentation are valuable to the manager, it is desirable to consider what characteristics documentation should possess to be of maximum value to the manager. These characteristics will be discussed in the next section.

Desirable Characteristics of Documentation

Documentation for research managers should exhibit a number of sometimes contradictory characteristics: it should convey a maximum amount of information in a minimum number of words; it should convey technical information in not-too-technical language; it should convey a complete picture yet minimize details. In addition, it should be easily assimilated and easily remembered.

These characteristics are desirable in all types of management documentation, whether they be written or oral and visual, formal or informal. In this section, however, the discussion will concentrate upon written documentation, and more specifically, upon management reports and technical reports. The reader should be able to visualize, however, that salient points can be readily extended to cover other types of written documentation, and by a further extension to cover types of oral and visual documentation.

Top managers of research organizations are faced with the requirement to constantly place any information they receive into proper perspective in the over-all management picture. They must recognize the role that their organization plays in relation to other organizations; they must recognize how each section of their organization contributes to the functioning of the over-all organization; they must visualize the cumulative manpower and funding needs of their organization; they must be aware of the research accomplishments within their organization and of the resulting potential applications.

The over-all management picture is a continuously changing picture. To keep it constantly in view, management must be willing to sacrifice some of the details of the picture (3):

> It is the essence of modern management methods that the responsibility for detail is progressively delegated to subordinate levels within the organization.
> Reports rising through the hierarchy in an organization should change during their ascent in a manner consonant with this principle; that is, they should progressively shed details as they enlarge their scope.

This same thought has been expressed by other authors, as, for example (8):

> Reports are a form of vision or communication, and, as these reports rise toward top management, they must give a complete picture of what is below yet with a considerable reduction of detail. .... Perspective and communications must not be lost, crowds of detail must not obscure the vision. All important factors must be reported upwards. The amount of detail for each elevation of management must be summarized without losing the basic picture.

It is not a simple matter to determine the best form for documentation to take in presenting information to managers. The information needs of management are changing, and as the volume of reports continues to grow, the problem of extracting pertinent management information grows. Surveys of research managers have shown that many of them are not getting the information that they need. Heyel (3) used the following table to illustrate this point:

Management Men Want Better R&D Laboratory Reports*

40% . . .	want a better conclusion
32% . . .	want more stress on long-term implications
32% . . .	want more stress on what findings mean in dollars
22% . . .	want them shorter
21% . . .	want more graphic material
13% . . .	want them less scientific
11% . . .	want more stress on new product implications

*from Chemical and Engineering News, January 20, 1958.

Although this table refers to laboratory reports, and although the survey was apparently limited to a single technical field, it is probably illustrative of the desires of many research managers.

When management reports and technical reports are considered, it is apparent that there are two big factors required to produce satisfactory reports for management: the authors must write effectively, and the formats of the reports must be efficient. These two factors will be discussed in some detail. The literature contains many works dealing with technical writing and report preparation. It is not one of the objectives of this study to survey all of the literature, but some of the works which contain pertinent information are used for illustrative purposes.

Guidelines and recommendations for authors abound. Singer (9) has the following to say about technical writing, and it is directly applicable to management reports and technical reports:

> Technical writing is, indeed, an art. It is not possible to make rules for turning out effective technical writing any more than one can make rules about good writing. One can merely set forth principles — guides to be applied with thought. It has been stated that "rules are substitutes for thoughts." ....Several guides to and recommendations for effective technical writing have been suggested by many authorities: simplify your writing; be brief; use the dictionary; weigh your words; use short sentences; diagram your writing; write as you speak; design your writing; recheck technical detail; include all information; write logically; be accurate; be creative; avoid unprovable superlatives; make your writing interesting; use clichés only after consideration; be sincere; don't talk down. It is apparent that each of these recommendations must be applied selectively rather than generally.

The President's Science Advisory Committee (1) had the following recommendations for authors of technical papers to make the papers more valuable and more easily retrievable:

> a. Title papers in a meaty and informative manner
> b. Index...contributions with keywords taken from standard thesauri.....
> c. Write informative abstracts
> d. Refrain from unnecessary publication

Technical communications in the United States Air Force should conform to a number of criteria, according to Martin (4):

(1) The information should be transmitted without delay

(2) Transmitted information should be accurate

(3) Transmitted information should be complete

(4) The information should be relevant to the problem to be solved

(5) Coverage should be adequate for potential users.

These criteria are applicable to all kinds of documentation. Authors of technical and management reports outside of the Air Force, too, will enhance the quality of their writings by applying these criteria.

Karger and Murdick (7) set forth the following guidelines for authors of progress reports: authors should be concise, specific, and should report only facts.

Hertz (5) states that authors should be purposive in their writing; that is, reports should be written with some objective which is clearly understood by the authors and which is stated in the text. In addition, the material should be written in a fashion which is suitable for the intended reader. The recommendations, if any, should be unambiguous, so that management clearly understands any action to be taken.

Marschner and Howe (10) have simply this to say to authors of written reports:

1. Write for the reader
2. Stick to the story
3. Say it once and say it well.

Leaving the author, and looking at the format of technical and management reports, one finds a vast amount of literature describing the good and bad points of a report. Only a few works will be referenced.

Hertz (5), when discussing technical progress reports, states that they should contain all of the following elements:

1. The title page
2. Abstract (often included on the title page)

3. Table of contents
4. Introduction
5. Body of the report
    a. Prior history
    b. Type of (qualitative and quantitative) information utilized
    c. Means used to collect the data
    d. Presentation of relevant data
    e. Interpretation of data, with information as to their significance
6. Conclusions
    a. Supported by the data available
    b. Extended or extrapolated
    c. Recommendations for future action
7. Appendix, if necessary
8. References and bibliography

Hertz goes on to say that the appearance of the written material influences the attitude that the reader has toward it. It should be legible and easy to read; double spacing is preferable to single spacing.

Heyel (3) recommends that the opening statement of a report contain essential information about the contents of the report, such as: project title and number, period covered by report, objective, summary, conclusions, and recommendations or proposed future work. The reader who is not interested in examining the substantiation for the conclusions need not go further than this summary. The proper use of photographs, charts, and diagrams can multiply the effectiveness of a report. In addition, reports should be distinctive in appearance, and should be convenient to handle, read, and file.

Singer (9) states that the form of technical reports will vary from one research group to the next, but they should include certain essential components:

(1) Statement of purpose — definition of the problem
(2) Summary (abstract of contents)
(3) Experimental detail
(4) Interpretation of data (based on a critical analysis of the presented data)
(5) Conclusions and recommendations
(6) Bibliography

The management report will be different from the technical report in that the summary and recommendations will assume a more prominent place. Experimental data, if included in a management report, will be appended for reference only. The most important parts of the management report, the conclusion and recommendation sections, might include opinion as well as experimental fact so that the manager obtains the benefit of the thinking and evaluation of the research group.

As mentioned, the form of reports will vary from organization to organization. The management report format is often patterned to fit the specific needs and desires of the management of the organization, and it often changes as the needs of management change. In well-established research organizations, there is a logical tendency to settle upon a particular report format after years of publication have indicated the strong and weak points of various schemes. It is obvious that there is no one best report format for all organizations. However, for purposes of illustration, the monthly report Report of NRL Progress, published by the United States Naval Research Laboratory, Washington, D. C., will be described as an example of a government research report. It is an example of a narrative summary report, and is more of a management type report than strictly a technical type report.

The Report of NRL Progress, January 1965 (11), has a Contents page, which is shown in Figure 1. It may be seen that the contents of this forty-two page report consist of two short articles, problem notes on nine research fields of the scientific program, an article on supporting techniques, a listing of papers published by Naval Research Laboratory staff members, a list of patents issued to members of the Laboratory, and an index of unclassified reports published during the year 1964. This is quite a comprehensive coverage for such a fairly short report.

The two articles are written in a narrative style which makes them interesting and informative to managers and scientists alike. They are short, meaty, and not difficult to assimilate. Two sample pages of one article are shown in Figures 2 and 3. This writing style, coupled with the fact that there are only two articles in this report, should encourage managers to read both articles. If the articles had been lengthy, if their style had been too technical, or if there had been a much greater number of articles in the report, it is probable that fewer managers would read all of them.

The Problem Notes, which are taken from nine of the fields of research in the Naval Research Laboratory, present the background of particular problems being investigated and the progress made in the investigations. Sample pages of the Problem Notes are illustrated in

CONTENTS

January 1965

FIGURE 1 - Contents, Report of NRL Progress, January 1965

Survey for Radioactive Contamination in the Vicinity of the USS THRESHER

C. F. DOHNE* AND J. I. HOOVER*

The spectral distributions of the gamma rays from radioactive isotopes in the deep ocean and in the vicinity of the USS THRESHER have been measured. The measurements were conducted from the Bathyscaphe TRIESTE II using a sodium iodide crystal coupled to an EMI photomultiplier tube, and a 400 channel pulse height analyzer. No spectral lines, other than those associated with normal sea water or bottom sediment, were evident in the spectral data taken in the vicinity of the THRESHER. It is concluded that no exchange took place between the reactor system and the sea.

INTRODUCTION

The loss of the USS THRESHER in April 1963 raised the question of the possibility of a transfer of radioactive contamination to the ocean. Preliminary experiments were conducted during that summer in an effort to detect the presence of such contamination. These experiments were extended during the summer of 1964 with improved navigation and radiation detection systems.

INSTRUMENTATION

The underwater radiation field measurements were made with a scintillation detector using a 3 inch by 3 inch sodium iodide crystal coupled to an EMI photomultiplier tube. The detector and associated circuitry, including the high voltage power supply, were enclosed in an aluminum (Type 6061-T6) pressure vessel. The inclusion of the high voltage power supply within the pressure vessel was necessary to meet the voltage specifications of the hull penetrators through the sphere. The detector assembly was mounted exterior to the TRIESTE II sphere in a position which afforded protection yet minimized shielding by structural members.

A small shielded Se^{75} calibration source was attached to the detector which could be exposed to the crystal from within the sphere during calibration, and shielded during normal operation. The low calibrating energy (273 Kev with a sum peak at 410 Kev) was chosen for ease of shielding and minimum interference over most of the spectrum.

A counter, multichannel spectrum analyzer, and punched tape data storage system were mounted within the sphere of the TRIESTE II. The counter was designed for the specific operation, keeping in mind the unfavorable environment existing within the sphere. Critical components were potted and extensive filtering was employed to eliminate spurious electrical signals generated by other instrumentation such as sonar. The multichannel analyzer was a standard commercial unit, whereas the punched tape data storage system was modified to satisfy the space limitations for this particular application.

The counter served several functions. It supplied filtered and regulated electric power to the detector and channeled the signal from the detector to the analyzer. In addition it contained a four decade scaler, a strip chart recorder (Rustrak), and an audio system. The scaler permitted digital counting and served as a visual indicator of increased radioactivity levels. The recorder made a continuous record of radioactivity levels at the detector. The audio system produced a signal which served to alert the operator to unusual radioactive background levels.

The analyzer was a 400 channel TMC model 404, and the punch data storage system was a modified TMC model 520. The analyzer performed the normal functions of a spectrum analyzer—sorting and storing data in the memory. The model 520 punch, on command, extracted and recorded the data from the analyzer memory in binary code on punch tape.

The detector, counter, analyzer and data storage system were inter-connected with appropriate cable. The schematic of the detector and counter is shown in Figure 1.

OPERATION

Gamma rays originating in the water from the decay of naturally occurring radioactive elements

*Radioactivity Branch, Nucleonics Division

FIGURE 2 - Sample Page of Article (#1 of 2), Report of NRL Progress January 1965

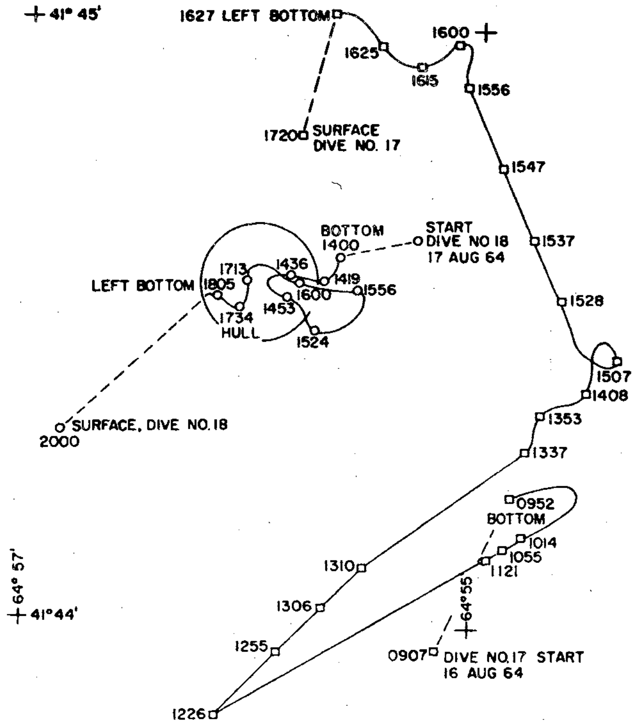


Figure 4 — TRIESTE II dive record

Previous to dive 18 the gain on the pulse height analyzer amplifier was increased during calibration which permitted the spectrum to be spread over more channels of the analyzer.

Considerable time was spent during dive 18 in the vicinity of the THRESHER hull. A long spectrum (297 min) was taken which represented the summation of seven individual spectra allowed to accumulate in the analyzer memory. Periodically the analyzer was stopped and the data were recorded, after which the counting continued without clearing the memory. The accumulation of these data started when the TRIESTE II left the surface and terminated on the hull of the THRESHER. Only a small fraction of the total spectrum was taken in the vicinity of the hull.

The TRIESTE II was then moved alongside the THRESHER hull and an additional 34 minute spectrum was taken. The 297 minute spectrum is shown in Figure 6 and the 34 minute spectrum is shown in Figure 7.

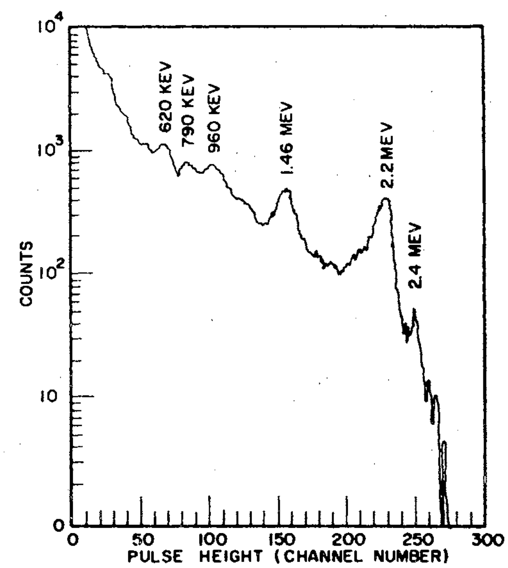


Figure 5 — 325 minute spectrum from dive 17

FIGURE 3 - Sample Page of Article (#2 of 2), Report of NRL Progress January 1965

Figures 4 and 5. They are brief, to the point, and the problems are well identified. A regular reader of the Report of NRL Progress can obtain a feeling for the scope of the Laboratory's research and the progress being made, over a period of months. The Problem Notes are very useful for managers and scientists, and require only a minimum amount of time to read.

The section on supporting techniques is intended to present achievements or solutions to problems in engineering design, fabrication, or instrumentation. A sample page is shown in Figure 6. Once again, the writing style is brief, meaty and not difficult to assimilate. This section of the report serves to keep managers and research workers aware of the latest laboratory operations.

The section on papers by the Naval Research Laboratory staff members provides a concise summarization of the number of papers produced, as well as the subjects covered in the papers. A sample page is shown in Figure 7. A review of the titles will provide the reader with an idea of the scope of activities going on in the Laboratory. This is quite valuable for managers who want to visualize the over-all picture of the Laboratory work.

The section on patents issued to employees of the Laboratory during the preceding month also serves to give the reader a feeling for the extent of the accomplishments in the Laboratory. Patents are normally issued as the result of research work progressing to the point of

PROBLEM NOTES

Significant technical progress on individual projects or problems of the research and development program is summarized briefly each month in these notes according to the field of research. Reports are confined to those which are unclassified. Frequently more than one branch or division is engaged in research under the same program. In such cases the progress report will be ascribed to the branch concerned with the particular problem on which the report is made.

APPLICATIONS RESEARCH

SYSTEMS ANALYSIS

Application of Formal Analytic Methods to Naval System Studies

Applications Research Division
Engineering Psychology Branch
(D. C. Burdick and A. E. Goins)

NRL Problem No: Y03-02
Project No: RF 005-01-41-4301

BACKGROUND: Despite the fact that much of the information used by CIC officers has been automated, there is such a variety of tactical situations that major and even minor tactical decisions will continue to be made by officers and controllers. Automation and improved sensors increase the amount of information available; hence the processing of this information by the decision maker will become more critical. Future systems, in contrast to past systems, will become more decision-limited and less information-limited. It is thus important to know what information the decision maker uses and how he uses it. Past studies at this Laboratory indicated that perhaps CIC decision makers use the opposing concepts of assigning interceptors either to the target which is most capable of attacking or to the target they feel is most likely to attack.

PROGRESS: A final report on the problem has been completed and will be published in the near future as NRL Report "Target Capability Versus Presumed Intention as a Basis for Decision in Combat Information Centers" by D. C. Burdick and A. E. Goins.

Abstract: The use of the opposing factors of target capability and target presumed intention as bases for decision by a sample of 131 CIC decision makers in 60 abstract tactical situations depicted by static displays was examined. Very wide differences in strategy and trade-off points were observed, with most decision makers weighting presumed intention more heavily. In comparison with rank and job experience, the CIC school attended was the most important factor correlating with decision strategy. Considerations of the subject's consistency in his decisions, difficulty of problem, and the subject's stated confidence in his decisions are discussed.

CHEMISTRY

POLYMERS

Polymeric Systems

Chemistry Division
Organic & Biological Chemistry Branch
(L. G. Isaacs and R. B. Fox)

NRL Problem No: C04-04
Project No: NASA S-49293-G

BACKGROUND: Passive communication satellites are hollow balloons consisting of a thin sheet of aluminum reinforced by polymer coatings. They are inflated in space after being placed in orbit by ejection from rockets. Although these satellites show promise as dependable rf reflectors, solar pressure has caused partial collapse of the balloons which has resulted in serious losses in reflectivity and unpredictable changes in the orbits of the satellites.

An aluminum mesh can be substituted for the aluminum sheet in the satellite with only slight loss in reflectivity; the mesh, of course, presents a much smaller surface to solar pressure. A polymeric coating of the mesh is required to inflate the satellite in space. After this is accomplished, the coating should be removed to minimize the surface which can be affected by solar

FIGURE 4 - Sample Page of Problem Notes (#1 of 2) Report of NRL Progress, January 1965

METALLURGY AND CERAMICS

PHYSICAL METALLURGY

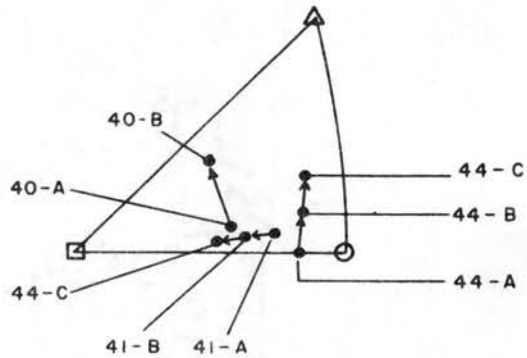
Metals and Alloys at Elevated Temperatures (Defect Structures in Refractory Metals)

Metallurgy Division
High Temperature Alloys Branch
(T. G. Digges, Jr., C. L. Vold, and M. R. Achter)

NRL Problem No: M01-09
Project Nos: RR 007-01-46-5407 and ARPA 418

BACKGROUND: Highly perfect niobium single crystals have been grown by the strain-anneal technique (1). The purpose of this note is to report the effect of crystal orientation on perfection. The control of orientation may be achieved by a bending technique.

PROGRESS: In the present work a cold swaged rod that has been recrystallized at 1610°C and strained 1% is partially lowered through the induction coil to initiate growth of a single crystal. Then the rod is removed from the coil and placed in the bending apparatus shown in Figure 1. A Laue back reflection photograph gives the initial orientation of the single crystal. The change in orientation is made in two steps. First, the rod is rotated to bring the Laue spot representing the desired crystallographic direction into the plane of bending. Second, the polycrystalline portion



Crystal No.	Dislocation Density
40 - A	1.04×10^6
40 - B	3.0×10^5
41 - A	1.0×10^5
41 - B	0.7×10^5
41 - C	9.4×10^5
44 - A	2.6×10^6
44 - B	1.05×10^6
44 - C	9.8×10^5

Figure 2 – Changes of orientations by bending technique with corresponding channels in dislocation densities. All crystals were brown at 2100°C.

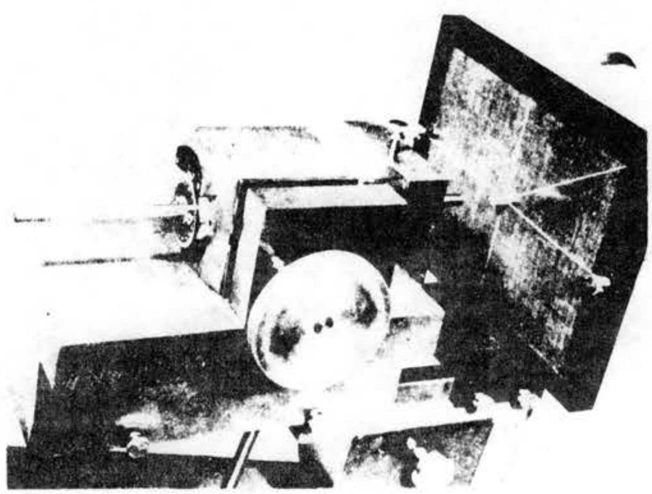


Figure 1 – Bending apparatus for changing orientation of niobium single crystals.

FIGURE 5 - Sample Page of Problem Notes (#2 of 2), Report of NRL Progress, January 1965

SUPPORTING TECHNIQUES

Reported herein are noteworthy achievements or solutions to problems in engineering design, fabrication, or instrumentation. While of special significance for their support of the Laboratory's research and development programs, these accomplishments may be useful elsewhere in solving problems similar to those described below.

A Dependable Apparatus for Automatic Filling of A Liquid Nitrogen Baffle

B. C. La Roy*

Ultra-high vacuum systems must frequently operate unattended for periods of several hours or overnight. In these cases, a liquid nitrogen baffle must be kept filled in order to capture and hold condensable vapors to keep them from contaminating the pump oil, and to prevent pump oil from backstreaming into the vacuum system.

Automatic filling of the baffle is complicated by the fact that a sensor cannot be inserted into the liquid nitrogen reservoir. Attempts to control filling by placing a sensor at the baffle vent pipe are usually unsuccessful. Such a sensor is generally in contact with metal parts of the baffle and is heated by them, thus prematurely calling for refill soon after the liquid transfer has ceased.

If the sensor is also employed to terminate the transfer, premature termination is experienced because the gas above an agitated liquid nitrogen bath is nearly at the liquid temperature. The latter difficulty is commonly avoided by transferring liquid into the baffle for a preset time interval after transfer initiation. However, this timer method cannot compensate for changes in external heating of the baffle or variation of the speed with which the liquid is transferred.

A simple automatic liquid nitrogen filling apparatus, shown in Figure 1, has been devised which avoids these difficulties. Liquid nitrogen from a pressurized container is passed to the baffle through a degreased water solenoid. The solenoid is actuated by a relay locking network, the main element of which is a millivolt meter-relay. The network energizes the solenoid when the meter relay reaches its low (transfer-start) set-point. Transfer continues until the high (transfer-stop) set-point is reached.

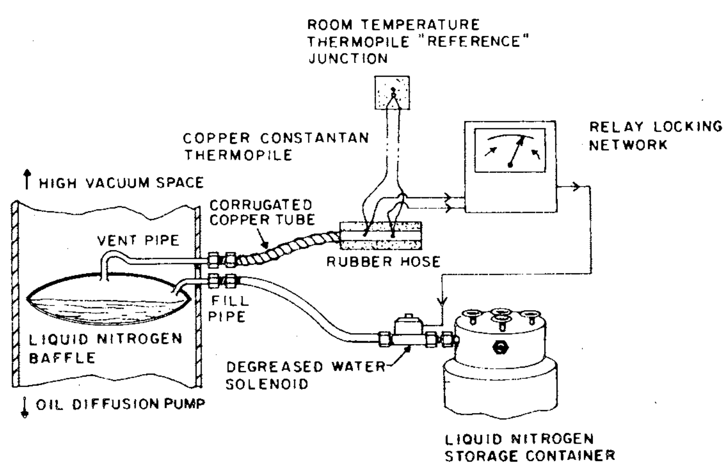


Figure 1 – Schematic drawing of automatic liquid nitrogen baffle fill system

*Metal Physics Branch, Metallurgy Division.

FIGURE 6 - Sample Page of Section on Supporting Techniques, Report of NRL Progress, January 1965

PAPERS BY NRL STAFF MEMBERS

PAPERS APPEARING IN CURRENT ISSUES OF SCIENTIFIC JOURNALS

"Analysis of High-Energy Nuclear Interactions from the International Cooperative Emulsion Flight" by B. Hildebrand, R. Silberberg (NRL); M. Koshiba, C. H. Tsao (University of Chicago); C. L. Deney, R. Fricken, R. W. Huggett (Louisiana State University); and J. J. Lord (University of Washington), *Nuovo Cimento Suppl.* **1**:1091 (1963)

"Combined Environments Versus Consecutive Exposures for Insulation Life Studies" by F. J. Campbell, *IEEE Trans.* NS-**11**:123, November 1964

"The Effect of Monomolecular Films on the Surface Temperature of Water" by N. L. Jarvis, C. O. Timmons, and W. A. Zisman, *Retardation of Evaporation by Monolayers Symposium,* Academic Press, New York, 1962, pp. 41-58.

"Electron Instrumentation for Oceanography" by A. H. Schooley, *Advances in Electronics and Electron Physics,* Academic Press, New York and London, 1964, V. 19, p. 1

"Example of Decay $\Omega^- \rightarrow \Xi^- + \pi^0$" by R. G. Glasser (NRL); G. S. Abrams, *et al* (University of Maryland), *Phys. Rev. Ltr.* **13**:670, November 30, 1964

"Inelasticity and Meson Emission Asymmetry in High-Energy Jets" by B. Hildebrand and S. Silberberg, *Nuovo Cimento Suppl.* **1**:1118 (1963)

*"Lunar Occultation of X-Ray Emission from the Crab Nebula" by S. Bowyer, E. T. Byram, T. A. Chubb, and H. Friedman, *Science* **146**:912, November 13, 1964

*"Phase-Considerations in the Navy Space Surveillance System" by M. G. Kaufman, *8th IEEE International Conference on MIL Electronics, Proc.*, 1964, pp. 293-296

"Progressive Failure Mechanisms in Glass Reinforced Plastic Rocket Cases" by J. A. Kies and H. Bernstein, *Fifth International Symposium on Space Technology and Science, 1963,* Agne Corp., 1964, pp. 669-682

"Radiation Effects on Insulation—State of the Art" by V. J. Linnenbom, *Insulation* **10**:21, March 1964

*"The Role of Molecular Structure in the Direct Determination of Phase" by H. Hauptman, *Acta Crystall.* **17**:1421, November 1964

"Single Aperture Monopulse Radar Multimode Antenna Feed and Housing Device" by D. D. Howard, *8th IEEE International Conference on MIL Electronics,* 1964, pp. 259-263

*"Solar X-Ray Spectrum Below 25 Angstroms" by R. L. Blake, T. A. Chubb, H. Friedman, and A. E. Unzicker, *Science* **146**:1037, November 1964

*"Some Observations on Triangular GaAs Lasers" by I. Ladany, *IEEE Proc.* **52**:1353, November 1964

"Stark Broadening Calculations" by H. R. Griem, *J. Quant. Spectros. Radiat. Transfer* **4**:669, September-October 1964

*"Steel Corrosion Mechanisms. The Growth and Breakdown of Protective Films in High-Temperature Aqueous Systems: 15% NaOh at 316°C" by M. C. Bloom, G. N. Newport, and W. A. Fraser, *Electrochem. Soc. J.* **111**:1343, December 1964

PAPERS PRESENTED AT RECENT SCIENTIFIC MEETINGS

"Cosmic X-Rays" by H. Friedman, Second Texas Symposium on Relativistic Astrophysics, Austin, Tex., December 17, 1964

"The First Photographs of the Sun's White Light Corona Made Without A Solar Eclipse" by R. Tousey, Optical Society of America, Annual Meeting, New York, N. Y., October 6-9, 1964

FIGURE 7 - Sample Page of Section on Papers by NRL Staff Members, Report of NRL Progress, January 1965

significant achievements. A sample page of the section on patents is shown in Figure 8. This section assists in giving the manager an over-all picture of Laboratory activities.

Finally, the section containing an index of unclassified reports published by employees of the Laboratory during the preceding year serves to show the reader how many reports are published, what research subjects are covered, and the division of reports among the various research fields. A sample page is shown in Figure 9. It is probable that this index appears only once each year, so it should not be visualized as a regular part of the report each month.

It was mentioned that the Report of NRL Progress is just an example of a government narrative summary-type research report. But it is a *good* example of such a report. When one considers the characteristics which documentation for research managers should exhibit as described at the beginning of this section, one can conclude that the Report of NRL Progress satisfies most of them. For example, it conveys a maximum amount of information in a minimum of words; it conveys technical information in not-too-technical language; it conveys a complete picture without being too detailed; and it appears to be capable of easy assimilation.

In this section, it has been shown that research managers must keep an over-all picture of the operations of the organization in view, and the research documentation which they receive must be devoid of

PATENTS

The following patents were issued during December 1964 on inventions made by employees of the Laboratory. The inventions may be used for governmental purposes without the payment of royalty to the inventors.

Sound Velocity Meter, Patent No. 3,160,224, issued 8 December 1964 to Werner G. Neubauer.

This sound velocity meter includes a target and a transducer supported on opposite ends of a v-shaped interconnecting bracket. The velocity of sound in a medium is determined from the geometry of sound reflections produced by the target immersed in the medium.

Battery Charger, Patent No. 3,160,805, issued 8 December 1964 to Wilmer M. Lawson.

This invention is a transistorized battery charger which prevents the voltage at the battery terminals from exceeding a preselected value.

"Exclusive or" Logical Circuit, Patent No. 3,160,819, issued 8 December 1964 to Cyrus J. Creveling.

The invention provides an electrical logical circuit which produces no output when pulses coincident in time and of equal amplitude and width are received at both input terminals.

Quartz Crystal Discriminating Circuit, Patent No. 3,160,822, issued 8 December 1964 to Edgar L. Dix.

This invention is a stable, extremely sensitive, discriminating circuit. These features are obtained by circuitry which includes a crystal having series and parallel resonant frequencies close together. This crystal is interconnected with two channels, one of which develops a positive potential related both to the frequency and amplitude of the input signal and the other of which is negative, independent of frequency, but related to the amplitude of the input signal. The output is obtained by summing these positive and negative potentials.

Fixed Pulse Rejection System for Radar Moving Target Indicator, Patent No. 3,161,874, issued 15 December 1964 to Irving H. Page.

This invention provides a moving target indicator for radar. The indicator includes a filter that blocks the lower harmonics of the pulse repetition frequency but passes the moving-target Doppler frequencies. I.F. mixing oscillators are coordinated both in phase and frequency to the transmitter. The receiver video pulse frequency spectrum is also inversely matched to the frequency response spectrum of the filter.

Narrow Band FSK System Employing Stabilized Frequency Control, Patent No. 3,162,812, issued 22 December 1964 to Robert R. Stone, Jr.

The present invention is a standard frequency FSK means useful over a wide range of frequencies and particularly adaptable to VLF operation in which the two transmitted frequencies undergo multiplication and then division, with the divider system designed for instantaneous lock-in of the input signal thereto at the nearest point of phase. In a preferred embodiment, means are provided for avoiding transients developed because of the instantaneous nature of the lock-in action.

FIGURE 8 - Sample Page of Section on Patents, Report of NRL Progress, January 1965

INDEX OF UNCLASSIFIED REPORTS

(January-December 1964)

APPLICATIONS RESEARCH

6055 "The Computation of Effective Display Sensitivity in Aircraft Landing" by B. L. Perry.

ATMOSPHERE AND ASTROPHYSICS

6025 "Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products" by L. B. Lockhart, Jr., and R. L. Patterson, Jr.

6054 "Characteristics of Air Filter Media Used for Monitoring Airborne Radioactivity" by L. B. Lockhart, Jr., and R. L. Patterson, Jr.

6092 "Code and Sequencing System for Automatic Weather Stations" by T. E. Marshall III and R. B. Bridge.

6104 "Summary Report on Fission Product Radioactivity in the Air Along the 80th Meridian (West) 1957-1962" by L. B. Lockhart, Jr., R. L. Patterson, Jr., A. W. Saunders, Jr., and R. W. Black.

6134 "The Mean Distance to the Moon as Determined by Radar" by B. S. Yaplee, S. H. Knowles, A. Shapiro, and K. J. Craig (of NRL) and D. Brouwer (of Yale University).

6152 "Experimental Observations of Forward Scattering of Light in the Lower Atmosphere" by J. A. Curcio and L. F. Drummeter, Jr.

6164 "Filter Pack Technique for Classifying Radioactive Aerosols by Particle Size. Part 2—Isotopic Fractionation With Particle Size" by L. B. Lockhart, Jr., R. L. Patterson, Jr., and A. W. Saunders, Jr.

CHEMISTRY

5969 "Shipboard BW/CW Defense and Countermeasures" by G. H. Fielding.

5973 "Feasibility of Utilizing Luminescent and Reflective Coatings as Visual Aids for Night Carrier Landings" by G. E. Rohl and J. E. Cowling.

6020 "A Study of Autophobic Liquids on Platinum by the Contact Potential Method" by C. O. Timmons and W. A. Zisman.

6033 "The Sulfate Cycle for Carbon Dioxide Removal and Oxygen Generation" by A. L. Pitman and S. T. Gadomski.

6035 "A Force-Area Study of Mixed Films of Trypsin and Ovomucoid" by J. D. Bultman and J. M. Leonard.

6038 "Proposed Phase Diagram for the System Magnesium Oxide—Vanadium Pentoxide" by A. J. Pollard.

6039 "Hydrophobic and Oleophobic Fluoropolymer Coatings of Extremely Low Surface Energy. Properties and Applications" by Marianne K. Bernett and W. A. Zisman.

6040 "Catalytic Combustion of Nuclear Submarine Atmospheric Contaminants" by J. G. Christian and J. E. Johnson.

6047 "Filament-Winding Plastics. Part 1—Molecular Structure and Tensile Properties" by J. R. Griffith and F. S. Whisenhunt, Jr.

6048 "Morphology of PbO_2 in the Positive Plates of Lead Acid Cells" by Jeanne Burbank.

6050 "Electrolytic Cell for X-Ray Diffraction Studies of Electrode Phenomena" by C. P. Wales and Jeanne Burbank.

6051 "The Solubility of Columbium-1% Zirconium in Sodium by Activation Analysis" by T. A. Kovacina and R. R. Miller.

FIGURE 9 - Sample Page of Section on Index of Unclassified Reports, Report of NRL Progress, January 1965

unnecessary details to help them obtain the over-all picture. Many research managers are not getting the kind of information they need. To produce satisfactory reports for management, authors must write effectively and the formats of the reports must be effective. Guidelines for authors abound, but it is agreed that authors should write clearly, should write for the intended reader, and should concentrate upon the objective of the writing. Guidelines for preparation of reports also abound. There is no one best format for all reports; they should be patterned after the needs of the reader. A current narrative summary-type report from a government research laboratory has been used as an example to show some of the characteristics of an effective report.

CHAPTER III

FIELD SURVEY

Survey Materials

It was planned that the field survey of nine National Aeronautics and Space Administration Field Centers be accomplished in two phases. Phase I required a visit to each center and discussions about the characteristics of the center's research documentation system with persons responsible for management and coordination of the center's research program. Phase II required that selected management personnel in each center provide written answers to questions about the effectiveness of the research documentation system in their center. Phase II did not entail an interview with each person queried. Instead, a printed questionnaire was sent to the management personnel chosen to participate, and the questionnaire was completed at the participant's convenience.

In order that data from each center could be produced for meaningful comparison and analysis, a standard survey form was prepared for the personal discussions in Phase I. The form contained a series of questions about the operations of the research documentation system in the center. The form is illustrated in Figure 10. The questions were categorized into four groups:

Form Used in

SURVEY OF RESEARCH DOCUMENTATION

IN NASA CENTERS

(Phase I)

I. Reviews or Presentations

1. Do you conduct any scheduled (on a regular or irregular basis) reviews of the progress and accomplishments of your research work?

   If so, how often?

   Who coordinates them?

   Who makes the presentations?

   Who attends?

   Are the reviews aimed at mangement level or technical level?

   Are the reviews primarily for Center personnel or for outsiders (e.g., Headquarters personnel)?

2. How often do Headquarters Program Managers visit for a review of your work?

   What kind of review is made (e.g., formal presentation or informal visits with task supervisor)?

II. Physical Displays

1. Does the Center generate any physical displays to show accomplishments?
2. If so, are they on permanent display or are they shown only on special occasions?
3. If there are displays, is there a coordinator for coverage of all research in the Center?

-continued-

III. Publications

1. How many of the following are produced each year by your Center, and how many of these cover research?
   a. NASA publications (kinds)
   b. Open literature publications
   c. Symposia papers
2. Do you produce any special reports dealing specifically with the Center research programs?

   Are they primarily for internal or external use?

   Are they aimed at management level or technical level?

IV. Documentation of Individual Tasks

1. Is there a central repository for documentation on all research tasks? If so, where?

   What kind of documentation is maintained on each task (e.g., task request, contract and/or contractor reports, milestone charts, progress reports)?

   What has your experience shown to be the most important uses for this type of documentation?
2. Is Automatic Data Processing used in your research management system?

   If so, what kind of data is included?
3. How often and in what form do research task technical supervisors report on the progress of their tasks?

FIGURE 10 - Form Used in Survey of Research Documentation in NASA Centers

I. Reviews or Presentations

II. Physical Displays

III. Publications

IV. Documentation of Individual Tasks

Each of these four groups of questions relate to distinct types of research documentation used in NASA Field Centers. The types of documentation in the Reviews or Presentations group and in the Physical Displays group belong to the general category Oral and Visual documentation shown in Table I. The types of documentation in the Publications group and in the Documentation of Individual Tasks group belong to the general category Written documentation shown in Table I. Each of the types of research documentation found in NASA Field Centers will be discussed briefly.

The Reviews or Presentations grouping includes such specific types of documentation as formal reviews, informal reviews, symposia, and conferences. Formal reviews may cover formulation of the program from a technical standpoint, allocation of funding and manpower, summarization of progress and accomplishments, solving problems, and planning for future efforts, among other topics. Formal reviews are most often held for the center management,or for NASA Headquarters management, or possibly for both management groups together. As described in the section entitled Kinds of Documentation, formal reviews usually follow a planned agendum and the speakers have their formal presentations well prepared.

Informal reviews are held for the purpose of covering the same topics that formal reviews may cover, but informal reviews usually have fewer persons in attendance, and presentations are usually made without elaborate preparations. Informal reviews are most often held at the request of a member of the center management, a member of NASA Headquarters management, or research personnel themselves.

Symposia in NASA Field Centers are held mainly to present information on the technical and scientific progress and accomplishments of the research program to interested attendants. Some symposia are designed specifically for technical and management personnel of the center; some are designed for personnel of the center as well as for personnel of NASA Headquarters and other NASA Centers; some are designed for outsiders, such as contractors and agencies of the Department of Defense, as well as for personnel of other NASA installations. One of the missions of NASA is to disseminate the information generated from the agency's space programs; the use of symposia is one means to accomplish this.

Research conferences in NASA Field Centers are generally held for purposes of exchanging information, obtaining decisions, or solving problems related to the research program. They are similar to formal and informal reviews in that information on the research program may be exchanged and decisions regarding the program may be made, but they differ in that the topics discussed are not usually formally presented by speakers. Instead, the chairman may call upon different attendants or they may participate voluntarily. Broadly speaking, the proceedings of a review are planned to a greater extent than the proceedings of a conference. Also, attendance at conferences is usually limited to invited persons who are likely to participate in the proceedings or who have a recognized need to know about the proceedings and results of the conference. The attendance at reviews is not so restricted and the size of the audience is often larger; often invitations to formal reviews are made by general announcements rather than by specific invitations. Conferences in NASA Field Centers are often held with attendants coming from only within the center, although many conferences are held to meet with persons from other NASA installations, or from outside of NASA.

The Physical Displays grouping includes such specific types of documentation as actual displays of research equipment, items produced as a result of research, photographs or drawings of research facilities and the work under way, working models, charts showing research progress, and other items of a similar nature. The displays may be of a permanent kind, always set up and available for visitors, or they may be of a special nature, set up for a specific event or to tell a specific story and then dismantled or put in temporary storage for future use. Physical displays are used in NASA Centers primarily for viewing by center management, official visitors, or the general public; for symposia; for reviews and conferences; and for shipment to other locations for temporary use. Physical displays in NASA Centers have proved to be an effective means of transmitting research information to practically everyone desiring it.

The Publications grouping contains specific types of written documentation such as technical reports and management report. In NASA Field Centers, a variety of technical and management reports are written and published. These include formal reports such as NASA Technical Reports, NASA Technical Notes, NASA Technical Memorandums and NASA Special Publications. Each of these kinds of reports will be described briefly (12):

> NASA Technical Reports include significant results of outstanding quality and are considered to be complete, comprehensive, and lasting contributions to existing knowledge. They are... unclassified, and are automatically given substantial distribution.
>
> NASA Technical Notes include information which is less broad in scope than that in Technical Reports, but they are nevertheless of importance as contributions to existing knowledge. Technical Notes are of immediate interest in continuing areas of research but lack the same importance, permanence, or completeness ascribed to the Technical Report. They are.... unclassified, and have no distribution limitations.
>
> NASA Technical Memorandums include information that requires or warrants limited distribution either because of security classification or because of

> unconfirmed or preliminary results. ... Some of these reports may be unreferenceable because of public unavailability.
>
> NASA Special Publications present information derived from or of value to NASA activities but not necessarily reporting the results of individual NASA-programmed scientific efforts. Special publications include conference proceedings, monographs, data tabulations, handbooks, sourcebooks, and special bibliographies.

NASA Technical Reports and NASA Technical Notes logically belong to the technical report type of documentation as shown in Table I and as defined in the section Kinds of Documentation. NASA Technical memorandums could belong to either the technical report or the management report types of documentation, depending upon the subject and the format of the report. NASA Special Publications belong to the management report type of documentation.

In addition to the formal NASA reports just described, a variety of informal reports is used in different NASA Field Centers. Most of these are designed to fill specific needs in given field centers. Informal reports may contain only technical information or they may contain non-technical information such as that concerning manpower, funding, schedules, or program status. Thus, informal reports could belong to either the technical report of the management report types of documentation. Informal reports are usually not distributed outside of the field center in which they originate.

In many NASA Field Centers, special reports are published to show the status, the progress, or the accomplishments of the research program. These program reports may be formal or informal, but their purpose is to present an over-all picture of the research program, or a selected portion of it, at a given time. Usually each individual research task is discussed; the cumulative collection of written discussions on all tasks constitutes the program report which is called a technical progress summary report. The frequency of publication is normally dictated by the desires of the field center management or by requirements of NASA Headquarters. Research in NASA Field Centers is funded from NASA Headquarters, and the technical progress summary report is one method by which Headquarters managers keep abreast of progress in the field centers. These reports on the research program are sometimes distributed to other NASA Field Centers to provide for an exchange of information.

The grouping Documentation of Individual Tasks refers to that documentation covering only a single research task, as contrasted to documentation covering the whole research program. Individual task documentation may be in the form of a management file on the task, funding or manpower reports on each task, a technical or management progress report on the task from the principal investigator, or a final technical report on the task by the principal investigator. Individual task documentation is most useful when research managers want to learn the details of a given task, rather than to look at the entire research program.

The Phase I interview form was designed to obtain information about all of the foregoing types of research documentation used in the NASA Field Centers which were surveyed. It was intended that the interview questions be unambiguous and uncomplicated, and capable of being answered by fairly short and simple statements. Furthermore, it was intended that the terminology used should be familiar to all persons interviewed. Finally, it was intended that the entire interview not take longer than two or three hours, so as not to impose too much upon the person being interviewed.

The Phase II management questionnaire, which is illustrated in Figure 11, was not designed for use in personal interviews, as the Phase I interview form was, but was designed so that individual managers could write in answers to the questions without assistance. The purpose of the Phase II management questionnaire differed from that of the Phase I interview form. The Phase II questionnaire was designed to provide information about the *adequacy* of the documentation system; the Phase I interview form was designed to provide information about the *characteristics* of the documentation system.

The Phase II questionnaire was also intended to be unambiguous and uncomplicated, and capable of being completed with short and simple answers. The number of questions was kept to a minimum, so

MANAGEMENT QUESTIONNAIRE CONCERNING DOCUMENTATION OF THE CENTER RESEARCH PROGRAM

(Phase II)

1. How well informed do you consider yourself to be on the research program in the Center?

   Adequately informed, no improvement needed.

   Fairly well informed, but some additional information would be of value

   Poorly informed, much additional information is needed

2. If you consider yourself to be "fairly well informed" or "poorly informed" (question 1), on what aspects of the research program would you like to be better informed?

3. Considering the information on the research program which you now receive, what specific type do you personally find to be of most value (e.g., narrative summary reports, status charts, oral presentations, NASA technical reports, etc.)?

4. Considering the present over-all research documentation system in the Center, rather than considering your personal needs, do you have any recommendations for improving the system so it will be of greater value to the majority of Center management personnel?

5. Leaving the Center research documentation system for the moment, can you think of any management review techniques that you have found to be particularly useful in your position?

6. Additional comments (if desired)

____________________ Date

____________________ Name and Title (Answer only if you so desire)

FIGURE 11 - Management Questionnaire Concerning Documentation of the Center Research Program

that participants would not be dismayed by a lengthy and complicated form. The contents of the questions were chosen with the dual objectives that the answers should provide useful information to the NASA Field Center itself, and should provide data for the broader research documentation survey described here. It was hoped that by providing useful information to the field center personnel about the adequacy of their own documentation system, they would willingly participate in the use of this questionnaire.

This section has described the materials used in the field survey of nine NASA Field Centers. The survey was divided into two phases. Phase I entailed a visit to each field center and discussions with personnel responsible for the management of the center's research program to determine the characteristics of their documentation system. A survey form was designed for this purpose and has been described. Phase II required that selected management personnel in the field centers write in answers to questions about the adequacy of their documentation system. A questionnaire was designed for this purpose and has been described.

Survey Procedure

In this section, the procedures used in the field survey will be described.

Before visiting the nine NASA Field Centers, it was necessary for the writer to establish a point of liaison in each center. There is an individual designated as the Inter-Center Research Coordinator in each center with the function of promoting the exchange of research information with other NASA Field Centers. Each Inter-Center Research Coordinator was informed by telephone of the survey and its purpose, and was told that detailed information would follow by letter. A letter describing the survey was then sent to each coordinator. Copies of the personal interview form (Figure 10) used in Phase I and copies of the management questionnaire (Figure 11) used in Phase II accompanied the letter. The letter explained that the questions on the Phase I interview form were to be covered during discussions at the time of the visit. The Inter-Center Research Coordinator was asked to arrange interviews with the persons in his center best qualified to discuss the Phase I topics. The letter further explained that it was desired that the Phase II questionnaire be distributed to selected management personnel in the center.

When the most appropriate times for the visits were established, the trips to each center were undertaken. One day was spent at each center. The Inter-Center Research Coordinator was usually the first person contacted. Thereafter, interviews were held with the persons, or person, involved in the Phase I portion of the survey. All questions on the Phase I personal interview form were discussed and answered. Little difficulty was encountered in obtaining complete and accurate information. All persons interviewed were cooperative and were interested in the survey. The interest stemmed in large part from their desire to know how their own research documentation system compared with those in other NASA centers. It was promised that a summary of the survey results would be sent to all centers. With the collection of complete and accurate information from all of the nine NASA Field Centers, the Phase I portion of the field survey was considered to be satisfactorily accomplished.

The Phase II portion of the survey was not as successful as the Phase I portion. Some resistance was encountered in several of the field centers when it came to the distribution of the management questionnaires, even though it was intended that the data obtained would be of value to the center itself. Some typical comments are paraphrased as follows:

> Even though the results would be of value, we cannot expect our management people to spend time on the questionnaire. The urgency and magnitude of current problems requires their full time.
>
> We cannot ask our management personnel to take time to fill out a form from which they will not personally benefit.

> The answers would not provide useful information to us. We already know how our management people feel about the adequacy of our research documentation system.
>
> We know that we have a documentation system which is adequate for our management. There is no need to ask them about it.

Generally speaking, there was an evident willingness among center research program managers to devote some of their own time to participate in the Phase I portion of the survey, but there was a reluctance from some of them to obligate other management personnel for the Phase II portion. Where resistance was encountered to the Phase II portion of the survey, the matter was not pushed beyond the point of cordial persuasion that the values obtained would outweigh the inconveniences entailed. When it was evident that a center's representatives definitely did not want to distribute the Phase II questionnaire, the matter was dropped.

In four of the nine NASA Field Centers, however, there was a willingness to participate in the Phase II portion of the Survey. Consequently, the questionnaires were distributed to appropriate management personnel in these four centers. Those questionnaires that were answered were collected and sent to this writer. A total of forty questionnaires were collected from the four field centers that participated in Phase II of the survey. The number of questionnaires from any one center ranged from a low of 3 to a high of 19. Further data will be given in the next section.

In this section, the procedures used in the field survey have been described. A visit was made to each of nine NASA Field Centers. Personal interviews were held with persons responsible for management of the centers' research programs to obtain answers to questions on the Phase I interview form; complete and accurate data were obtained from all centers. Only four of the nine centers elected to participate in Phase II of the survey; in these four centers, the questionnaires were completed by selected management personnel.

Summarization of the Data

In this section, the data obtained in Phase I of the field survey will be summarized first. Thereafter, the data obtained in Phase II of the field survey will be summarized.

For identification purposes, each of the nine NASA Field Centers will be designated by a capital letter, e.g., Center A. Each field center will be referred to by its letter designation throughout the remainder of this report. The nine field centers differ in size and in primary mission, as shown in Table II. The personnel strength of a center is a handy indication of its size; Table II shows that the centers range in size from less than 1000 persons to more than 7000 persons. The primary mission of a center is research or it is development. In those centers where research is the primary mission, it can be logically assumed that management will have more time to follow the

TABLE II

MISSIONS AND SIZES OF NASA FIELD CENTERS

Center	Primary Mission	Size*
A	Research	Medium-Small
B	Development	Small
C	Research	Medium-Large
D	Research	Medium-Large
E	Development	Medium-Large
F	Development	Medium-Large
G	Development	Medium-Large
H	Development	Medium-Small
J	Development	Large

*Sizes based upon personnel strength:

Small	less than 1000 persons
Medium-Small	2200-3700 persons
Medium-Large	4200-5000 persons
Large	more than 7000 persons

research efforts than in the development centers, where management must devote considerable attention to the development projects. In development centers, the primary efforts may be upon development of manned or unmanned space payloads, space launch vehicles, ground launch facilities, experimental aircraft, related items, or a combination of these. In development centers, much of the research work is in direct support of development projects, and is closely related to the development projects. In research centers, by contrast, much of the research work is of a more fundamental nature, and may support future development projects rather than well-defined current development projects. These basic differences between research centers and development centers should be borne in mind when comparing research documentation systems of the various centers.

The Phase I survey form (Figure 10) contained a series of questions about the operations of the research documentation systems in the field centers. The questions were categorized into four groups. The data from Phase I of the survey will be summarized in the same fashion.

The Phase I data concerning reviews and presentations are summarized in Table III. The first column in this table identifies the field centers in the same fashion as they were identified in Table II. The second column lists the presentations prepared specifically for the management of the center. It may be seen that all of the field centers

TABLE III

RESEARCH PROGRAM REVIEWS AND PRESENTATIONS IN NASA FIELD CENTERS

Center	Presentations for Center Management	Formal Program Reviews for Headquarters*	Irregular Reviews for Individual Headquarters Managers	Other Reviews or Presentations
A	None	Semiannually	Semi-formal and informal	None
B	Semiannual formal review	None	Informal	None
C	Monthly research department conferences	None	Semi-formal and informal	Irregularly held large technical meeting for outsiders
D	Weekly research managers conferences	Annually	Informal	None
E	Semiannual formal review	Annual large technical symposium (see last column)	Informal	Annual large technical symposium open to other NASA centers
F	Monthly research symposia	Semiannually	Semi-formal and informal	None
G	Monthly research symposia	Quarterly	None	None
H	Annual formal review	Quarterly	None	None
J	Monthly research symposia (see last column)	Quarterly	Semi-formal and informal	Monthly large research symposia open to outsiders

*Program reviews for Headquarters also serve center management except one have some means of internal documentation to keep management abreast of developments and progress in the research program. The third column shows the formal research program reviews held for NASA Headquarters. In all cases, these Headquarters program reviews also serve as a review for the center's own management. The frequency of these formal reviews, and the kind of material presented in the reviews, is most often dictated by the Headquarters offices that fund the research work in the field centers. In some cases, Headquarters offices insist upon a review every three months (quarterly). In other cases, Headquarters offices do not require a review at all. In Center E, there is an annual two-day technical symposium designed to give Headquarters and center management a comprehensive view of all research being performed in the center. The fourth column indicates whether individual research program managers in Headquarters visit the field centers for personal reviews of the work they fund, and whether the reviews are informal or semi-formal. These personal reviews are held at irregular intervals, usually when most convenient to the individual research program managers. It may be seen that seven of the nine field centers conduct these personal reviews for Headquarters individuals. The fifth, and last, column lists the reviews and presentations for outside attendants, in addition to center management and Headquarters personnel. Center C holds a large "open house" type of technical meeting about once every two years to acquaint other NASA installations, Department of Defense agencies, and NASA contractors with the current state of the art in the research fields in which the center engages. Center E invites other NASA Field Centers to attend its annual technical symposium, although the symposium was originally planned solely for attendants from NASA Headquarters and the center itself. Center J invites NASA Headquarters, other NASA Centers, Department of Defense agencies, and NASA contractors to attend its monthly research symposium, which was originally designed to keep the center's management abreast of research accomplishments.

The Phase I data concerning physical displays is summarized in Table IV. It may be seen that only two NASA Field Centers, Center F and Center J, maintain a permanent central display area to show the research accomplishments of the center. Three other centers, C, D, and G, maintain displays at scattered locations in the center. The other four centers do not maintain permanent displays, but generate displays as needed for special occasions. These special occasions include events at the center such as open-house, national technical society meetings, visits by distinguished persons, or similar events. In addition, NASA Headquarters managers often request the field centers to furnish physical displays illustrating research accomplishments, so that they can be used as examples of the benefits obtained from research when requesting further research funding. Generally speaking,

TABLE IV

PHYSICAL DISPLAYS ON RESEARCH IN NASA FIELD CENTERS

Center	Displays
A	No permanent displays. Special displays generated as needed.
B	No permanent displays. Special displays generated as needed.
C	Displays maintained at various locations; used as needed for special events.
D	Displays maintained at various locations; used as needed for special events.
E	No permanent displays. Special displays generated as needed.
F	Permanent displays maintained at central location. Special displays generated as needed.
G	Displays maintained at various locations; used as needed for special events.
H	No permanent displays. Special displays generated as needed.
J	Permanent displays maintained at central location. Special displays generated as needed.

all NASA Field Centers, with the exception of Centers F and J, wait until a specific need arises before physical displays are prepared. After use, the displays are usually stored or set up at random locations in the centers, and are maintained for possible future use. By contrast, Centers F and J undertake a continuing effort to prepare and maintain up-to-date physical displays of research accomplishments, so that they are available for continuous display and as needed on special occasions. At Center J, the display was not fully operational, but was in a state of final preparation at the time of the survey.

The Phase I data concerning publications are summarized in Table V. This table describes special research program publications dealing specifically with the center's over-all research program, or some selected part of the over-all program. These special publications are intended to give a broad, comprehensive summary picture of the research under way, rather than to give complete details on any specific research task or research project. Two of the centers, B and D, do not prepare special publications on the research program, and Center C publishes only the proceedings of its large "open-house" type of technical meeting held about once every two years. The other six field centers prepare special publications on their research programs at various intervals; the semiannual technical progress summary report is preferred by four of the centers. Center J is the only center which distributes its special publication to other NASA Field

TABLE V

PUBLICATIONS ON RESEARCH PROGRAMS IN NASA FIELD CENTERS

Center	Publications
A	Semiannual technical progress summary report on overall program
B	None
C	Proceedings of irregularly held large technical meetings
D	None
E	Quarterly technical progress summary report on selected parts of overall program
F	Semiannual technical progress summary report on overall program
G	Semiannual technical progress summary report on part of overall program
H	Annual technical progress summary report on overall program
J	Semiannual technical progress summary report on overall program. Series of technical reports based on monthly research symposium

NOTE: All Centers publish NASA formal reports (Technical Reports, Technical Notes, Technical Memorandums, and Special Publications) covering various aspects of the research program.

Centers; all other centers restrict distribution to their own center and to NASA Headquarters. The survey showed that individual researchers in all NASA Field Centers published NASA formal reports, journal articles, and papers presented at technical meetings and symposia. However, it was not possible to obtain accurate and meaningful numbers of these kinds of publications from all of the centers. In some centers, records were not kept on publications of journal articles and symposia papers. Also, in most centers it was impossible to distinguish between those technical reports dealing with research and those dealing with development work. Therefore, in the summarization of the data concerning publications, attention has been centered upon the special over-all research program publications as shown in Table V.

The Phase I data concerning documentation of individual research tasks has not been summarized in a table because it did not lend itself to standardization. The survey disclosed that in all NASA Field Centers there is a central management file, or files, containing programming, funding, and manpower information about the research tasks which compose the research program of the center. However, the locations of the files, and the kinds of information kept in them, were different in all centers, and were dependent upon the unique organization of each center and the responsibilities of various organizational elements. A comparison of the organizational differences will not be undertaken. Instead, it may be generalized that management files are used in each center, and that their locations and contents vary with the needs of the individual centers. The survey also showed that none of the field centers have a fully operable Automatic Data Processing system designed specifically for the management of the center's research program, although Center J has made fair progress in establishing such a system.

The data from Phase I of the survey, which have just been summarized, dealt with the characteristics of research documentation systems in the nine NASA Field Centers. Phase II of the survey provided information about the adequacy of these documentation systems in the field centers. The Phase II data will now be summarized.

As stated in the preceding section, only four of the nine NASA Field Centers, A, F, G, and J, participated in Phase II of the survey. A total of 40 responses was obtained from the four centers: three came from Center A; nineteen came from Center F; four came from Center G; fourteen came from Center J. These responses were submitted from all levels of middle and lower management; none came from top management.

The Phase II data should not be considered as true random data applicable to all of the nine NASA Field Centers. In reality, the data are biased because of the following factors:

(1) Only four of the nine field centers participated.

(2) The number of responses from the field centers varied widely.

(3) Not all levels of management participated, and in some cases the organizational level of the participant could not be ascertained.

(4) The responses are often subjective opinions rather than objective statements.

With these limitations in mind, the Phase II data will now be summarized.

The Phase II management questionnaire (Figure 11) consisted of five questions and a blank space for comments. The first question requested the participant to indicate how well informed he considered himself to be on the research program of his center. The responses are summarized in Table VI. It can be seen that in only one field center, F , do the participants consider themselves to be adequately informed. Slightly over one-half of the total participants considered themselves to be fairly well informed, and one-fourth considered themselves to be poorly informed.

The second question requested the participant to identify those aspects of the research program on which he would like to be better informed, if he did not consider himself to be adequately informed already. The responses are summarized in Table VII. There were 28 valid responses to the question. Of these, eleven participants were most interested in learning more about research related to their own work. Ten persons indicated a preference to obtain a broad view of the entire research program, i.e., to learn about research in fields other than their own. Four persons were most interested in learning about the goals and objectives of research, and where the results of research would be applied. Two persons indicated a desire to learn more about the research work contracted by their center to out-of-house contractors. One person indicated a desire to learn more about the research facilities existing in his center. Four persons gave responses not related to the question, and twelve persons, including the nine who considered themselves to be adequately informed, did not answer the question. The total number of responses was greater than the total number of participants because some participants responded with more than a single answer.

TABLE VI

RESPONSES TO SURVEY QUESTION "HOW WELL INFORMED DO YOU CONSIDER YOURSELF TO BE ON THE RESEARCH PROGRAM?"

Responses	Number of Responses				
	Total	Center A	Center F	Center G	Center J
Adequately Informed	9	0	9	0	0
Fairly Well Informed	21	3	7	2	9
Poorly Informed	10	0	3	2	5

TABLE VII

RESPONSES TO SURVEY QUESTION "ON WHAT ASPECTS OF THE RESEARCH PROGRAM WOULD YOU LIKE TO BE BETTER INFORMED?"

Response	Number of Responses				
	Total	Center A	Center F	Center G	Center J
On areas closely allied to own work	11	1	5	0	5
On over-all program (including areas other than own)	10	2	3	0	5
On goals or applications of research tasks	4	0	1	1	2
On out-of-house (contracted) research	2	0	1	0	1
On research facilities in center	1	0	0	0	1
Responses not related to question	4	0	1	1	2
No response	12	0	9	2	1

The third question asked the participant to identify the most valuable specific type of information on the research program which he receives. The responses are summarized in Table VIII. A total of 60 valid responses were received, with some participants naming two or three types of information. A total of 24 responses indicated that narrative summary reports were one of the most valuable types of documentation. A total of 15 indicated that oral presentations were one of the most valuable types. A total of 12 responses showed that technical reports were considered one of the most valuable. Two replies indicated that status charts were among the most valuable. A total of seven replies were placed in the miscellaneous category. Some of these miscellaneous replies were:

> Discussions with individual research people (Center A)
>
> Program funding summaries (Center G)
>
> Semiannual reports to NASA Headquarters (Center F)
>
> Semiannual review of research and advanced development (Center F)
>
> Reports listed in the Library Additions [Library Acquisition List] (Center F)
>
> Monthly progress report [of my own division] (Center F)

The fourth question of Phase II of the survey asked the participants to make recommendations for improving the present research documentation system of their center so that it would be of greater value to the majority of center management personnel. The responses

TABLE VIII

RESPONSES TO SURVEY QUESTION "WHAT TYPE OF INFORMATION ON THE RESEARCH PROGRAM WHICH YOU NOW RECEIVE DO YOU CONSIDER OF MOST VALUE?"

Responses	Number of Responses				
	Total	Center A	Center F	Center G	Center J
Narrative summary reports	24	3	14	1	6
Oral presentations	15	2	5	1	7
Technical reports	12	0	7	0	5
Status charts	2	0	1	0	1
Miscellaneous (each response different)	7	1	5	1	0
Responses not related to question	3	0	0	1	2
No response	2	0	1	1	0

are summarized in Table IX. Eight participants recommended that there be an annual summary of the over-all research program. This was the only recommendation cited by more than a single participant. Fourteen responses were categorized as miscellaneous because all were different. Some of the miscellaneous responses were:

> I feel that a weekend retreat type meeting of the Division staffs would be extremely helpful. Each division could make a summary report on its activities. (Center G)

> There is....a need for a more efficient document exchange system between NASA Centers. (Center F)

> There should be more effort to correlate related activities throughout the Center so that personnel in one division are better informed of what the responsibilities of other divisions are in overlapping areas.... (Center F)

> [Narrative summary reports] should bear the author's name for the individual contribution so that questions could be answered. (Center F)

> [Narrative summary reports should contain] long articles reporting completed research instead of serial reporting. (Center F)

> Review the existing documentation formats [to] determine that these are adequate or not. Publish guidelines...for each type of document for the benefit of authors. (Center F)

> ....the principal problem is that there is too much material to cover adequately and yet it has already been pretty well condensed. (Center F)

> Reduce paper volume in all documents that are determined to be necessary by careful design of the format....Standardized formats for all intra- and inter-Center reports — especially for those to Headquarters. (Center F)

> Better means are needed to assure that reports reach interested individuals. (Center J)
>
> Much of the material...just doesn't filter down to the working level. (Center J)
>
> Reduce overlapping technical reporting requirements. Avoid multiple and rapid response exercises. (Center J)
>
> I would like to receive a brief summary memo on a quarterly basis giving title of each research task, task number, [technical] supervisor and organization, and current FY [Fiscal Year] funding requested and approved by program area. (Center J)

Thirteen participants replied that they did not have any recommendations for improving the system, and six participants gave responses which were not related to the question.

TABLE IX

RESPONSES TO SURVEY QUESTION "DO YOU HAVE ANY RECOMMENDATIONS FOR IMPROVING YOUR CENTER'S RESEARCH DOCUMENTATION SYSTEM?"

Responses	Total	Number of Responses Center A	Center F	Center G	Center J
Annual summary of of over-all program	8	1	2	1	4
Miscellaneous (each response different)	14	0	8	1	5
Reply "No"	13	2	9	0	2
No response or response not related to question	6	0	1	2	3

The fifth question of Phase II of the field survey requested the participant to name management review techniques found to be particularly useful. Eleven participants responded affirmatively, as follows:

> Program reviews conducted for Headquarters Program people serve a valuable function. (Center A)
>
> Branch meetings to review research program and progress. (Center A)
>
> Pre-review prior to NASA semiannual reports [to Headquarters]. (Center F)
>
> Division design reviews are very beneficial. (Center F)
>
> I like the [center's] yearly review [report]. (Center F)
>
> Monthly review – by reports – of task status. (Center F)
>
> I personally rely primarily on reviewing and approving a clearly defined set of [research] tasks at the beginning of the year, and following progress by means of our monthly [divisional] progress reports. (Center F)
>
> I think the periodic progress report... is useful to [make] the project engineers keep themselves abreast of their various...projects. (Center J)
>
> Periodic oral progress reports. (Center J)
>
> Monthly or periodic review of progress and status reports at the working level with management in attendance to summarize written reports and to discuss technical or management problems that have arisen. (Center J)
>
> The [monthly research symposia] .... (Center J)

The sixth, and last, item on the Phase II management questionnaire asked for additional comments from the participants. This item was not completed by most participants, but four valid comments were received:

> The main problem associated with staying adequately informed is that of sifting out the useful reports from the almost overwhelming volume of paper that one receives each day. (Center F)
>
> I have no difficulty in obtaining information from existing documentation whenever it is needed. I do not review all of the [center's research] activities because of the press of other business. (Center F)
>
> Most of the lack of information is my own fault. There doesn't seem to be enough time to attend these reviews or read much documentation because of the press of everyday work. (Center J)
>
> A preview of planned [development] projects is needed in order to better plan research in [my work area] . (Center J)

In this section, the data obtained in Phases I and II of the field survey of nine NASA Field Centers have been summarized. Phase I data were obtained from all of the nine field centers, and are fairly complete. Phase II data were obtained from only four of the nine field centers, and are biased because of several factors. However, the data are still valuable and revealing.

CHAPTER IV

INTERPRETATION OF SURVEY RESULTS

Differences in Documentation Systems

The field survey data as presented in the preceding section showed distinct differences between the research documentation systems which exist in the nine NASA Field Centers. These differences will be brought into sharper focus in this section. First, the system in each of the centers will be summarized. Thereafter, some of the factors which influence the kinds of system used in the centers will be discussed.

Center A is a medium-small sized center, employing between 2000 and 3700 persons. Its primary mission is research rather than development. Research work makes up a large part of the center's activities. Most of the research is done inhouse, with relatively little contracted out-of-house. Center A does not hold any reviews or presentations on its research program solely for the management of the center, but it does conduct two formal reviews each year on part of the center's research program for NASA Headquarters, and these reviews serve the center management also. Center A holds semi-formal and informal reviews on selected parts of the center's research program for individual program managers from NASA Headquarters on an irregular basis. It does not hold any reviews or presentations for outsiders. Center A does not maintain any permanent physical displays of its research work but generates displays as needed for specific special occasions. The center does publish a semiannual technical progress report on its over-all research program, and this report is distributed among management personnel of the center and to NASA Headquarters.

Center B is a small center, employing less than 1000 persons. Its primary mission is development, and its research work is closely related to the development projects of the center. The amount of research work is considerably less than in most of the other centers. The small size of the center and the small size of the research program promote informal internal communications about research work, and thus reduce the need for more formal documentation. Center B holds formal reviews of its research program twice each year for center management, but does not hold formal research program reviews for NASA Headquarters. When individual program managers from NASA Headquarters visit the center, informal reviews are arranged to show the progress and status of research work. Center B does not hold any reviews or presentations for outsiders. It does not maintain any permanent physical displays of its research work, but prepares displays as needed for specific special occasions. The center does not publish any reports on its research program, but progress on specific research tasks is often discussed in reports on the development projects which are supported by the research.

Center C is a medium-large center, employing between 4200 and 5000 persons. Its primary mission is research, and research work constitutes a large part of the center's activities. Most of the research work is performed inhouse, and relatively little is contracted out-of-house. Center C holds monthly research department conferences for the purpose of hearing presentations on various research projects; members of the center's management attend and are thus kept abreast of research progress. The center does not hold any formal research program reviews for NASA Headquarters. However, when individual program managers from Headquarters visit the center, semi-formal and informal reviews are held to cover the research projects of interest. Center C holds a large "open-house" type of technical meeting about once every two years to make outsiders aware of the work and accomplishments in the research fields in which the center engages. Physical displays are prepared especially for the "open-house" meeting and for other occasions, and these displays are then usually set up for operation at various locations in the center. They are used on following occasions as much as possible. The center publishes the proceedings of the "open-house" technical meeting, and distributes them widely to other NASA installations, agencies of the Department of Defense, and to firms in industry.

Center D is a medium-large sized center, employing between 4200 and 5000 persons. Its primary mission is research, and research work makes up a large part of the center's activities. Most of the research is done inhouse, and relatively little is contracted out-of-house. The center holds briefings on selected research projects each week to keep management aware of their status. Center D holds a formal technical review of a major part of the over-all research program once each year for NASA Headquarters; center management also attends. When individual program managers from Headquarters visit the center, informal reviews are held on the research projects of interest. The center does not hold any reviews or presentations for outsiders. Center D maintains physical displays of its research work in an operating condition at various locations in the center, and utilizes them or generates new ones as needed for special occasions. The center does not publish any special reports on its over-all research program.

Center E is a medium-small sized center, employing between 2200 and 3700 persons. Its primary mission is development, although it has a fair-sized research program. The research work is closely related to development projects, but the press of development work makes it necessary to contract most of the research work out-of-house. Center E holds a formal technical and budgetary review of its over-all research program twice each year for the center's management. Each year there is a two-day technical symposium for the purpose of informing center management, members of NASA Headquarters, and members of other NASA installations of the progress and accomplishments of the center's programs in research and in development. When individual program managers from NASA Headquarters visit the center, informal reviews are arranged to cover the research projects of interest. The center does not maintain any permanent physical displays of its research work, but it does prepare displays as needed for the annual technical symposium and other special occasions. Center E prepares quarterly technical progress reports on selected projects in the research program; every project is covered one or more times in a year. These reports are for center management and for NASA Headquarters.

Center F is a medium-large sized center, employing between 4200 and 5000 persons. Its primary mission is development, although it has a large research program, largely in support of development projects. Much of the research work is done inhouse, but the press of development projects makes it necessary to contract a lot of the research out-of-house. Center F holds a monthly technical symposium to review selected research projects; members of the center's management as well as other center personnel attend. The center holds a formal review of the research program twice each year for NASA

Headquarters; center management personnel also attend. Semi-formal and informal reviews are held for individual Headquarters' program managers when they visit the center. There are no reviews or presentations held for outsiders. Center F maintains up-to-date physical displays of its research work in a permanent central location. These displays are utilized for special occasions, or other displays are generated if needed. The center publishes a technical progress report on its over-all program twice each year; it is distributed to center management, NASA Headquarters, and to other NASA Field Centers.

Center G is a medium-large sized center, employing between 4200 and 5000 persons. Its primary mission is development; its research program is of moderate size and is closely related to development projects. The growth of the research program has been restricted by the necessity to concentrate upon development projects. Center G holds a technical symposium each month for management personnel of the center; research projects are reviewed along with development projects. The center holds a formal research program review every three months for NASA Headquarters, with the frequency interval being dictated by Headquarters; only a limited number of the center management personnel attend if the review is held away from the center. Because of the quarterly review, individual program managers from Headquarters rarely find it necessary to visit the center for individual reviews. Center G does not hold any reviews or presentations for outsiders. Physical displays on some research projects, as well as on many development projects, are set up at various locations in the center and are used as much as possible in special events. The center publishes a technical progress report every six months on part of the research program; it is distributed to center management and to NASA Headquarters.

Center H is a medium-small sized center, employing between 2200 and 3700 persons. Its primary mission is development, and it has only a small research program. Most of the research work is contracted out-of-house. The center has an annual technical review of the research program for center management, and most of the out-of-house research contractors give their final technical presentations at the center so that members of the center management can attend. The center holds a formal research program review every three months for NASA Headquarters, but as with Center G only a few of the center management personnel attend when the review is often held away from the center. Individual program managers from Headquarters seldom find it necessary to visit the center for individual reviews. Center H does not hold any reviews or presentations for outsiders. The center does not maintain any physical displays on its research, but generates special displays as needed. The center publishes an annual report on the over-all research program; it contains technical and programming information and is distributed to members of the center's management.

Center J is a large-sized center, employing more than 7000 persons. Its primary mission is development, and research work constitutes a fairly small portion of the center's activities, although the research program is of substantial size. The research program consists largely of tasks supporting the center's development projects; much of the research work is contracted out-of-house. The center holds a monthly technical symposium to review selected parts of the research program; in the course of a year, the over-all research program is reviewed. These symposia are attended by center management and other center personnel, by members of NASA Headquarters and other NASA Field Centers, by members of Department of Defense agencies, and by NASA contractors. The center holds a formal research program review every three months for NASA Headquarters, and as with Centers G and H, only a few of the center management personnel attend when the review is held away from the center. Individual program managers from NASA Headquarters visit the center at irregular intervals for semi-formal or informal reviews on parts of the research program. Center J maintains up-to-date physical displays of its research work in a permanent central location. These displays are used for special occasions, and other displays are generated if needed. The center publishes a technical progress report on the over-all research program every six months; distribution is made to center management, NASA Headquarters, and other NASA Field Centers. The center also publishes a series of technical reports based upon the monthly technical symposia; distribution is made to center management, to NASA Headquarters and other NASA Field Centers, to agencies of the Department of Defense, to universities, and to NASA contractors.

Now that the system in each center has been described in some detail, some of the factors which influence the differences between the research documentation systems in the centers will be discussed.

One of the factors that influences the kind of documentation system used is the size of the center. It has already been mentioned that at Center B, which is the smallest NASA Field Center, the small size of the center and the small size of its research program promote informal communications about the research program, and thus reduce the need for more formal documentation. Center B, however, does hold an internal research program review every six months for center management. Table II shows that there are three centers of medium-small size, with personnel strengths between 2200 and 3700. These are Centers A, E, and H. It is interesting to note from Table III that Center A does not hold any internal reviews of its research program; Center E holds an internal review every six months, and Center H holds an internal review only once each year. By contrast, every one of the centers of medium-large (4200 to 5000 persons) and large (more than 7000 persons) size hold internal reviews for management on a monthly basis or more often, as shown in Table III. These centers are C, D, F, G, and J. It should be noted that the more frequent internal reviews held in the medium-large and large centers do not cover the entire research program, as they do in the small and medium-small centers. Thus, the survey data indicates that there is a definite correlation between the size of an organization and the kind and frequency of internal research reviews held for the management of the organization. It appears that as the size of organizations increase, the time interval between reviews decreases, and the portion of the over-all research program covered in each review decreases. In other words, management in the smaller organizations can assimilate information on the over-all program in infrequent formal sessions, whereas management in the larger organizations gets the information piecemeal in more frequent formal sessions. One possible explanation is that the informal documentation systems operate more efficiently in smaller organizations, and thus reduce the need for the formal documentation necessary in larger organizations.

Another factor that affects the kind of documentation system is the primary mission of the center. Table II shows that the primary mission of Centers A, C, and D is research, and that the primary mission of the remaining centers is development. During the visits to all centers, it was obvious that in the development centers management logically gave first attention to development projects, and less attention to the research program. In most of the development centers, the persons managing the research programs have found it necessary to rely rather heavily upon written summary-type research program progress reports to document the accomplishments of the research programs for their center management. This fact is illustrated in Table V, which shows that all of the development centers, with the exception of Center B, publish formal technical progress summary reports on parts or all of their research programs. The exception of Center B may be possibly explained by its small size and its effective informal communication system. Table V also shows that Center A is the only one of the three research centers that publishes a formal progress report on its research program. Centers C and D do not publish formal progress reports, and the survey indicated that the persons coordinating the research programs in these centers felt that their management was well enough informed about the research program so that formal progress reports were not necessary. Thus, the survey data indicated that there is a correlation between the primary mission of the center and the use of a formal summary publication on the research program. In research centers, the use of this kind of publication is the exception, but in development centers it is always used. A possible explanation is that a formal written document, which can be read whenever time is available, is a preferred means of communicating with managers who consider the subject matter of the document to be of less than first importance.

In conducting the field survey, it was sensed that several other factors influenced the kind of documentation system used in the various centers. These factors are somewhat tenuous, and data were not collected to substantiate or disprove their influence, but the impression was gained that they did have an effect upon the systems in some centers. The first factor was the size of the research program. One criterion for defining the size of the program is the amount of money spent in the program each year. This money originates from many sources, and it is extremely difficult to obtain absolute figures for the dollars spent in each center for any given year. There is a rough correlation between the size of the center and the amount of money spent in the research program, however, with the larger centers generally having the largest research programs. It has already been shown that in larger centers, internal reviews are held more frequently than in small centers, and these reviews cover a smaller part of the research program. It is possible that the large size of the programs in the larger centers makes it necessary for management to review them in digestible-sized increments, rather than to review the entire program as is possible with smaller programs in smaller centers. This observation, together with the fact that informal communication systems operate less efficiently in large organizations, may help to explain the more frequent, piecemeal reviews held in all of the medium-large and large NASA Field Centers.

The second somewhat tenuous factor concerns the age of the field centers. In the younger, more recently established NASA Field Centers, all of which have development as their primary mission, it was apparent that the research program was not as well entrenched and firm as in the older centers. Some of the comments from the newer centers may be paraphrased as follows to illustrate this point: "Sure, our technical and scientific people are anxious to go deeper into research on a continuing year-to-year basis, but the importance of pressing development-type problems makes it necessary for them to concentrate upon development work. We are hopeful that in a few years the development problems may ease up or we may get some extra people, and then we will be able to afford the luxury of letting some of our people concentrate upon research more fully in order to advance the state of the art. As it now stands, we can only undertake that research which is necessary to provide answers for our critical development problems." Since the newer (younger) NASA Field Centers with less well-established research programs are all development centers, and since development centers favor formal written reports, there is a possible correlation between the age of a center and the preference by its busy management for written reports on the research program.

The third somewhat tenuous factor concerns the personalities of key managers in the various centers. It was evident during the survey that in some centers the research documentation systems were patterned to fit the needs or desires of one or more key managers. If a key manager was keenly interested in knowing about his center's research, or if he insisted that reporting on all center activities be punctual and be done in a formal fashion, the research documentation system reflected these requirements. In several centers, the manager of the over-all center research program was such a strong advocate of research that he personally established a research documentation system which would effectively convey research information to interested persons both within and outside of the center.

In this section, the differences between the research documentation systems which exist in the nine NASA Field Centers have been emphasized. First, the documentation system in each center has been described so that the differences are evident. Second, some of the factors which influence the kind of documentation system used in the centers are discussed. The survey data indicated that in the larger centers more frequent internal research reviews were held, but the reviews covered only parts of the over-all research program. Possible explanations are 1) more frequent formal reviews are necessary to keep management informed because the informal communication systems are less efficient in larger organizations, and/or 2) more frequent reviews covering only parts of the research program are necessary because the size of the research program increases as the size of the center increases, and because management cannot afford the time for an over-all review, or cannot assimilate a review of the over-all program at one time. The survey data also indicated that in centers where development was the primary mission rather than research, a formal written summary-type progress report was a preferred means of communicating with center management about the research program. A possible explanation is that formal written reports have proved to be one of the more effective documentation methods for busy management personnel concerned primarily with other matters. The survey also indicated, but without supporting data, that the needs or desires of key managers influence the kind of research documentation system used.

Adequacy of Documentation Systems

The previous section discussed the differences between documentation systems in the nine NASA Field Centers based upon data obtained in Phase I of the survey. In this section, the adequacy of these systems will be discussed, based upon the data obtained in Phase II of the survey.

As previously stated, only four of the nine centers participated in Phase II of the field survey. Phase II of the survey required that selected management personnel in the centers fill in a management questionnaire (Fig. 11). Three responses were obtained from Center A, nineteen from Center F, four from Center G, and fourteen from

Center J. The nineteen responses from Center F and the fourteen responses from Center J constitute a greater sample size than the responses from Centers A and G. Therefore, the adequacy of the research documentation systems in Centers F and J will be discussed first, based upon the Phase II data.

Before proceeding, a word of caution is in order. The discussion in this section, as with any analysis of the Phase II data, should be recognized as being based upon data which are statistically deficient. Not all levels of management participated, and the responses may be biased in that some organizational segments in a center may be over-represented and other segments under-represented. Also, other statistical limitations have been mentioned previously in the section entitled Summarization of the Data.

Center F, with nineteen participants in Phase II of the survey, had a greater response than any other center. As shown in Table VI, nine of the participants indicated that they considered themselves to be adequately informed on the center's research program, seven considered themselves to be fairly well informed, and three considered themselves to be poorly informed. Center F was the only center having participants indicating that they were adequately informed. Table VIII shows that fourteen participants from Center F considered narrative summary reports to be one of their most valuable sources of information on the research program, seven considered technical reports to be one of the most valuable, and five considered oral presentations as one of the most valuable. Thus, there seems to be a correlation between the sense of feeling well informed and consideration of narrative summary reports as a valuable source of information. Also, it is interesting to note from Table VIII that written documentation (narrative summary reports, technical reports) outweigh oral and visual documentation (oral presentations, status charts) as most valuable sources of information by a ratio of 21 to 6. Center F publishes a series of well-prepared NASA formal technical reports on each of the center's development projects, and these reports include coverage of the research work conducted in support of the development projects. Some of the reports are written in a summary fashion and are not difficult to read and assimilate. In addition, the center publishes a semiannual technical progress summary report on the overall research program, as shown in Table V.

Center F holds monthly research symposia and a semiannual formal research program review for Headquarters, as shown in Table III, and these types of oral documentation obviously contribute to keeping the center personnel informed. Also, as shown in Table IV, Center F maintains a permanent physical display on research at a central location. This type of visual documentation probably also contributes to keeping center personnel informed. However, the Phase II survey data do not reflect a strong correlation between being well informed and these kinds of oral or visual documentation.

Most of the participants from Center F are satisfied with their knowledge of the center's over-all research program, as shown in Table VII. Only three of them indicated a desire to become better informed on the over-all program, but five participants indicated a desire to become better informed on research closely allied to their own work. Ten suggestions for improving the center's research documentation system were made by the participants, as shown in Table IX, but nine participants replied that they did not have any suggestions. Center F participants stated under Comments of the Phase II questionnaire that the press of other work, and the problem of selecting the most useful documents from the overwhelming volume of daily paper, prevented them from learning more about the research work in the center.

Center J, next to be discussed, had fourteen participants in Phase II of the survey. Table VI shows that none of the particpants considered themselves to be adequately informed on the center's research program, nine considered themselves to be fairly well informed, and five considered themselves to be poorly informed. Table VIII indicates that there is an approximately equal response from the participants regarding their consideration of narrative summary reports, oral presentations, and technical reports as most valuable sources of information on the research program. However, there is an eleven-to-eight preference for written documentation (narrative summary reports, technical reports) over oral and visual documentation (oral presentations, status charts) as most valuable sources of information. Center J publishes a semiannual technical progress summary report on the over-all research program, but this report is classified, which restricts its use and reduces its value for many readers. The center also publishes a series of technical reports based upon the center's monthly research symposium; these reports are well written and widely distributed.

Center J holds monthly research symposia, which are open to all center personnel as well as to a large number of invited outsiders, as shown in Table III. The technical presentations at the symposia are well prepared and of high quality. This probably accounts for the fact that oral presentations are one of the favored sources of information. Table IV shows that Center J maintains a permanent physical display on research at a central location, but the display is not widely publicized or visited because it is in a state of final preparation. Consequently, at the time of the survey, it did not actually serve as a strong visual source of information.

Participants from Center J as a group are desirous of learning more about the research in their center, as reflected in Table VII. Five participants indicated a desire to learn more about the research related to their own work; five indicated a desire to be better informed on the over-all research program; two indicated a desire for knowledge about the goals or applications of the research; one indicated a desire to learn more about research contracted out-of-house by the center; one indicated a desire to learn more about the research facilities in his center. These strong desires to learn more about the center's research work can be related to the fact that none of the participants considered themselves to be adequately informed.

Nine suggestions for improving Center J's research documentation system were made by the participants, as shown in Table IX, and only two participants replied that they did not have any suggestions. Four of the suggestions were for an annual summary of the center's over-all research program, which may indicate that these participants were not obtaining the full picture required by managers. Under the Comments part of the Phase II questionnaire, one participant stated that the press of everyday work hampered him from becoming more knowledgeable about research work in the center.

Even though the Phase II participants from Centers F and J were not large in number, the data from their responses have indicated a few significant factors. In contrast, the very few Phase II participants from Centers A and G did not present enough statistically meaningful data. Therefore, no attempt will be made to analyze these data on a center-by-center basis.

The discussion will now be directed to the cumulative totals of responses from the four centers that participated in Phase II of the survey.

Table VI shows that a total of nine participants (all from Center F) considered themselves to be adequately informed; twenty-one considered themselves to be fairly well informed; and ten considered themselves to be poorly informed. Since, on the average, less than one out of four participants considers himself to be adequately informed, the conclusion is drawn that on the whole the research documentation systems in the four centers can be improved.

Table VII shows that eleven participants desired to be better informed on research closely allied to their own work, and that ten participants desired to be better informed on the over-all research program. The number of responses in other categories was far less than these. Therefore, the conclusion is drawn that there is a need to improve research documentation covering specialized areas of work, as well as documentation covering the over-all picture.

Table VIII shows that twenty-four participants considered narrative summary reports to be one of the most valuable types of documentation; fifteen considered oral presentations to be one of the most valuable; and twelve considered technical reports to be one of the most valuable. Looking at Table VIII, one sees that if the responses from Center F (which heavily favor narrative summary reports) are disregarded for the moment, then a total of ten participants from the other three centers name narrative summary reports, ten name oral presentations, and five name technical reports as one of the most valuable types of documentation. Therefore, the conclusion is drawn that narrative summary reports are the most valuable type of documentation in Center F, and the narrative summary reports and oral presentations are the most valuable types of documentation in the remaining three centers.

It may be seen from Table IX that eight participants recommended an annual summary of the over-all research program as a means of improving the research documentation system of their centers. This is the only recommendation having a significant number of responses. The conclusion is drawn that there is a need to improve the research documentation systems to better show the over-all picture of the research programs.

Three of the four responses under Comments of the Phase II questionnaire dealt with the facts that the press of everyday work and the heavy volume of written material presented obstacles to learning more about the research programs. The conclusion is drawn that there is a need for research documentation of a nature which will give managers a maximum amount of information with a minimum expenditure of time.

In this section, the adequacy of the research documentation systems in four of the NASA Field Centers has been discussed, based upon the data obtained in Phase II of the survey. The data were statistically deficient in several respects, but were sufficient to allow some conclusions to be drawn. Narrative summary reports are the preferred type of research documentation in one center which has a significant number of participants who consider themselves to be adequately informed. In other centers, where none of the participants considered themselves to be adequately informed, the preferred types of documentation are narrative summary reports, oral presentations, and technical reports. From an analysis of the combined data of the four participating centers, the conclusions are drawn that: the existing research documentation systems in the centers allow room for improvement; there is a need to improve the documentation covering specialized areas of work as well as that covering the over-all research program; narrative summary reports are the most preferred type of research documentation and oral presentations rank second; better types of research documentation are needed so busy managers can obtain maximum amounts of information with minimum expenditure of time.

CHAPTER V

SUMMARY AND IMPLICATIONS

Summary and Conclusions

Many agencies of the United States Government perform research. Management personnel in these agencies, and in the headquarters offices of the agencies, need to know about the progress and results of research so that they can perform their managerial functions most efficiently. Managers learn about research through some form of documentation. There is a wide variation in the kinds of research documentation used in government agencies. The purpose of this study is to conduct a review of the literature and a field survey of selected government agencies to determine the types of research documentation used and their adequacy. The results are expected to be applicable to the improvement of existing research documentation systems.

This investigation has been limited to a study of documentation systems used to keep management groups informed of the progress and results of research work. The field survey was limited to a survey of nine field centers of the National Aeronautics and Space Administration. This limitation was imposed by the fact that the writer is an employee of NASA, by the desire to keep the survey to a manageable size, and by the fact that the nine NASA Field Centers have common characteristics which facilitate a meaningful comparison between them.

The literature review showed that the Federal Government is the largest single supporter of research and development activity in this country. The obligation of the government to provide adequate information about the research and development work that it supports is well recognized by persons within the government, including the President's Science Advisory Committee, as well as by those outside. The documentation process is an integral part of research. Good documentation is recognized as a necessary tool of good management. Research managers in the Federal Government have a need for many kinds of information about research, including the results of research; actual technical research data; and data on funds, manpower, schedules, organizations, equipment, and facilities. Managers use these kinds of information to perform their managerial activities. In addition to their obligations to promote communications to more effectively manage ongoing research programs, the managers of research have an obligation to promote communications so that the entire body of science and technology can grow. When government research managers improve the documentation systems in their own agencies, the benefits extend far beyond the agencies' boundaries.

The review of the literature, plus the writer's awareness of the types of documentation used in government agencies, led to a classification of types of research documentation into two broad, general categories: Oral and Visual documentation and Written documentation. These categories were subdivided into two subcategories: Formal documentation and Informal documentation. Types of Formal Oral and Visual documentation are symposia, technical meetings, reviews, conferences, displays and exhibits, and motion pictures. Types of Informal Oral and Visual documentation are briefings, person-to-person conversations, and telephone conversations. Types of Formal Written documentation are management reports, technical reports, and journal articles. Types of Informal Written documentation are memoranda, informal reports, and personal letters. Each type of documentation has advantages and disadvantages, and there is a definite need for all types in the management and performance of research.

The review of the literature showed that managers of research organizations need documentation which enables them to see the overall management picture. To keep this picture in view, managers must sacrifice some of the details of the picture, and delegate the responsibility for detail to subordinate levels within the organization. Therefore, documentation for management must summarize the details without losing the basic picture. Surveys have shown that many research managers are not getting the information that they need. To produce satisfactory documentation for management, the originators must communicate effectively, and the format of the documentation must be efficient. Guidelines for authors of written documentation abound, but it is agreed that authors should write clearly, should write for the intended reader, and should concentrate upon the objective of the writing. The format of the documentation should be patterned to fit the needs of the recipient; there is no one best format for all organizations. In well-established research organizations, there is a logical tendency to settle upon a particular documentation format after years of experience have indicated the strong and weak points of various schemes. The Report of NRL Progress, published by the United States Naval Research Laboratory, Washington, D. C., was shown to exhibit desirable characteristics of research documentation for government research managers.

The field survey of the nine National Aeronautics and Space Administration Field Centers was planned to be accomplished in two phases. Phase I required a visit to each center and discussions about the characteristics of the center's research documentation system with persons responsible for management and coordination of the center's research program. A standard interview form containing a series of questions about the operations of the research documentation system in the center was prepared for this first phase. The interview form was designed to obtain information about all of the types of research documentation used in the NASA Field Centers, and it used terminology familiar to all persons interviewed. The interview questions were planned to be unambiguous and uncomplicated, and capable of being answered by fairly short and simple statements in a period of time that would not impose a burden upon the person being interviewed. Phase II of the field survey required that selected management personnel in each center provide written answers to questions about the effectiveness, or adequacy, of the research documentation system in their center. This second phase did not entail a visit to each person queried; a printed questionnaire was sent to the management personnel chosen to participate and was completed when the participant found time to do so. The number of questions was kept to a minimum, so that participants would not be dismayed by a lengthy and complicated form. The questions were chosen with the dual objectives that the answers should provide useful information to the field center itself, and should provide data for the broader field survey.

The actual field survey was accomplished by a visit to each of the NASA Field Centers. Interviews were held with the persons involved in the Phase I portion of the survey. Little difficulty was encountered in obtaining complete and accurate answers to the questions on the standard interview form from all of the nine centers. All persons interviewed were cooperative and interested in the survey. The Phase II portion of the survey was not as successful as the Phase I portion. Only four of the nine centers participated in the second phase, primarily because of a reluctance in the other five centers to obligate management personnel to complete the questionnaires. Forty

Phase II questionnaires were completed by managers in the four centers that participated.

In summarizing the field survey data, the size (personnel strength) and the primary mission (research or development) of each of the nine NASA Field Centers were used to indicate basic differences between the centers. The Phase I survey data from the nine centers were summarized under the following categories, which reflect the types of research documentation used in the centers: research program reviews and presentations, physical displays, and publications on research programs. The Phase I data were considered to be complete and accurate. In contrast, the Phase II data were not considered as true, random data applicable to all of the nine centers because: only four of the centers participated, the number of responses from the centers varied widely, not all levels of management participated, and the responses were sometimes subjective opinions rather than objective statements. However, the data were still valuable and revealing. The Phase II data were summarized under the following categories: how well informed on the research program the participant considered himself to be, on what aspects of the research program would the participant like to be better informed, what type of existing information the participant considered to be of most value, what recommendations the participant had for improving his center's research documentation system, what management review techniques the participant found to be particularly useful, and comments from the participants.

Interpretation of the Phase I data, which dealt with the characteristics of the documentation systems currently used in each center, revealed marked differences between the systems. The following conclusions were drawn from the interpretation of the data:

(1) In the large NASA Field Centers, more frequent internal research reviews are held, but the reviews cover only parts of the over-all research program. Possible explanations for the more frequent reviews are that they are necessary because 1) the informal communication systems are less efficient in larger organizations, and/or 2) the larger size of the research programs in larger organizations makes it difficult to cover the over-all program in a single review.

(2) In NASA Field Centers where the primary mission is development, rather than research, a formal written summary-type progress report is a preferred means of communicating with center management about the research program. By contrast, the use of this kind of publication is the exception in research centers. A possible explanation is that formal written reports have proved to be one of the more effective documentation methods for busy management personnel concerned primarily with other matters.

(3) The needs or desires of key managers influence the kind of research documentation system used.

Phase II data, which dealt with the adequacy of the research documentation systems currently in use in four of the NASA Field Centers, were statistically deficient in some respects, but were sufficient to permit the following observations and conclusions to be drawn:

(1) The existing research documentation systems in the centers allow room for improvement, since, on the average, less than one out of four managers queried considered himself to be adequately informed.

(2) There is a current need to improve documentation covering the over-all research program as well as documentation covering specialized areas of work.

(3) Narrative summary reports are the most-preferred type of research documentation and oral presentations rank second.

(4) There is a need for better types of research documentation to give busy managers maximum amounts of information with minimum expenditures of time.

This section has provided a summary of the material presented in all of the sections preceding it. In the next section, some of the implications of this study will be presented.

Implications of the Study

It is anticipated that the results of this study will be applied to the improvement of the research documentation systems which currently exist in the NASA Field Centers that were surveyed. It is known that at least one of the centers has already used the survey data to expand its research documentation system to incorporate a technique used successfully in another center. It is probable that other applications will follow, because persons responsible for the management and coordination of the centers' research programs expressed their interest in the study, and requested that they be informed of the results. Copies of a summary of the Phase I data have been distributed to these persons in all of the nine NASA Field Centers for their own analysis and evaluation. It appears that this study was the first and only effort to date to obtain a comprehensive view of research documentation systems in NASA Centers.

In addition to the applications in participating NASA Centers, it is believed that the results of this study can also be applied even more usefully to the review, evaluation, and improvement of research documentation systems in other organizations, both government and non-government. It is expected that the survey data will be useful for some time in the future as well as at present. Managers in these other organizations may recognize similarities or differences between their own systems and the systems in NASA Centers, and may use the data and conclusions of this study to modify their systems. As the literature survey revealed, when government research managers improve the documentation systems in their own agencies, the benefits extend far beyond the agencies' boundaries.

The survey has shown that formal written reports are not only heavily used, but they are the most-preferred type of research documentation. These results may encourage research managers to take a close look at their own written reports to see whether they can be improved. The section entitled Desirable Characteristics of Documentation, which concentrates upon written reports, should be useful in providing the reader a broad picture of the criteria for a satisfactory report, and should lead him to more detailed sources of information on the subject.

It is believed that research managers will find the classification of types of research documentation into the categories and the subcategories defined in this study to be useful in reviewing and evaluating the types of documentation in their own research documentation systems. This classification scheme will permit managers to see whether there is a void, or an undesirable duplication, in the types of documentation used in their organizations.

In addition to the foregoing potential applications, it is believed that the results of this study will serve to make interested readers more fully aware of the complications and problems inherent in research documentation systems. There is a sparsity of detailed literature on research documentation systems; consequently, this thesis can also serve as an introduction to the subject for those readers who are not familiar with it.

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VITA

George Curtis Bucher

Candidate for the Degree of

Doctor of Philosophy

Thesis: A SURVEY OF RESEARCH DOCUMENTATION SYSTEMS IN SELECTED GOVERNMENT AGENCIES

Major Field: Industrial Engineering and Management

Biographical:

Personal Data: Born in St. Louis, Missouri, December 15, 1925, the son of George H. and Leonora F. Bucher.

Education: Attended grade school in Ferguson, Missouri; graduation from Ferguson Senior High School in 1943; received the Bachelor of Science degree from Washington University, St. Louis, Missouri, with a major in Mechanical Engineering in June, 1950; received the Master of Science degree from the University of Alabama, with a major in Engineering, in May, 1960; completed requirements for the Doctor of Philosophy degree in July, 1966.

Professional Experience: Served in the United States Navy from 1943 to 1946; worked as Mechanical Engineer with Texas Pipe Line Company from 1951 to 1952; worked as Mechanical Engineer and Research Contract Administrator with the St. Louis Ordnance District from 1952 to 1956; worked as Section Chief and Scientific and Technical Assistant with the Army Ballistic Missile Agency from 1956 to 1960; worked as Scientific and Technical Assistant to Director, Research Projects Laboratory, Marshall Space Flight Center, National Aeronautics and Space Administration, from 1960 to the present.

Publications: Published approximately fifteen technical reports, articles, and books, including: co-editor, Astronautical Engineering and Science, commemorating the 50th birthday of Wernher von Braun, McGraw-Hill Book Company, 1963; author, "Space Power Supplies and Heat Rejection," 3 chapters in Space Science and Engineering, McGraw-Hill Book Company, 1965; co-editor, Physics of the Moon, National Aeronautics and Space Administration, 1965.

Professional Affiliations: Member of: American Institute of Aeronautics and Astronautics, Rocket City Astronomical Association, Pi Tau Sigma Mechanical Engineering Fraternity, Sigma Tau Engineering Fraternity, Alpha Pi Mu Industrial Engineering Fraternity; Registered Professional Engineer, State of Missouri.