NASA/DoD Aerospace Knowledge Diffusion Research Project

NASA Technical Memorandum 107693

Report Number 15

Technical Uncertainty and Project Complexity as Correlates of Information Use by U.S. Industry-Affiliated Aerospace Engineers and Scientists: Results of an Exploratory Investigation

Thomas E. Pinelli
NASA Langley Research Center
Hampton, Virginia

Nanci A. Glassman and Linda O. Affelder
Continental Research
Norfolk, Virginia

Laura M. Hecht and John M. Kennedy
Indiana University
Bloomington, Indiana

Rebecca O. Barclay
Rensselaer Polytechnic Institute
Troy, New York

September 1993

NASA
National Aeronautics and Space Administration

Department of Defense

INDIANA UNIVERSITY

INTRODUCTION

The *NASA/DoD Aerospace Knowledge Diffusion Research Project* attempts to understand, among other things, the information environment in which U.S. aerospace engineers and scientists work and the factors that influence their use of scientific and technical information (STI) (Pinelli, Kennedy, and Barclay, 1991). Such an understanding could (1) lead to the development of practical theory, (2) contribute to the design and development of aerospace information systems, and (3) have practical implications for transferring the results of federally funded aerospace research and development (R&D) to the U.S. aerospace community.

In this report, the results of an exploratory study that investigated the influence of two variables -- technical uncertainty and project complexity -- on the use of information and information sources in completing or solving a project, task, or problem are reported. Several authors have explored relationships among uncertainty, complexity, and information use (Tushman and Nadler, 1978; Gifford, Bobbitt, and Slocum, 1979; and Randolph, 1978). Tushman and Nadler (1978), for example, reported that the more complex the R&D task, the greater the use of STI. Randolph (1978) found that the greater the uncertainty associated with the task, the greater the use of STI. These findings, plus the work of Bodensteiner (1970); Holland, Stead and Leibrock (1976); Atkin (1973); and Kuhlthau (1991), led us to investigate the extent to which the perceived technical uncertainty and complexity of a project, task, or problem affected the use of information and information sources by U.S. aerospace engineers and scientists. The work of Paisley (1980), Wilson (1981), Roberts (1982), Dervin (1983), and Taylor (1991) regarding "information use environments" influenced the conceptual framework, underlying assumptions, and direction of this study.

Finally, information on the aerospace information environment and on the information-seeking behavior of U.S. aerospace engineers and scientists is included to help establish a context for the study. The study's methodology is described in detail. The variables and their measurement are explained. The study's hypotheses, the data used to test the hypotheses, and a discussion of the results are presented.

THE AEROSPACE INFORMATION ENVIRONMENT

Organizations such as aerospace that are involved in innovation are open systems that must deal with complexity and sources of work-related uncertainty (Katz and Kahn, 1966). This proposition traces its origins to, among others, Galbraith (1973) and Duncan (1973), who have conceptualized organizations as information processing systems that must deal with uncertainty. Tyson (1992) and Mowery (1985) state that the aerospace industry, in particular the commercial aviation sector, is characterized by the high degree of systemic complexity embodied in the design and development of its products. Industries such as aerospace must deal with technical and market uncertainty from outside the organization as well as uncertainty concerning problem solving within the organization (Myers and Marquis, 1969; Utterback, 1974). Miller (1971) states that organizations use business and technical information, obtained largely from the external environment, to reduce complexity and uncertainty.

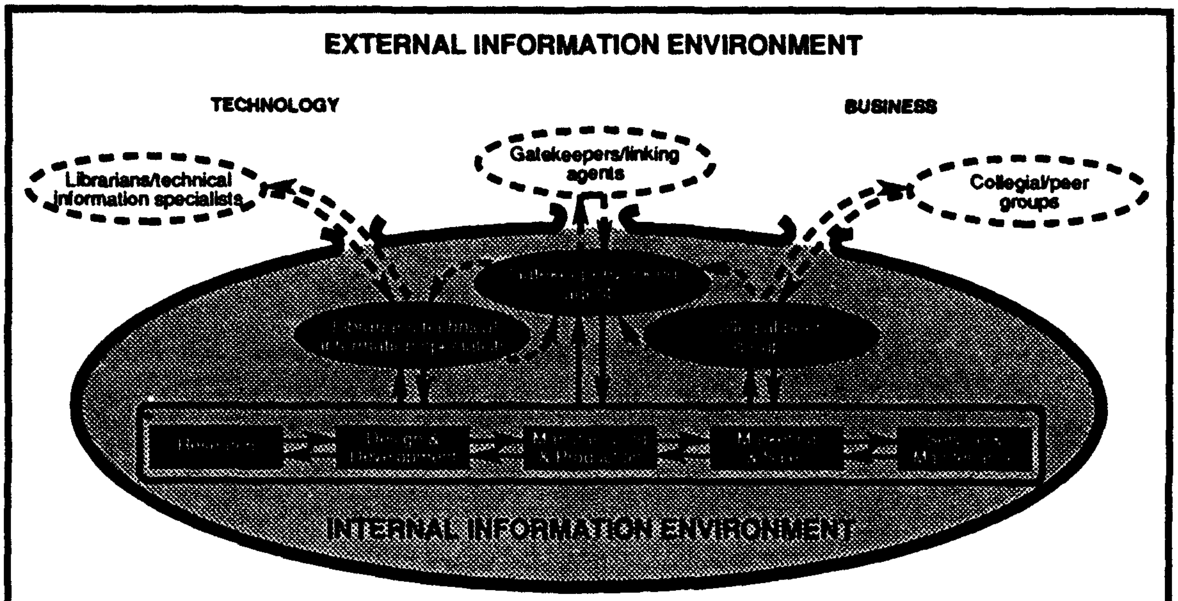
Three factors (task characteristics, task environment, and task interdependence) combine to influence the degree of complexity and uncertainty with which organizations involved in innovation must contend (Tushman and Nadler, 1980). Uncertainty increases as the task becomes more complicated, as the environment becomes more dynamic, and as task interdependence becomes more complex. The greater the complexity and uncertainty, the greater the information processing requirements and the greater the need for information external to the organization (Rosenbloom and Wolek, 1970; Allen, 1970).

In the second SAE telephone survey (Pinelli, Kennedy, and White, October 1992), respondents were asked how the technical uncertainty of a project affected the need for STI. Most aerospace engineers (71 percent) agreed that technical uncertainty increased the need for STI. About 58 percent strongly agreed that technical uncertainty increased the need for internal STI and 42 percent strongly agreed that it increased the need for external STI. Non-aerospace engineers (66 percent) also agreed that technical uncertainty increased the need for STI. About 40 percent strongly agreed that technical uncertainty increased the need for internal STI, and about 36 percent strongly agreed that technical uncertainty increased the need for external STI.

However, it is the nature of organizations that are involved in innovation, such as aerospace, to isolate themselves from their external environment and to erect barriers to communication with the external environment (Gerstenfeld and Berger, 1980). This behavior is due, in large part, to the need for organizations to maintain stability and control, and because these organizations are involved in activities of a proprietary nature that involve trade secrets and intellectual property (Fischer, 1980; Allen, 1970). Aerospace organizations are frequently involved in work that may be classified for reasons of national security. As Fischer (1980) points out, however, there is a danger for organizations engaged in innovation to become isolated from their external environment and from information external to the organization.

Organizations use a variety of techniques or "boundary-spanning" activities to maintain contact with the external environment and to acquire business and technical information that is external to the organization. The three primary boundary-spanning activities used by organizations involved in innovation fall into two groups -- the **informal** that relies on collegial/peer group contacts and gatekeepers/linking agents and the **formal** that relies on librarians and technical information specialists. (See figure 1.) The more "active" and coordinated these activities, the more effective the boundary-spanning function. The work of Aguilar (1967), Duncan (1972), Keegan (1974), Hambrick (1979), and Auster and Choo (1993) is relevant to this discussion.

Derian (1990) has described the U.S. aerospace industry as a "sheltered" (as opposed to an exposed) culture because of the role played by government in the innovation process and because aerospace operates in both government and private sector markets. He points out that, unlike other U.S. industries, aerospace, principally the commercial aviation sector, has been the beneficiary of federally funded R&D for nearly a century. According to Mowery (1985), "The commercial aircraft industry is virtually unique among U.S. manufacturing industries in that a Federal research organization, the National Advisory Committee for Aeronautics (NACA) and

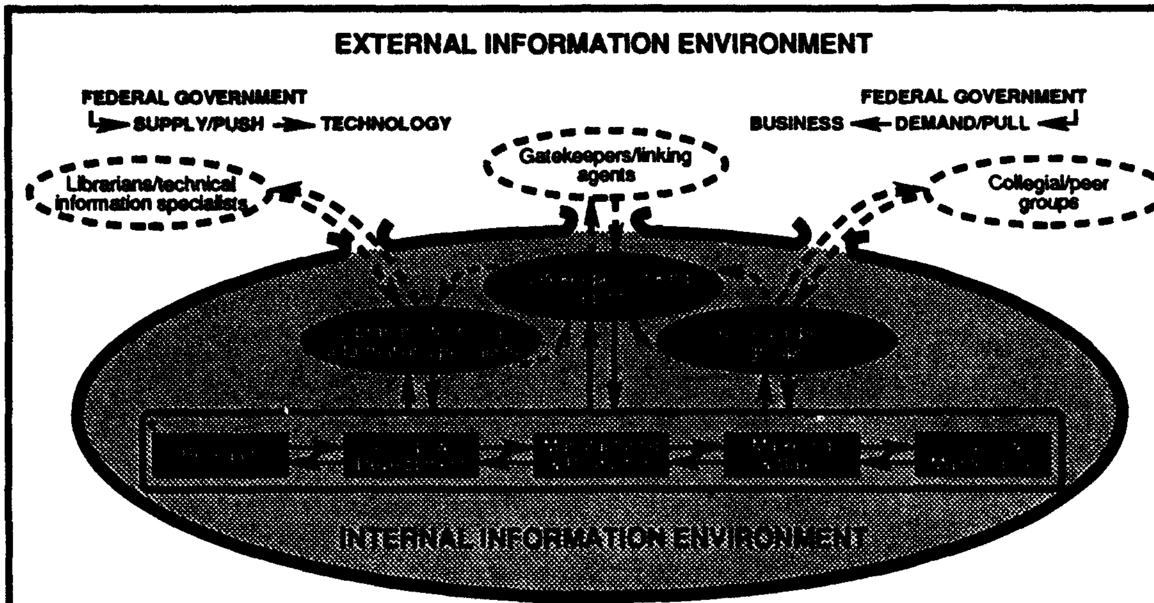


* In this model, the innovation process is conceptualized as a process of related activities or units beginning with research at one end and service and maintenance on the other. The proposition that innovation is a linear process, a view presented by Myers and Marquis (1969), is not universally accepted. Langrish, et al. (1972) and Kline (1985) have rejected "linear models" of the innovation process as unrealistic.

Figure 1. Boundary-Spanning Activities in an R&D Information Environment

subsequently the National Aeronautics and Space Administration (NASA), has for many years conducted and funded research on airframe and propulsion technologies." The commercial aviation sector has also benefitted from considerable investment, in terms of research and procurement, by the Department of Defense (DoD). "Although not intended to support innovation in any but military airframe and propulsion technologies, [this investment] has, nonetheless, yielded indirect, but very important, technological spillovers to the commercial aircraft industry" (Mowery, 1985).

Derian (1990) states that the aerospace industry is subject to a unique set of *externalities* that result from government intervention which, in turn, change the structure and regulation of the marketplace. Thus, the external environments of sheltered and exposed cultures are distinctive as is the interaction between the two cultures and the external environment. In the case of the U.S. aerospace industry, the interaction with and isolation from the external environment are moderated somewhat by the "supply-push/demand-pull" effect created by the U.S. government's involvement, primarily through NASA and the DoD, in the aerospace innovation process. (See figure 2.) From a policy perspective, the U.S. government is both a performer and a dominant purchaser of aerospace R&D, supports precommercial research in civilian and military aircraft technologies, and plays a major role in diffusing the results of that research throughout the aerospace industry.



* In this model, the innovation process is conceptualized as a process of related activities or units beginning with research at one end and service and maintenance on the other. The proposition that innovation is a linear process, a view presented by Myers and Marquis (1969), is not universally accepted. Langrish, et al. (1972) and Kline (1985) have rejected "linear models" of the innovation process as unrealistic.

Figure 2. Boundary-Spanning Activities in the U.S. Aerospace Information Environment

INFORMATION USE BY U.S. AEROSPACE ENGINEERS AND SCIENTISTS

Information use by engineers and scientists has been variously studied by information and social scientists, the earliest studies having been undertaken in the late 1960s. The results of these studies have not accumulated to form a significant body of knowledge that can be used to develop a general theory regarding the information-seeking behavior of engineers and scientists. The difficulty in applying the results of these studies has been attributed to the lack of a unifying theory, a standardized methodology, and the common definitions (Rohde, 1986).

The information-seeking behavior of U.S. aerospace engineers and scientists is being investigated as a Phase 1 activity of the *NASA/DoD Aerospace Knowledge Diffusion Research Project*. The following three research questions were formulated as background for this study.

1. Is there a difference between the information-seeking behavior of U.S. engineers in general and U.S. aerospace engineers and scientists?

2. Is there a difference between the information-seeking behavior of U.S. aerospace engineers and U.S. aerospace scientists?

3. Is there a difference between the information sources used by U.S. aerospace engineers and scientists in problem solving and those used to find out about U.S. government technical reports?

Methodology

The data reported herein were collected from U.S. aerospace engineers and scientists belonging to the American Institute of Aeronautics and Astronautics (AIAA). The AIAA is a professional research society and the characteristics of its members reflect a research orientation. Over 31 percent of the respondents hold a doctorate and an additional 39 percent have earned master's degrees. Most of the respondents are managers, researchers, or academics. Only 28 percent reported their principal job activity as "design or development." The vast majority of the respondents reported that they were educated and work as engineers. Following Vincenti's (1990) statement that "engineering implies a knowledge-producing activity embedded within a larger problem-solving activity," we found that those surveyed were definitely involved in "seeking and using" information.

The data used to answer the research questions were obtained through the use of self-administered questionnaires. The data were derived from two surveys (samples) of the AIAA membership. Sample 1 was used to undertake a pilot (exploratory) study that was conducted between July and September 1988. Approximately 2,000 individuals, randomly selected from the 1988 AIAA membership list, were sent questionnaires and 606 usable responses were received (30 percent response rate) by the established cut-off date. The results of the pilot study (study 1) are documented in NASA Technical Memorandum 101534 (Pinelli et al., 1989).

A random sample was used to select 3,298 (study 2) persons from the 1989 AIAA membership list. Overall, 2,016 U.S. aerospace engineers and scientists responded to the second study. The adjusted response rate (corrected for sampling problems) for study 2 was about 70 percent. Study 2 was conducted during the summer and fall of 1989. The results of study 2 are documented in NASA Technical Memorandum 102774 (Pinelli, 1991).

Research Question 1

A review of the literature reveals certain general characteristics about the information-seeking behavior of engineers (Pinelli, 1991). They are not interested in guides to the literature nearly so much as they are in reliable answers to specific questions. They prefer informal sources of information, especially conversations with individuals **within** their organization. Engineers may have psychological traits that predispose them to solve problems alone or with the help of colleagues rather than seeking answers in the literature. "Engineers like to solve their own problems by drawing on past experiences, using the trial and error method, and asking colleagues known to be efficient and reliable instead of searching or having someone search the literature for them" (Anthony, East, and Slater, 1969). According to Allen (1977), engineers seldom use information services which are directly oriented to them. When they use a library, it is more in a personal search mode, generally not involving the professional (but "non-technical") librarian.

To answer Question 1, we compared selected results of Shuchman's (1981) study with selected results from study 1 (Pinelli, et al., 1989). The comparison appears in table 1. Shuchman's (1981) study is a broad-based investigation of information transfer in engineering. The respondents represented 14 industries and the following major disciplines: civil, electrical,

Table 1. Information Sources Used by U.S. Engineers and U.S. Aerospace Engineers and Scientists To Solve Technical Problems

Sources	Percent of Respondents Using Source --	
	U.S. Engineers (Shuchman, 1981)	U.S. Aerospace Engineers and Scientists (Pinelli, et al., 1989)
Personal Store	93	88
A Co-worker In My Organization	87	79
My Supervisor	61	50
Library Research	50	68
Colleague Outside My Organization	33	56
Data Base Search	20	53
Librarian In My Organization	14	36

mechanical, industrial, chemical and environmental, and aeronautical. Seven percent, or 93 respondents, were aeronautical engineers. The engineers in Shuchman's study, regardless of discipline, displayed a strong preference for informal sources of information. Further, these engineers rarely found all the information they needed for solving technical problems in one source; the major difficulty engineers encountered in finding the information they needed to do their job was identifying a specific piece of missing data and then learning who had it.

In terms of information sources and problem solving, Shuchman (1981) reports that engineers first consult their personal store of information, followed in order by informal discussions with co-workers and discussions with supervisors. Next, they search the library. If they fail to obtain the needed information, they contact a "key" person in the organization who usually knows where the needed information may be located. Having failed to that point, they search or have a data base searched and/or seek the assistance of the organization's librarian. Based on these findings, Shuchman concluded that librarians are used by a fraction of the engineering profession.

Research Question 2

The nature of science and technology and differences between engineers and scientists influence their information-seeking behavior. Evidence exists to support the belief that differences between science and technology and scientists and engineers directly influence information-seeking habits, practices, and preferences. The results of a study conducted by the Systems Development Corporation (1966) determined that "an individual differs systematically from others in his use of STI" for a variety of reasons. Chief among these are five institutional variables -- type of researcher, engineer or scientist; type of discipline, basic or applied; stage of project, task, or problem completeness; the kind of organization, fundamentally thought of as academia, government, and industry; and the years of professional work experience."

To answer Question 2, the U.S. aerospace engineers and scientists in study 2 were asked to describe briefly the most important technical project, task, or problem they had worked on in the past 6 months. Respondents were given a list of nine information sources and were asked to identify the steps followed (sources used) in looking for the information needed to complete the project or task or to solve the problem.

Survey participants were instructed to enter "1" beside the first step, "2" beside the second, and so forth. Weighted average rankings were calculated to determine the actual steps followed (sequence in which information sources were used) by survey respondents to acquire the information needed or used to complete their most important technical project, task, or problem in the past 6 months. The steps followed in the search for information were examined from the standpoint of the respondents' educational preparation as either an engineer or scientist (table 2).

In terms of project and task completion and problem solving, the U.S. aerospace engineers and scientists in our study are a relatively homogeneous group. With few exceptions, the steps used to acquire information are fairly uniform for both engineers and scientists. Both begin their search for information using their personal store of knowledge, followed by discussions with colleagues. Asking a librarian either inside or outside the organization is the last step taken in the overall information acquisition strategy. Based on these data, we find *no difference* between the information-seeking behavior of U.S. aerospace engineers and U.S. aerospace scientists.

Using Shuchman's list of information sources, our survey respondents were asked to indicate those sources used to solve technical problems. Although the amount of use appears higher for U.S. aerospace engineers and scientists, their responses, which appear in table 1, compare favorably with Shuchman's findings. Like the engineers in Shuchman's study, the U.S. aerospace engineers and scientists in our study display a preference for using their personal store of STI, especially that which they keep in the office; personal contacts; and informal sources of information. Engineers, in general, and U.S. aerospace engineers and scientists, in particular, begin with an informal search for information followed by what Allen (1977) calls "an informal personal search for information followed by the use of formal information sources. Having completed these steps, engineers turn to librarians and library services for assistance." Based on these focused but admittedly limited data, we find *no difference* between the information-seeking behavior of engineers in general and U.S. aerospace engineers and scientists.

Table 2. Order in Which Information Sources Are Used by U.S. Aerospace Engineers and Scientists To Complete Their Most Important Technical Project, Task, or Problem

Engineers (n = 1,627) (Pinelli, 1991)			Scientists (n = 235) (Pinelli, 1991)		
Steps Followed	n	Weighted avg. rank[a]	Steps followed	n	Weighted avg. rank[a]
Used Personal Store of Technical Information	1212	7.51	Used Personal Store of Technical Information	180	7.33
Discussed Problem With a Colleague in My Organization	1098	7.15	Discussed Problem With a Colleague in My Organization	161	7.03
Discussed Problem With a Key Person in the Organization	839	6.86	Discussed Problem With a Key Person in the Organization	106	6.73
Discussed Problem With My Supervisor	709	6.74	Intentionally Searched Library Resources	146	6.57
Intentionally Searched Library Resources	942	6.06	Discussed Problem With My Supervisor	82	6.38
Discussed Problem With a Colleague Outside the Organization	769	6.02	Searched Data Base Or Had Data Base Searched	109	6.35
Searched Data Base or Had Data Base Searched	739	6.01	Discussed Problem With a Colleague Outside the Organization	105	6.19
Asked a Librarian in the Organization	499	5.29	Asked a Librarian in the Organization	73	5.15
Asked a Librarian Outside the Organization	336	3.99	Asked a Librarian Outside the Organization	49	4.64

[a]Highest number indicates step was used first; lowest number indicates step was used last.

Research Question 3

To the extent that a generalization can be formed, U.S. engineers in general and the U.S. aerospace engineers and scientists in our studies appear to be a relatively homogeneous group in terms of their information-seeking behavior. Their search strategy begins with an examination of their personal store of knowledge and includes information kept in the office or work place. Discussions with co-workers is the next phase of the strategy, followed by a personal search of formal information products and services in the library or technical information center. If engineers fail to obtain needed information, at this point they turn to the librarian or technical information specialist.

We found nothing in the literature that led us to conclude that their approach to finding out about U.S. government technical reports would be different. They check their personal store or collection; talk with co-workers; go to the library and look for themselves; and, if all else fails, ask a librarian or technical information specialist.

To answer Question 3, we asked survey respondents in study 2 if they used U.S. government technical reports to complete their technical project, task, or problem. Next, we asked the approximately 65 percent who did use them how they found out about these reports. We compared the responses to this question with the responses to the question concerning the sources used in problem solving. The data used in making the comparison appear in table 3.

Table 3. Sources Used by U.S. Aerospace Engineers and Scientists To Solve Technical Problems and To Find Out About U.S. Government Technical Reports

	Percent of Respondents Using Source For --	
Sources	Problem Solving (Pinelli, et al., 1989)	U.S. Government Technical Reports (Pinelli, 1991)
Personal Store of Technical Information	88.1	83.1
A Co-worker in My Organization	78.8	57.7
Library Search	68.4	49.7
Colleague Outside My Organization	55.6	49.9
Data Base Search	53.3	30.5
My Supervisor	49.7	22.8
Librarian in My Organization	36.1	27.1

In completing their most important technical project, task, or problem, the U.S. aerospace engineers and scientists in our studies used their personal store of technical information first, followed by discussions with a co-worker or key individuals. Next, they searched the library or a data base and last, asked a librarian. The sources used by U.S. aerospace engineers and scientists to find out about U.S. government technical reports were very similar to those used to solve technical problems. Based on these data, we find ***no difference*** between the information sources used by U.S. aerospace engineers and scientists in problem solving and those used to find out about U.S. government technical reports used in problem solving.

CONCEPTUAL FRAMEWORK

The conceptual framework is based on the work of Paisley (1968, 1980), Allen (1977), Taylor (1991), and Mick (1979) and represents an extension of Orr's (1970) scheme of the engineer-scientist as an information processor. This study focuses on the "information use environment," the environment in which U.S. aerospace engineers and scientists process information, and the influence of two (independent) variables (technical uncertainty and project complexity) on information and information source use.

Information is central to the concept of the engineer-scientist as an information processor. It acts to moderate (reduce) uncertainty and complexity. Rogers (1982) has stated that the process of innovation involves considerable risk and grappling with unknowns which may be technical, economic, or merely the manifestation of personal and social variables. When faced with uncertainty and complex tasks, individuals seek information, which is why information (communication) behavior cannot be ignored when studying technological innovation.

Three consistent findings emerge from the numerous information use studies that have been conducted over the past 25 years: the reliance of engineers on interpersonal communication (e.g., face-to-face conversations), the proclivity of engineers to use information that is closest in proximity (e.g., personal collection of information) to their work site, and the tendency of engineers not to rely on libraries and the assistance of librarians for obtaining information. Engineers do use written communications. Their use of information is not always limited to their personal collections, however. They do use libraries and seek the assistance of librarians. They tend to use all of these sources presumably if their need for information has not been met.

Assumptions

This study is guided by the assumption that information use and patterns of information use by U.S. aerospace engineers and scientists differ with the degree of technical uncertainty and technical complexity characteristic of the project, problem or task at hand. The basic assumptions are: (1) technical uncertainty and technical complexity are correlated positively; (2) as uncertainty/complexity increases, the time spent communicating technical information increases; and (3) as uncertainty/complexity increases, reliance on information from internal, informal sources gives way to the use of information from external, formal sources. Specifically, it is expected that U.S. aerospace engineers and scientists working on projects, problems, and tasks with high technical uncertainty and complexity will make greater use of external sources of information. External sources include: (1) colleagues outside of the organization and (2) published sources of written information that originate outside of the organization (e.g., conference/meeting papers, journal articles, and technical reports). Further, U.S. aerospace engineers and scientists working on projects, problems and tasks with high technical uncertainty and complexity will make greater use of the formal information process. The formal information process can be defined as (1) the use of the organization's library or technical information center and (2) the use of the organization's librarians and technical information specialists.

This study also assumes that the results of federally funded aerospace R&D are used by U.S. aerospace engineers and scientists in industry to moderate (reduce) technical uncertainty and complexity. Federally funded R&D is defined here as information available in NASA or DoD reports. It is expected that U.S. aerospace engineers and scientists will be more likely to use federally funded R&D reports when working on projects, problems, and tasks that are high in technical uncertainty and complexity than on projects characterized by low levels of uncertainty and complexity. Finally, it is expected that the use of formal information sources by U.S. aerospace engineers and scientists as a means to learn about federally funded aerospace R&D increases as technical uncertainty and complexity of the project, problem, or task increase.

Hypotheses

This study seeks to understand the influence of both technical uncertainty and technical complexity on (1) information production and information use, (2) the use of external information, (3) the use of formal information sources, and (4) the use of federally funded aerospace R&D. The following hypotheses, informed by the assumptions reviewed above, were generated for testing:

Technical Uncertainty and Information Production/Use

H_1 As the technical uncertainty of job-related projects, tasks, or problems increases, the hours per week spent communicating technical information in writing increases.

H_2 As the technical uncertainty of job-related projects, tasks, or problems increases, the hours per week spent communicating technical information to others orally increases.

H_3 As the technical uncertainty of job-related projects, tasks, or problems increases, the hours per week spent working with written technical information received from others increases.

H_4 As the technical uncertainty of job-related projects, tasks, or problems increases, the hours per week spent working with technical information received orally from others increases.

Technical Uncertainty and External Information Use

H_5 As the technical uncertainty of job-related projects, tasks, or problems increases, the frequency of use of written technical information (journal articles) produced outside of the organization increases.

H_6 As the technical uncertainty of job-related projects, tasks, or problems increases, the frequency of use of written technical information (conference/meeting papers) produced outside of the organization increases.

H_7 As the technical uncertainty of job-related projects, tasks, or problems increases, the frequency of use of written technical information (U.S. government technical reports) produced outside of the organization increases.

H_8 The technical uncertainty of job-related projects, tasks, or problems is related to the frequency of use of written technical information obtained from colleagues outside of the organization.

Technical Uncertainty and the Use of Formal Information Sources

H_9 The level of technical uncertainty of job-related projects, tasks, or problems is related to the use (non-use) of technical information obtained from the organization's library.

H_{10} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use (non-use) of technical information obtained from librarians and technical information specialists inside of the organization.

Technical Uncertainty and the Use of Federally Funded Aerospace R&D

H_{11} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of federally funded aerospace R&D.

H_{12} The level of technical uncertainty of job-related projects, tasks, or problems is related to the reported importance of federally funded aerospace R&D.

H_{13} The level technical uncertainty of job-related projects, tasks, or problems is related to the use of federally funded R&D found in NASA or DoD technical reports.

H_{14} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of colleagues outside of the organization to learn about federally funded aerospace R&D.

H_{15} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of librarians inside of the organization to learn about federally funded aerospace R&D.

H_{16} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of searches of computerized data bases to learn about federally funded aerospace R&D.

H_{17} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of STAR to learn about federally funded aerospace R&D.

Complexity and Information Production/Use

H_{18} As the complexity of job-related projects, tasks, or problems increases, the time (hours per week) spent communicating technical information in writing increases.

H_{19} As the complexity of job-related projects, tasks, or problems increases, the time (hours per week) spent communicating technical information to others orally increases.

H_{20} As the complexity of job-related projects, tasks, or problems increases, the time (hours per week) spent working with written technical information received from others increases.

H_{21} As the complexity of job-related projects, tasks, or problems increases, the time (hours per week) spent working with technical information received orally from others increases.

Complexity and External Information Use

H_{22} As the complexity of job-related projects, tasks, or problems increases, the frequency of use of written technical information (journal articles) produced outside of the organization increases.

H_{23} As the complexity of job-related projects, tasks, or problems increases, the frequency of use of written technical information (conference/meeting papers) produced outside of the organization increases.

H_{24} As the complexity of job-relate projects, tasks, or problems increases, the frequency of use of written technical information (U.S. government technical reports) produced outside of the organization increases.

H_{25} The complexity of job-related projects, tasks, or problems is related to the use of written technical information obtained from colleagues outside of the organization.

Complexity and the Use of Formal Information Sources

H_{26} The complexity of job-related projects, tasks, or problems is related to the use of technical information obtained from the organization's library.

H_{27} The complexity of job-related projects, tasks, or problems is related to the use of technical information obtained from librarians and technical information specialists inside of the organization.

Complexity and the Use of Federally Funded Aerospace R&D

H_{28} The complexity of job-related projects, tasks, or problems is related to the use of federally funded aerospace R&D.

H_{29} The complexity of job-related projects, tasks, or problems is related to the importance of federally funded aerospace R&D.

H_{30} The complexity of job-related projects, tasks, or problems is related to the of use of federally funded R&D found in NASA or DoD technical reports.

H_{31} The complexity of job-related projects, tasks, or problems is related to the use of colleagues outside of the organization to learn about federally funded aerospace R&D.

H_{32} The complexity of job-related projects, tasks, or problems is related to the use of librarians inside of the organization to learn about federally funded aerospace R&D.

H_{33} The complexity of job-related projects, tasks, or problems is related to the use of searches of computerized data bases to learn about federally funded aerospace R&D.

METHODOLOGY

This research was conducted as a Phase 1 activity of the *NASA/DoD Aerospace Knowledge Diffusion Research Project.* The project fact sheet appears as Appendix A. A list of project publications appears as Appendix B. The study utilized survey research in the form of a self-administered (self-reported) mail questionnaire. Survey participants consisted of U.S. aerospace engineers and scientists who were on the Society of Automotive Engineers (SAE) mailing list (not necessarily members of the SAE). The survey instrument appears as Appendix C.

The Survey

The questionnaire used in this study was jointly prepared by the project team and representatives from Continental Research. On July 7, 1991, 35 pretest surveys were sent to U.S. aerospace engineers and scientists across the country along with a form to voice their opinions about the survey. Of the pretest surveys that were returned, comments indicated only a few minor concerns. Telephone follow-ups were also completed with pretest participants.

After final approval, 2,000 surveys were printed and mailed on August 6-7, 1991. Included in the envelope were an 11-page questionnaire; a cover letter; and a self-addressed, franked reply envelope. A toll-free telephone number was provided in the cover letter for respondents to call if the survey was not relevant to them. "Address Correction Requested" was stamped on the outside of each envelope so undeliverable mail would be returned.

Five hundred forty-one responses to the survey were generated from August 7 to September 6, 1991. Several people used the toll-free number to inform Continental Research that the survey was not relevant. Some respondents returned their completed surveys while others sent them back incomplete with a note indicating that the survey was not relevant. Some surveys were returned with a note indicating the person to whom the envelope was addressed was no longer with the company. The returned "Address Correction Requested" surveys were re-addressed and remailed. On September 6, 1991, follow-up post cards were sent to the 1,459 individuals who had not yet responded to encourage them to complete and return the survey. By October 1, 1991, the mailings had yielded 764 completed survey responses.

A reminder letter with a second copy of the survey was mailed to the 1,236 individuals who had not responded to the first mailing or the post card reminder. Between October 30 and November 6, 1991, telephone calls were made to each person on the sample list who had not responded. All calls were made at the Continental Research central telephone facility by professional staff interviewers between the hours of 9:00 a.m. and 9:00 p.m. By November 29, 1991, the cut-off date, 946 completed surveys were received. The adjusted completion rate for the survey was 67 percent.

Data Collection and Analysis

A variation of Flanagan's (1954) critical incident technique was used to guide data collection. According to Lancaster (1978), the theory behind the critical incident technique is that it is much easier for people to recall accurately what they did on a specific occurrence or occasion than it is to remember what they do in general. In this study, respondents were asked to categorize the most important job-related projects, task, or problem they had worked on in the past 6 months. The categories included (1) educational, (2) research, (3) design/development, (4) manufacturing/production, (5) computer applications, (6) management, and (7) other.

Respondents were also asked to rate the amount of technical uncertainty and complexity they faced when they started their most important project, task, or problem. Technical uncertainty and complexity were measured on 5-point scales (1.0 = little uncertainty; 5.0 = great uncertainty; 1.0 = little complexity, 5.0 = great complexity). Survey participants were also asked to indicate whether they worked alone or with others in completing/solving the most important job-related project, task, or problem they had worked on in the past six months.

Technical uncertainty, complexity, and the importance of federally funded aerospace R&D were measured using ordinal scales. Hours spent communicating and the number of journal articles, conference/meeting papers, and U.S. government technical reports were measured on an interval scale. Use of formal information sources and federally funded aerospace R&D were measured using a nominal scale. Hypothesis tests are based on responses of the 872 industry-affiliated respondents (total number of respondents = 946). A one tailed *t*-test was used to test hypotheses involving the mean number of hours and information products used; Pearson's *r* was used to test correlations. The chi-square test of independence was used to test hypotheses involving nominal data.

Descriptive Findings

A total of 946 usable surveys was received by the established cut-off date. Of the 946 respondents, 872 (92.2%) worked in industry, 63 (6.7%) worked in government, 6 (0.6%) worked in academia, and 5 (0.5%) had some other affiliation. Survey demographics for the industry-affiliated respondents appear in table 4. The following "composite" participant profile was developed for the industry-affiliated respondents: has a bachelor's degree (52.5%), has an average of 18.7 years of work experience in aerospace, was educated as and works as an engineer (90.7%, 90.8%), and works in design/development (60.4%).

Project, Task, Problem

Survey participants were asked to categorize the most important job-related project, task, or problem they had worked on in the past six months. The categories and responses are listed in table 5. A majority of the job-related projects, tasks, and problems (56.4%) were categorized as design/development. About 11 percent and 14 percent of the job-related projects, tasks, and problems were categorized as manufacturing/production and management, respectively. Most respondents (82.7%) worked with others (did not work alone) in completing their most important job-related project, task, or problem.

On average, respondents worked with 2.75 groups; each group contained an average of 6.7 members (see table 5). A majority of respondents (72%) performed engineering duties while working on their most important job-related project, task, or problem. About 24 percent performed management duties.

Table 4. Survey Demographics
[n = 872 in the Industry Sub-sample]

Demographics	Number	%
Do you currently work in:		
Industry	872	92.2
Government	[63]	[6.7]
Academia	[6]	[0.6]
Not-for-Profit	[5]	[0.5]
Your highest level of education:		
No degree	50	5.7
Technical/Vocational degree	22	2.5
Bachelor's degree	458	52.5
Master's degree	232	26.6
Doctorate	45	5.2
Other type of degree	65	7.5
Your years in aerospace:		
1 to 5 years	85	9.9
6 to 10 years	206	24.0
11 to 20 years	215	25.1
21 to 40 years	332	38.8
41 or more years	17	2.0
Mean = 18.7 years Median = 16.0 years		
Your education:		
Engineer	791	90.7
Scientist	64	7.3
Other	17	1.9
Your primary duties:		
Engineer	792	90.8
Scientist	18	2.1
Other	62	7.1
Is your work best classified as.		
Teaching/Academic	1	0.1
Research	58	6.7
Management	139	15.9
Design/Development	527	60.4
Manufacturing/Production	101	11.6
Service/Maintenance	23	2.6
Sales/Marketing	12	1.4
Other	11	1.3

Respondents were asked to rate the overall complexity of their most important job-related project, task, or problem. The mean complexity score was 3.70 (of a possible 5.00) (see table 6). Respondents were also asked to rate the amount of technical uncertainty they faced when they started their most important project, task, or problem. The average (mean) technical uncertainty score was 3.19 (of a possible 5.00).

Correlation coefficients (Pearson's *r*) **were calculated to compare (1) the overall "level of project, task, or problem complexity" and "technical uncertainty" and (2) the level of "project, task, or problem complexity by category" and "technical uncertainty."** The correlation coefficients appear in table 6. Positive and significant correlations were found for both comparisons. These findings support the hypothesis that there is a (positive) relationship between technical uncertainty and complexity.

Table 5. Problem, Task or Problem Categorization
[n = 872]

	Number	%
Categories of project, task or problem:		
Educational	13	1.5
Research	78	8.9
Design	269	30.8
Development	223	25.6
Manufacturing/Production	100	11.5
Computed Applications	37	4.2
Management	125	14.3
Other	27	3.1
Worked on project, task or problem:		
Alone	151	17.3
With others	721	82.7
Mean number of groups = 2.75		
Mean number of people/group = 6.7		
Nature of duties performed:		
Engineering	627	71.9
Science	20	2.3
Management	213	24.4
Other	12	1.4

Table 6. Correlation of Project Complexity and Technical Uncertainty
by Type of Project, Task or Problem
[n = 872]

Complexity - Uncertainty Correlation	n	r
Overall**	872	.4658*
Education/Research	91	.3711*
Design	296	.5002*
Development	223	.4830*
Manufacturing/Production	100	.4235*
Management	105	.4091*

* *r* values are statistically significant at $p \leq 0.05$.

** Overall mean complexity (uncertainty) score = 3.70 (3.19) out of a possible 5.00.

<u>Information Production/Use</u>

Data which describe factors concerning the production and use of technical information are summarized in table 7. Industry participants were asked to indicate the importance of communicating technical information effectively (e.g., producing written materials or oral discussions). A 5-point scale was used to measure importance (1.0 = very unimportant; 5.0 = very important). The mean importance rating was 4.35; approximately 84 percent of respondents indicated that it was important to communicate technical information effectively. Respondents were also asked to report the total number of hours per week they spent communicating technical information, both in written form and orally, during the past 6 months. Respondents reported spending an average of 19.6 hours/week communicating written and oral information (combined) over the past 6 months. (The combined median was 18 hours/week for the past 6 months.) Respondents reported spending slightly more time on producing oral discussions (an average of 10.69 hours/week) than written materials (an average of 8.91 hours/week). Approximately 61 percent of the respondents indicated that the amount of time they spent communicating technical information had increased over the past five years. About 7 percent indicated a decrease in the amount of time spent communicating technical information over the same period.

Industry respondents were also asked to report the total number of hours per week spent working with technical information, both written and oral, received from others in the past 6 months (see table 7). Respondents reported spending a combined (written and oral) average of 14.88 hours/week working with this information in the past 6 months. (The combined median was 10.00 hours/week). Respondents reported spending slightly more time working with written technical information received from others (an average of 7.78 hours/week) than with oral materials (an average of 7.10 hours/week). Approximately 57 percent of the respondents indicated that, compared with 5 years ago, the amount of time spent working with technical information received from others had increased. About 12 percent indicated a decrease in the amount of time they spent communicating technical information when compared with 5 years ago.

Table 7. Information Production and Use
[n = 872]

Communication And Receipt Of Information	Number	%
Importance Of Communicating Information:		
Unimportant	68	7.8
Neither important nor unimportant	70	8.0
Important	734	84.2
Mean = 4.35 Median = 5.00		
Time Spent Producing Written Material:		
0 to 3 hours per week	159	19.0
4 to 7 hours per week	217	26.0
8 to 15 hours per week	285	34.1
16 or more hours per week	174	20.8
Mean = 8.91 Median = 8.00		
Time Spent Communicating Information Orally:		
0 to 3 hours per week	118	14.2
4 to 7 hours per week	177	21.2
8 to 15 hours per week	347	41.7
16 or more hours per week	194	22.9
Mean = 10.69 Median = 10.00		
Change Over Past 5 Years in the Amount of Time Spent Communicating Information:		
Increased	534	61.2
Stayed the same	275	31.5
Decreased	63	7.2
Time Spent Working With Written Information Received From Others:		
0 to 3 hours per week	198	36.3
4 to 7 hours per week	269	18.8
8 to 15 hours per week	294	34.6
16 or more hours per week	87	10.3
Mean = 7.78 Median = 5.00		
Time Spent Receiving Information Orally From Others:		
0 to 3 hours per week	239	29.2
4 to 7 hours per week	256	31.2
8 to 15 hours per week	249	30.4
16 or more hours per week	75	9.2
Mean = 7.10 Median = 5.00		
Change Over Past 5 Years In The Amount Of Time Spent Receiving Information:		
Increased	496	56.9
Stayed the same	276	31.7
Decreased	100	11.5

Use and Importance of External Information

Industry participants were asked to indicate the number of times each of five technical information products was used (while performing professional duties) in the previous six months. These data are summarized in table 8. In-house technical reports were used to a much greater extent than other information products (an average of 9.48 times during the six month period). Journal articles were used to a lesser extent ($\bar{X}$ = 6.76), followed by conference papers ($\bar{X}$ = 3.74), DoD reports ($\bar{X}$ = 2.49), and NASA technical reports ($\bar{X}$ = 2.00). Median usage scores are also listed in table 8. An interesting result is that the median number of times that both DoD and NASA reports were used in the past six months was 0.00, indicating that the majority of respondents did not use these information sources during that period.

Table 8. Average Number of Times (Mean and Median) Technical Information Products Used in a 6-Month Period
[n = 872]

Information Products	Mean	Median
Conference/Meeting	3.74	2.00
Journal Articles	6.76	2.00
In-house Technical Reports	9.48	5.00
DoD Technical Reports	2.49	0.00
NASA Technical Reports	2.00	0.00

Respondents were also asked how important it was to use these information sources in the performance of their work. Importance was measured using a 5-point scale (1.0 = very unimportant; 5.0 = very important). Means and median importance scores for each information source are reported in table 9. Table 10 lists the number and percentage of respondents who assigned an importance score of either "4" or "5" when rating the importance of the various technical information sources. More respondents rated in-house technical reports important to their work than they rated other technical information products important. Nearly 45 percent indicated that in-house technical reports were an important resource. Sixteen percent indicated that the use of conference/meeting papers was important to their work. About 20 percent indicated that the use of journal articles was important. Twenty-one percent reported that DoD technical reports were important, and 18 percent indicated that NASA technical reports were an important information source.

Table 9. Average Importance Rating of Technical Information Products For Their Work
[n = 872]

Information Products	Mean	Median
Conference/Meeting	2.50	3.00
Journal Articles	2.61	3.00
In-house Technical Reports	3.28	3.00
DoD Technical Reports	2.65	3.00
NASA Technical Reports	2.54	3.00

Table 10. Number and Percent of Respondents Rating Technical Information Products As Important
[n = 872]

Information Products	Number	%
Conference/Meeting	140	16.0
Journal Articles	172	19.7
In-house Technical Reports	382	44.8
DoD Technical Reports	185	21.2
NASA Technical Reports	157	18.0

Use of Formal Information Sources

Respondents were given a list of the following information sources used to complete their most important job-related project, task, or problem: (1) used personal store of technical information, (2) spoke with co-workers inside the organization, (3) spoke with colleagues outside of the organization, (4) spoke with a librarian/technical information specialist, and (5) used literature resources in the organization's library. They were asked to identify the steps they followed to obtain needed information by sequencing these items (e.g., #1,#2,#3,#4, and #5). They were instructed to place an "X" beside the step(s) (i.e., information source) they did not use. The results appear in table 11.

Table 11. Information Sources Used to Solve Problem, Task, or Project
[n = 872]

Information Source	Used First %	Used Second %	Used Third %	Used Fourth %	Used Fifth %	Not Used %
Personal Store of Technical Information	60.0	17.7	10.2	2.3	1.1	8.7
Spoke With Co-Worker(s) Inside the Organization	26.9	45.3	11.5	5.6	0.6	10.1
Spoke With Colleagues Outside of the Organization	5.4	15.5	32.0	13.1	6.2	27.9
Used Literature Resources in My Organization's Library	4.6	11.1	19.6	20.0	7.7	37.0
Spoke With a Librarian/ Technical Information Specialist	3.1	3.8	7.5	11.8	15.8	58.0

The industry participants in this study exhibit a pattern of information source use similar to the patterns reported in tables 1, 2 and 3. They tended to consult their personal stores of technical information first. Next, they spoke with a co-worker in their organization, then spoke with a colleague outside of their organization, used literature resources in their organization's library, and spoke with a librarian/technical information specialist. In terms of overall use/non-use, 91.3 percent used their personal stores of technical information, 89.9 percent spoke with co-workers inside the organization, 72.1 percent spoke with colleagues outside the organization, 63.0 percent used literature resources in their organization's library, and 42.0 percent spoke with a librarian/technical information specialist. Overall use/non-use of these information sources is consistent with the results of previous investigations regarding the use of information sources by engineers in general (see, for example, Shuchman, 1981) and our findings in a study of U.S. aerospace engineers and scientists who belong to the AIAA (see Pinelli, Kennedy, and Barclay, June 1991).

Use of Federally Funded Aerospace R&D

About 42 percent of industry participants used the results of federally funded aerospace R&D in their work. Respondents who used federally funded aerospace R&D in their work were given a list of twelve sources. They were asked to indicate how often they had learned about the results of federally funded aerospace R&D from each of the twelve sources. A 4-point scale (4.0 = frequently; 1.0 = never) was used to measure frequency. In table 12, the "frequently" and "sometimes" responses were combined to determine the overall use of the twelve sources.

Table 12. Sources Most Frequently Used to Learn About the Results of Federally Funded Aerospace R&D [n = 370]

Source	Percentage	Number
1. Professional and Society Journals	79.2	293
2. Co-Workers Inside My Organization	77.8	288
3. Trade Journals	70.6	261
4. NASA and DoD Technical Reports	70.2	260
5. Colleagues Outside My Organization	54.3	203
6. NASA and DoD Contacts	51.4	190
7. Professional and Society Meetings	40.3	149
8. Searches of Computerized Data Bases	36.8	136
9. NASA and DoD Sponsored Conferences and Workshops	33.3	123
10. Visits to NASA and DoD Facilities	28.3	105
11. Publications such as *STAR*	24.3	90

Of the six most frequently used sources, half involve interpersonal communication and half are formal (written) communication. Three of the five "federal initiatives" were the sources used least to learn about the results of federally funded aerospace R&D.

The respondents who reported using the results of federally funded aerospace R&D were asked if they used these results in completing the most important job-related project, task, or problem they had worked on in the past six months. The 25 percent (218) of respondents who answered "yes" were asked about the importance of these results in completing the project, task, or problem. A 5-point scale (1.0 = very unimportant, 5.0 = very important) was used to measure importance. The mean importance rating was 3.5. Almost one-half of those who used federally funded R&D (105 respondents) responded with an importance rating of "4" or "5". Sixty-three percent (138) of those who used the results of federally funded aerospace R&D in completing their most important job-related project, task, or problem indicated that the results were published in either a NASA or DoD technical report.

The respondents who used the results of federally funded aerospace R&D in completing their most important job-related project, task, or problem were asked which problems, if any, they encountered in using these results (see table 13). Respondents were given a list of six problems from which to choose. About 54 percent indicated that the "time and effort it took to locate the results" was a problem. About 43 percent reported that the "time and effort it took to physically obtain the results" was a problem. Twenty-four percent indicated that "accuracy, precision, and reliability of the results" was a problem, and about 23 percent reported that "distribution limitations or security restrictions" constituted a problem. About 15 percent indicated that "legibility or readability" of the results constituted a problem.

Table 13. Problems Related to Use of Federally-Funded Aerospace R&D
[n = 218]

Problem	Percentage	Number
Time and Effort to Locate Results	54.1	118
Time and Effort to Obtain Results	43.1	94
Accuracy, Precision and Reliability of Results	23.9	52
Distribution Limitations or Security Restrictions of Results	22.9	50
Organization or Format of Results	15.1	33
Legibility or Readability of Results	8.7	19

TESTS OF THE HYPOTHESES

Technical Uncertainty and Information Production/Use

Hypotheses H_1 through H_4 state that as the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent in the past six months communicating information increases. Technical uncertainty was initially measured using a 5-point scale (1 = little uncertainty; 5 = great uncertainty). Job-related projects, tasks, or problems were sorted into two categories for hypothesis testing: "low uncertainty" (technical uncertainty = 1, 2) and "high uncertainty" (technical uncertainty = 3, 4, 5). The mean number of hours per week spent (1) communicating technical information to others, both written and orally, and (2) working with information, both written and oral, received from others was calculated for each uncertainty group. T-tests were used to determine whether a significant relationship exits between the amount of time spent communicating technical information and the level of technical uncertainty associated with the project, task, or problem in question. Results of these tests follow:

Communicating Technical Information: <u>To</u> Others: **(Output)**	Uncertainty <u>Group</u>	($\bar{X}$)	(n)	Significant Difference of <u>Group Means</u>?
In Writing:	Low	8.35	217	Yes*
	High	9.11	618	
Orally:	Low	10.26	220	No
	High	10.85	613	

Working With Technical Information: Received <u>From</u> Others: **(Input)**	Uncertainty <u>Group</u>	($\bar{X}$)	(n)	Significant Difference of <u>Group Means</u>?
In Writing:	Low	6.66	223	Yes*
	High	8.18	635	
Orally:	Low	6.17	213	Yes*
	High	7.42	606	

*$p \leq 0.05$.

The differences between the group means for communicating written information to others and working with technical information received from others (both written information and communicating orally) are statistically significant. These results provide support for hypotheses H_1, H_3, and H_4: as the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent communicating technical information to others and working technical information received from others, both written and oral, increases. The difference between the group means for communicating technical information to others orally is not statistically significant. Thus H_2, which states that the number of hours per week spent working with information received orally from others increases as the uncertainty of the project, task, or problem increases, was not supported.

<u>Technical Uncertainty Rating and Information Use -- Products Used</u>

Hypotheses H_5 through H_7 state that as the technical uncertainty of job-related projects, tasks, or problems increases, the mean number of externally produced information products used increases. Again, technical uncertainty scores were sorted into the categories "low uncertainty" and "high uncertainty." Means were calculated for these two groups with regard to the number of journal articles, conference/meeting papers, and U.S. government technical reports (NASA and DoD reports) used in the past six months. Hypotheses H_5 through H_7 were tested by calculating (1) correlations between the number of externally produced information products used in the past 6 months (Pearson's *r*) with technical uncertainty and (2) performing t-tests to determine whether a significant relationship exists between the number of externally produced products used and the level of technical uncertainty of the project, task or problem. Results of these tests follow:

Technical Uncertainty Rating and Information Products Used:

	r
Journal Articles	.1097**
Conference/Meeting Papers	.0688
U.S. Government Technical Reports	.0862*

* $p \leq 0.01$.
** $p \leq 0.001$.

	Uncertainty Group	($\bar{X}$)	(n)	Significant Difference of Group Means?
Journal Articles**	Low	4.81	231	Yes*
	High	7.46	641	
Conference/Meeting Papers**	Low	2.70	231	Yes*
	High	4.10	641	
U.S. Government Technical Reports**	Low	2.70	231	Yes*
	High	4.10	641	

*$p \leq 0.05$.
** Item non-responses coded as 0.

The t-tests indicate that the differences in the mean number of externally produced information products used by the two uncertainty groups (low and high) are statistically significant. These results support the hypotheses which collectively state that as technical uncertainty increases, the frequency of use of externally produced information products increases.

Technical Uncertainty and External Information Use -- Colleagues Outside of the Organization

Hypothesis H_8 states that the use/non-use of technical information obtained from colleagues outside of the organization is related to the level (high or low) of technical uncertainty of job-related projects, tasks, or problems. This hypothesis was tested by cross-tabulating low and high technical uncertainty with the use/non-use of colleagues outside of the organization. The chi-square analysis follows. The chi-square test of independence revealed that information obtained from colleagues outside of the organization is related to the technical uncertainty of the job-related project, task, or problem.

Use of Colleagues Outside of the Organization

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	0	91 37.4% 39.4% 26.6	152 62.6% 23.7% -26.6	243 27.9%
Use	1	140 22.3% 60.6% -26.6	489 77.7% 76.3% 26.6	629 72.1%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	20.77192	1	.00001*

* p ≤ 0.05. ** Item non-responses coded as 0.

The chi-square statistic is significant at $p \leq 0.05$. Hypothesis H_8 (technical uncertainty is related to the use of colleagues outside of the organization) is supported.

Technical Uncertainty and the Use of Formal Information Sources

Hypotheses H_9 and H_{10} state that the technical uncertainty of job-related projects, tasks, and problems is related to: (1) the use of information obtained from a librarian/technical information specialist inside of the organization and (2) the use of information obtained from the organization's library. The technical uncertainty associated with the most important job-related project, task, or problem is categorized as low uncertainty and high uncertainty. The level of uncertainty is then cross-tabulated with (1) the use/non-use of a librarian/technical information specialist inside the organization and (2) the use/non-use of technical information obtained from the organization's library. The chi-square statistic is used to test for a significant relationship.

Use of a Librarian/Technical Information Specialist Inside the Organization

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	0	150 29.6% 64.9% 16.0	356 70.4% 55.5% -16.0	506 58.0%
Use	1	81 22.1% 35.1% -16.0	285 77.9% 44.5% 16.0	366 42.0%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	6.15629	1	.01309*

* p ≤ 0.05. ** Item non-responses coded as 0.

Use of Information Obtained From the Organization's Library

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	0	117 36.2% 50.6% 31.4	206 63.8% 32.1% -31.4	323 37.0%
Use	1	114 20.8% 49.4% -31.4	435 79.2% 67.9% 31.4	549 63.0%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	24.95292	1	.00000*

* $p \leq 0.05$
** Item non-responses coded as 0.

The chi-square test of independence revealed that a relationship exists between (1) the use of a librarian/technical information specialist inside the organization and the level (low or high) of technical uncertainty or a project, task or problem and (2) the use of technical information obtained from the organization's library and the level (low or high) of technical uncertainty of a project, task, or problem. Hypotheses H_9 and H_{10} are therefore supported.

Technical Uncertainty and the Use of Federally Funded Aerospace R&D

Hypotheses H_{11} through H_{17} state that the technical uncertainty of job-related projects, tasks, or problems is related to the use of federally funded aerospace R&D. Specifically, the seven hypotheses state that job-related projects, tasks, or problems characterized by high technical uncertainty are related to: (1) the use of federally funded R&D, (2) the use of federally funded aerospace R&D found in NASA or DoD technical reports, (3) the reported importance of federally funded aerospace R&D, (4) the use of colleagues outside of the organization to find out about the results of federally funded aerospace R&D, (5) the use of librarians/technical information specialists inside the organization to find out about the results of federally funded aerospace R&D, (6) the use of computerized data bases to find out about the results of federally funded aerospace R&D, and (7) the use of *STAR* to find out about the results of federally funded aerospace R&D. The results of chi-square analyses follow:

Use of Federally Funded Aerospace R&D

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	206 31.5% 89.2% 32.8	448 68.5% 69.9% -32.8	654 75.0%
Use	1.00	25 11.5% 10.8% -32.8	193 88.5% 30.1% 32.8	218 25.0%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	33.68742	1	.00000*

* p ≤ 0.05
** Item non-responses coded as 0.

Use of Federally Funded Aerospace R&D found in NASA or DoD Technical Reports

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	213 29.0% 92.2% 18.6	521 71.0% 81.3% -18.6	734 84.2%
Use	1.00	18 13.0% 7.8% -18.6	120 87.0% 18.7% 18.6	138 15.8%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	15.22424	1	.00010*

* p ≤ 0.05
** Item non-responses coded as 0.

The Importance of Federally Funded Aerospace R&D

Reported importance (1 = very unimportant; 5 = very important) of federally funded R&D used to complete or solve job-related projects, tasks, or problems was correlated with the level of technical uncertainty. Technical uncertainty was also correlated with the use of 1) colleagues outside of the organization, 2) librarian/technical information specialists inside the organization, 3) computerized data bases, and 4) *STAR* to find out about the results of federally funded aerospace (1 = never used; 4 = frequently used). Pearson's *r* correlation coefficients are listed below:

Technical Uncertainty Rating and Sources Used	*r*
Importance of Federally-Funded R&D	.2354*
Use of:	
Colleague Outside the Organization	.2241*
Librarian/Technical Information Specialist Inside the Organization	.2089*
Computerized Data Base	.2354*
STAR	.1600*

* $p \leq 0.001$.

Use of Colleagues Outside of the Organization

	Count / Row Pct / Col Pct / Residual	Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	179 33.0% 77.5% 35.2	364 67.0% 56.8% -35.2	543 62.3%
Use	1.00	52 15.8% 22.5% -35.2	277 84.2% 43.2% 35.2	329 37.7%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	30.98700	1	.00000*

* $p \leq 0.05$
** Item non-responses coded as 0.

Use of Librarian/Technical Information Specialist Inside the Organization

Count Row Pct Col Pct Residual		Technical Uncertainty: Low .00	 High 1.00	Row Total
Don't Use	.00	194 32.0% 84.0% 33.5	412 68.0% 64.3% -33.5	606 69.5%
Use	1.00	37 13.9% 16.0% -33.5	229 86.1% 35.7% 33.5	266 30.5%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	31.11160	1	.00000*

* p ≤ 0.05
** Item non-responses coded as 0.

Searches of Computerized Databases

Count Row Pct Col Pct Residual		Technical Uncertainty: Low .00	 High 1.00	Row Total
Don't Use	.00	194 32.6% 84.0% 36.1	402 67.4% 62.7% -36.1	596 68.3%
Use	1.00	37 13.4% 16.0% -36.1	239 86.6% 37.3% 36.1	276 31.7%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	35.50518	1	.00000*

* p ≤ 0.05
** Item non-responses coded as 0.

Use of Publications Such as *STAR*

	Count Row Pct Col Pct Residual	Technical Uncertainty: Low .00	 High 1.00	 Row Total
Don't Use	.00	196 29.9% 84.8% 22.2	460 70.1% 71.8% -22.2	656 75.2%
Use	1.00	35 16.2% 15.2% -22.2	181 83.8% 28.2% 22.2	216 24.8%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	15.60333	1	.00008*

* $p \leq 0.05$
** Item non-responses coded as 0.

The chi-square test of independence revealed that an association exists between the technical uncertainty of job-related projects, tasks, and problems and (1) the use of federally funded aerospace R&D, (2) the use of federally funded aerospace R&D found in NASA or DoD technical reports, (3) the importance of federally funded aerospace R&D, (4) the use of colleagues outside of the organization to find out about the results of federally funded aerospace R&D, (5) the use of librarians/technical information specialists inside the organization to find out about the results of federally funded aerospace R&D, (6) the use of computerized data bases to find out about federally funded aerospace R&D, and (7) the use of *STAR* to find out about the results of federally funded aerospace R&D. Therefore, hypotheses H_{11} through H_{17} are supported.

<u>Summary</u>

Seventeen hypotheses concerned with technical uncertainty and (1) information production/use, (2) external information use, (3) the use of formal information sources, and (4) the use of federally funded aerospace R&D were tested. The results of the tests follow:

	Technical Uncertainty and --	
	Not Accepted	Accepted
Information Production/Use		
Information Written to Others		X
Communicating Orally to Others	X	
Written Information from Others		X
Oral Communication from Others		X
External Information Use		
Journal Articles		X
Conference/Meeting Papers		X
U.S. Government Technical Reports		X
Colleagues Outside the Organization		X
Use of Formal Information Sources		
Librarian/Technical Information Specialist		X
Technical Information Obtained from the Organization's Library		X
Use of Federally Funded Aerospace R&D		
Use of Federally Funded Aerospace R&D		X
Use of NASA or DoD Technical Reports		X
Importance of Federally Funded Aerospace R&D		X
Colleagues Outside the Organization		X
Librarian/Technical Information Specialist		X
Computerized Data Base		X
Publications Such as *STAR*		X

Project Complexity and Information Product/Use

Hypotheses H_{18} through H_{21} state that as the complexity of job-related projects, tasks, or problems increases, the number of hours per week spent communicating technical information (orally and in writing) increases. Job-related projects, tasks, or problems were sorted into two categories for hypothesis testing: "low complexity" (complexity = 1, 2) and "high complexity" (complexity = 3, 4, 5). The mean number of hours per week spent (1) communicating technical information to others (both in writing and orally) and (2) working with technical information received (in writing and orally) from others was calculated for the two complexity groups. T-test results are as follows:

Communicating Technical Information To Others: (Output)	Complexity Group	($\bar{X}$)	(n)	Significant Difference of Group Means?
In Writing:	Low	9.25	71	No
	High	8.88	801	
Orally:	Low	9.91	71	No
	High	10.76	795	

Working With Technical Information Received From Others: (Input)	Complexity Group	($\bar{X}$)	(n)	Significant Difference of Group Means?
In Writing:	Low	6.71	71	No
	High	7.87	793	
Orally:	Low	6.00	70	No
	High	7.20	791	

*$p \leq 0.05$.

The differences between the group means for communicating technical information (written and oral) to others are not statistically significant. The differences between the group means for working with technical information (written and oral) received from others are also not statistically significant. Therefore, hypotheses H_{18} through H_{21}, which state that as the complexity of job-related projects, tasks or problems increases, the number of hours per week spent communicating technical information to others and working with technical information received from others, are not supported.

Project Complexity and External Information Use -- Products Used

Hypotheses H_{22} through H_{25} state that as the complexity of job-related projects, tasks, or problems increases, (1) the mean number of journal articles, conference/meeting papers, and U.S. government technical reports increases and (2) the frequency of use of information obtained from colleagues outside of the organization increases. Job-related projects, tasks, or problems are categorized as low complexity (complexity = 1, 2) or high complexity (complexity = 3, 4, 5). Correlations (Pearson's *r*) between complexity and the number of externally produced information products used in the past six months are listed, followed by t-test results used to test the four hypotheses:

Project Complexity Rating and Information Products Used

	r
Journal Articles	.1393**
Conference/Meeting Papers	.1225**
U.S. Government Technical Reports	.1360**

**p ≤ 0.001

	Complexity Group	($\bar{X}$)	(n)	Significant Difference of Group Means?
Journal Articles**	Low	4.81	231	Yes*
	High	7.46	641	
Conference/Meeting Papers**	Low	2.70	231	Yes*
	High	4.10	641	
U.S. Government Technical Reports**	Low	2.70	231	Yes*
	High	4.10	641	

*p ≤ 0.05. ** Item non-responses coded as 0.

Project Complexity and External Information Use -- Colleagues Outside of the Organization

The use of information obtained from colleagues outside of the organization was tested by cross-tabulating low and high project complexity with the use/non-use of colleagues outside of the organization. The results of the chi-square analysis follow.

Use of Colleagues Outside the Organization

	Count Row Pct Col Pct Residual	Project Complexity: Low .00	 High 1.00	Row Total
Don't Use	.00	29 11.9% 40.8% 9.2	214 88.1% 26.7% -9.2	243 27.9%
Use	1.00	42 6.7% 59.2% -9.2	587 93.3% 73.3% 9.2	629 72.1%
	Column Total	71 8.1%	801 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	6.47700	1	.01093*

* p ≤ 0.05. ** Item non-responses coded as 0.

The differences between the means for the use of journal articles, conference/meeting papers, and U.S. government technical reports are statistically significant. Furthermore, the chi-square test of independence revealed a relationship between the use of information obtained from colleagues outside of the organization and the level (low or high) of the complexity of a project, task, or problem. Hypotheses H_{22} through H_{25}, which state that there is a relationship between project complexity (low and high) and external information use, are supported.

Project Complexity and the Use of Formal Information Sources

Hypotheses H_{26} and H_{27} state that the complexity of job-related projects, tasks, or problems is related to: (1) the use of a librarian/technical information specialist inside the organization and (2) the use of technical information obtained from the organization's library. Again, job-related projects, tasks, and problems were grouped into categories representing low and high levels of complexity. Complexity was then cross-tabulated with (1) the use/non-use of a librarian/technical information specialist inside the organization and (2) the use/non-use of technical information obtained from the organization's library. The chi-square results follow:

Use of a Librarian/Technical Information Specialist Inside the Organization

	Count Row Pct Col Pct Residual	Project Complexity: Low .00	 High 1.00	Row Total
Don't Use	.00	51 10.1% 71.8% 9.8	455 89.9% 56.8% -9.8	506 58.0%
Use	1.00	20 5.5% 28.2% -9.8	346 94.5% 43.2% 9.8	366 42.0%
	Column Total	71 8.1%	801 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	6.04672	1	.01393*

* $p \leq 0.05$. ** Item non-responses coded as 0.

Use of Technical Information Obtained From the Organization's Library

	Count Row Pct Col Pct Residual	Project Complexity: Low .00	 High 1.00	 Row Total
Don't Use	.00	37 11.5% 52.1% 10.7	286 88.5% 35.7% -10.7	323 37.0%
Use	1.00	34 6.2% 47.9% -10.7	515 93.8% 64.3% 10.7	549 63.0%
	Column Total	71 8.1%	801 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	7.52848	1	.00607*

* $p \leq 0.05$
** Item non-responses coded as 0.

The chi-square test of independence revealed a relationship between level (low or high) of complexity of a project, task or problem and (1) the use of a librarian/technical information specialist inside the organization and (2) the use of technical information obtained from the organization's library. Hypotheses H_{26} and H_{27} are supported.

Project Complexity and the Use of Federally Funded Aerospace R&D

Hypotheses H_{28} through H_{33} state that the complexity of job-related projects, tasks, or problems and the use of federally funded aerospace R&D are related. Specifically, the seven hypotheses state that a relationship exists between the complexity of job related projects, tasks, or problems and (1) the use of federally funded aerospace R&D, (2) the use of federally funded aerospace R&D found in NASA or DoD technical reports, (3) the importance of federally funded aerospace R&D, (4) the use of colleagues outside of the organization to find out about the results of federally funded aerospace R&D, (5) the use of librarians/technical information specialists inside the organization to find out about the results of federally funded aerospace R&D, (6) the use of computerized data bases to find out about federally funded aerospace R&D, and (7) the use of *STAR* to find out about the results of federally funded aerospace R&D. The results of the chi-square analysis are as follow:

Use of Federally Funded R&D

Count / Row Pct / Col Pct / Residual		Project Complexity: Low .00	High 1.00	Row Total
Yes	1.00	4 1.8% 5.6% -13.8	214 98.2% 26.7% 13.8	218 25.0%
No	2.00	67 10.2% 94.4% 13.8	587 89.8% 73.3% -13.8	654 75.0%
	Column Total	71 8.1%	801 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	15.46072	1	.00008*

* p ≤ 0.05
** Item non-responses coded as 0.

Use of Federally Funded Aerospace R&D Found in NASA or DoD Technical Reports

Count / Row Pct / Col Pct / Residual		Project Complexity: Low .00	High 1.00	Row Total
Yes	1.00	2 1.4% 2.8% -9.2	136 98.6% 17.0% 9.2	138 15.8%
No	2.00	69 9.4% 97.2% 9.2	665 90.6% 83.0% -9.2	734 84.2%
	Column Total	71 8.1%	801 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	9.81915	1	.00173*

* p ≤ 0.05
** Item non-responses coded as 0.

The Importance of Federally Funded Aerospace R&D

The reported importance of using federally funded aerospace R&D to complete or solve job-related projects, tasks or problems was correlated (Pearson's *r*) with the level of project complexity (see below). The use of 1) colleagues outside of the organization, 2) librarian/technical information specialists inside the organization, 3) computerized databases, and 4) *STAR* to find out about the results of federally funded aerospace R&D were also correlated with job complexity (1 = never used; 4 = frequently used).

Project Complexity and Importance of Sources Used

	r
Importance of Federally - Funded R&D	.2384*
Use of:	
Colleague Outside the Organization	.2296*
Librarian/Technical Information Specialist Inside the Organization	.2278*
Computerized Data Base	.2311*
STAR	.1881*

* $p \leq 0.001$

Use of Colleagues Outside of the Organization

	Count / Row Pct / Col Pct / Residual	Project Complexity: Low .00	High 1.00	Row Total
No	.00	60 11.0% 84.5% 15.8	483 89.0% 60.3% -15.8	543 62.3%
Yes	1.00	11 3.3% 15.5% -15.8	318 96.7% 39.7% 15.8	329 37.7%
	Column Total	13 8.1%	357 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	16.26704	1	.00006*

* $p \leq 0.05$
** Item non-responses coded as 0.

Use of Librarian/Technical Information Specialist Inside the Organization

Use of Librarian/Technical Information Specialist Inside the Organization

Count Row Pct Col Pct Residual		Project Complexity: Low 1.00	High 2.00	Row Total
No	.00	63 10.4% 88.7% 13.7	543 89.6% 67.8% -13.7	606 69.5%
Yes	1.00	8 3.0% 11.3% -13.7	258 97.0% 32.2% 13.7	266 30.5%
	Column Total	71 8.1%	801 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	13.49258	1	.00024*

* $p \le 0.05$
** Item non-responses coded as 0.

Searches of Computerized Data Bases

Count Row Pct Col Pct Residual		Project Complexity: Low 1.00	High 2.00	Row Total
No	.00	67 11.2% 94.4% 18.5	529 88.8% 66.0% -18.5	596 68.3%
Yes	1.00	4 1.4% 5.6% -18.5	272 98.6% 34.0% 18.5	276 31.7%
	Column Total	13 8.1%	357 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	24.18541	1	.00000*

* $p \le 0.05$
** Item non-responses coded as 0.

Use of Publications Such As *STAR*

	Count Row Pct Col Pct Residual	Project Complexity: Low 1.00	High 2.00	Row Total
No	.00	65 9.9% 91.5% 11.6	591 90.1% 73.8% -11.6	656 75.2%
Yes	1.00	6 2.8% 8.5% -11.6	210 97.2% 26.2% 11.6	216 24.8%
	Column Total	71 8.1%	801 91.9%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	11.04726	1	.00089*

* $p \leq 0.05$
** Item non-responses coded as 0.

The chi-square test of independence revealed that a relationship exists between the complexity of job-related projects, tasks, or problems and (1) the use of federally funded aerospace R&D, (2) the use of federally funded aerospace R&D found in NASA or DoD technical reports, (3) the importance of federally funded aerospace R&D, (4) the use of colleagues outside of the organization to find out about the results of federally funded aerospace R&D, (5) the use of librarians/technical information specialists inside the organization to find out about the results of federally funded aerospace R&D, (6) the use of computerized data bases to find out about federally funded R&D, and (7) the use of *STAR* to find out about the results of federally funded aerospace R&D. Therefore, hypotheses H_{28} through H_{33} are supported.

Summary

Seventeen hypotheses (H_{18} through H_{33}) concerned with project complexity and (1) information production and use, (2) use of external information, (3) the use of formal information sources, and (4) the use of federally funded aerospace R&D were tested. The results of these tests are summarized as follows:

	Project Complexity and --	
	Not Accepted	Accepted
Information Production/Use		
Information Written to Others	X	
Communicating Orally to Others	X	
Written Information from Others	X	
Oral Communication from Others	X	
External Information Use		
Journal Articles		X
Conference/Meeting Papers		X
U.S. Government Technical Reports		X
Colleagues Outside the Organization		X
Use of Formal Information Sources		
Librarian/Technical Information Specialist		X
Technical Information Obtained from the Organization's Library		X
Use of Federally Funded Aerospace R&D		
Use of Federally Funded Aerospace R&D		X
Use of NASA or DoD Technical Reports		X
Importance of Federally Funded Aerospace R&D		X
Colleagues Outside the Organization		X
Librarian/Technical Information Specialist		X
Computerized Data Base		X
Publications Such as *STAR*		X

SUMMARY AND DISCUSSION OF THE RESULTS

An exploratory study was conducted that investigated the influence of two variables -- technical uncertainty and project complexity -- on the use of information and information sources in completing or solving a project, task, or problem. The results support the findings of previous research. The results also support the following study assumptions.

1. In the U.S. aerospace industry, technical uncertainty and complexity are positively correlated.

2. Information use and information-source use patterns differ for industry-affiliated U.S. aerospace engineers and scientists working on projects, problems, and tasks with high and low technical uncertainty and complexity.

3. As technical uncertainty and/or project complexity increase(s), information-source use changes from **internal** to **external** and from **informal** to **formal**. Specifically, industry-affiliated U.S. aerospace engineers and scientists working on projects, problems, and tasks with high technical uncertainty and complexity make greater use of **external** sources of information such as (1) colleagues outside their organization, (2) published sources of written information originating outside their organization (e.g., conference/meeting papers, journal articles, and technical reports), and (3) **formal** information sources including the organization's library or technical information center and the organization's librarian/ technical information specialist.

4. The use of federally funded aerospace R&D is different for industry-affiliated U.S. aerospace engineers and scientists working on projects, problems, and tasks with high and low technical uncertainty and complexity.

5. As technical uncertainty and/or project complexity increase(s), so too does the use of federally funded aerospace R&D, thereby supporting the assumption that the results of federally funded aerospace R&D are used by U.S. aerospace engineers and scientists in industry to moderate (reduce) technical uncertainty and project complexity.

6. The use of formal information sources to learn about federally funded aerospace R&D is different for industry-affiliated U.S. aerospace engineers and scientists working on projects, problems, and tasks with high and low technical uncertainty and complexity.

Given the limited purposes of this exploratory study and the research design, the results help explain but cannot be used to predict information use. A more rigorous research design and methodology is needed before any such claims of prediction could be made. Certain scales of measurement used in this study would have to be changed and Flanagan's critical incident technique followed more closely.

REFERENCES

Allen, Thomas J. (1970). "Roles in Technical Communication Networks." In *Communication Among Scientists and Engineers,* Carnot E. Nelson and Donald K. Pollack, eds. (Lexington, MA: D.C. Heath), 191-208.

Allen, Thomas J. (1977). *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information Within the R&D Organization.* (Cambridge, MA: MIT Press.)

Aguilar, F. J. (1967). *Scanning the Business Environment.* (NY: Macmillan.)

Anthony, L. J.; H. East; and M.J. Slater. (1969). "The Growth of the Literature of Physics." *Reports on Progress in Physics* 32, 709-767.

Atkin, Charles. (1973). "Instrumental Utilities and Information Seeking." Chapter 7 in *New Model for Mass Communication Research,* Peter Clarke, ed. (Beverley Hills, CA: Sage Publications), 205-242.

Auster, Ethel and Chun Wei Choo. (1993). "Environmental Scanning By CEOs in Two Canadian Industries." *Journal of the American Society For Information Science* 44:4 (May), 194-203.

Bodensteiner, W. D. (1970). *Information Channel Utilization Under Varying Research and Development Project Conditions: An Aspect of Inter-Organizational Communications Channel Usage.* Ph.D. Diss., University of Texas, Austin. UMI 70-18205.

Derian, Jean-Claude. (1990). *American's Struggle For Leadership in Technology.* (Cambridge, MA: The MIT Press.)

Dervin, Brenda. (1983). "Information As a User Construct: The Relevance of Perceived Information Needs to Synthesis and Interpretation." In *Knowledge Structure and Use: Implications for Synthesis and Interpretation,* S. A. Ward and L. J. Reed, eds. (Philadelphia, PA: University Press), 153-183.

Duncan, Robert B. (1972). "Characteristics of Organizational Environments and Perceived Environmental Uncertainty." *Administrative Science Quarterly* 17, 313-327.

Duncan, Robert B. (1973). "Multiple Decision-Making Structures in Adapting Environmental Uncertainty: The Impact on Organizational Effectiveness" *Human Relations* 26:3, 273-291.

Fischer, William A. (1980). "Scientific and Technical Information and the Performance of R&D Groups." In *Management of Research and Innovation,* Burton V. Dean and Joel L. Goldhar, eds. (NY: North-Holland Publishing Company), 67-89.

Flanagan, John. (1954). "The Critical Incident Technique." *Psychological Bulletin* 51:4 (July), 327-358.

Galbraith, John K. (1973). *Designing Complex Organizations.* (Reading, MA: Addison-Wesley.)

Gerstenfeld, Arthur and Paul Berger. (1980). "An Analysis of Utilization Differences for Scientific and Technical Information." *Management Science* 26:2 (February), 165-179.

Gifford, W., H. Bobbitt, and S. Slocum. (1979). "Message Characteristics and Perceptions of Uncertainty by Organizational Decision Makers." *Academy of Management Journal* 22:1, 458-481.

Hambrick, Donald C. (1979). *Environmental Scanning, Organizational Strategy and Executive Roles: A Study in Three Industries.* Ph.D. Diss., Pennsylvania State University, UMI 79-22294.

Holland, W. E.; B. A. Stead; and R. C. Leibrock. (1976). "Information Channel/Source Selection As a Correlate of Technical Uncertainty in a Research and Development Organization." *IEEE Transactions on Engineering Management* EM-23:4 (November): 163-167.

Katz, Daniel and Robert L. Kahn. (1966). *The Social Psychology of Organizations.* (NY: John Wiley.)

Keegan, W.J. (1974). "Multinational Scanning: A Study of the Information Sources Utilized by Headquarters Executives in Multinational Companies." *Administrative Science Quarterly* 19, 441-442.

Kline, Stephen J. (1985). "Innovation Is Not a Linear Process." *Research Management* (July/August), 36-45.

Kuhlthau, Carol C. (1991). "Inside the Search Process: Information Seeking From the User's Perspective." *Journal of the American Society for Information Science* 42:5 (June), 361-371.

Lancaster, F. Wilfrid. (1978). *Critical Incident Technique.* (Urbana, IL: University of Illinois, Graduate School of Library and Information Science.)

Langrish, J; M. Gibbons; W.G. Evans; and F.R. Jevons. (1972). *Wealth From Knowledge: A Study of Innovation in Industry.* (NY: John Wiley.)

Mick, Colin K., Georg N. Lindsey, Daniel Callahan, and Frederick Spielberg. (1979). *Towards Usable User Studies: Assessing the Information Behavior of Scientists and Engineers.* Washington, DC: National Science Foundation. (Available from NTIS, Springfield, VA; PB80-177165.)

Miller, Roger-Emile. (1971). *Innovation, Organization, and Environment: A Study of Sixteen American and West European Steel Firms.* (Sherbrooke: University of Sherbrooke Press).

Mowery, David C. (1985). "Federal Funding of R&D in Transportation: The Case of Aviation." Paper commissioned for a workshop on *The Federal Role in Research and Development,* November 21-22, 1985, held in Washington, DC, and sponsored by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

Myers, Sumner and Donald G. Marquis. (1969). *Successful Industrial Innovations: A Study of the Factors Underlying Innovation in Selected Firms.* Washington, DC: National Science Foundation. (Not available from NTIS.)

Orr, Richard H. (1970). "The Scientist as an Information Processor: A Conceptual Model Illustrated with Data on Variables Related to Library Utilization." In *Communication Among Scientists and Engineers,* Carnot E. Nelson and Donald K. Pollack, eds. (Lexington, MA: D.C. Heath), 143-189.

Paisley, W. J. (1968). "Information Needs and Uses." In *Annual Review of Information Science and Technology,* Vol. 3, Carlos A. Cuadra, ed. (NY: John Wiley), 1-30.

Paisley, W. J. (1980). "Information and Work." In Vol. 2 of *Progress in Communication Sciences,* B. Dervin and M.J. Voight, eds. (Norwood, NJ: Ablex Publishing), 113-165.

Pinelli, Thomas E. (1991). *The Relationship Between the Use of U.S. Government Technical Reports by U.S. Aerospace Engineers and Scientists and Selected Institutional and Sociometric Variables.* Washington, DC: National Aeronautics and Space Administration. NASA TM-102774, January. (Available from NTIS, Springfield, VA; N9118898.)

Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. (1989). *Technical Communication in Aeronautics: Results of an Exploratory Study.* Part 1. Washington, DC: National Aeronautics and Space Administration. NASA TM-101534, February. (Available from NTIS, Springfield, VA; 89N26772.)

Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. (1992). *Engineering Work and Information Use in Aerospace: Results of a Telephone Survey.* Washington, DC: National Aeronautics and Space Administration. NASA TM-107673, October. (Available from NTIS, Springfield, VA; 92N34233.)

Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. (June 1991). "The Diffusion of Federally Funded Aerospace Research and Development (R&D) and the Information-Seeking Behavior of U.S. Aerospace Engineers and Scientists." Paper Presented at the *Special Libraries Association (SLA) 82nd Annual Conference*, San Antonio, TX. (Available from AIAA 92A29652).

Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. (1991). "The NASA/DoD Aerospace Knowledge Diffusion Research Project." *Government Information Quarterly* 8:2, 219-233.

Randolph, W. Alan. (1978). "Organization Technology and the Media and Purpose Dimensions of Organization Communications." *Journal of Business Research* 6, 237-259.

Roberts, N. (1982). "In Search of Information Man." *Social Science Information Studies* 2, (April), 93-104.

Rogers, Everett M. (1982). "Information Exchange and Technological Innovation." In *The Transfer and Utilization of Technical Knowledge*, Devendra Sahal, ed. (Lexington, MA: D.C. Heath) 105-123.

Rohde, Nancy F. (1986). "Information Needs." In *Advances in Librarianship*, Vol. 14. W. Simonton, ed. (NY: Academic Press), 49-73.

Rosenbloom, Richard S. and Francis W. Wolek. (1970). *Technology and Information Transfer: A Survey of Practice in Industrial Organizations*. (Boston: Harvard University.)

Shuchman, Hedvah L. (1981). *Information Transfer in Engineering*. (Glastonbury, CT: The Futures Group.)

Systems Development Corporation. (1966). *A System Study of Abstracting and Indexing in the United States*. Technical Memorandum WD-394. Falls Church, VA: Systems Development Corporation, 16 December. (Available from NTIS Springfield, VA; PB 174-249.)

Taylor, Robert S. (1991). "Information Use Environments." In Vol. 10 of *Progress in Communication Sciences*, B. Dervin and M.J. Voight, eds. (Norwood, NJ: Ablex Publishing), 217-255.

Tushman, Michael L. and David A. Nadler. (1978). "Information Processing as an Integrating Concept in Organizational Design." *Academy of Management Review* 3:1, 613-624.

Tushman, Michael L. and David A. Nadler. (1980). "Communication and Technical Roles in R&D Laboratories: An Information Processing Model." In *Management of Research and Innovation,* Burton V. Dean and Joel L. Goldhar, eds. (NY: North-Holland Publishing Company), 91-112.

Tyson, D'Andrea Laura. (1992). "Industrial Policy and Trade Management and the Commercial Aircraft Industry." In *Who's Bashing Whom? Trade Conflict In High-Technology Industries*. (Washington, DC: Institute for International Economics), 155-216.

Utterback, James M. (1974). "Innovation in Industry and the Diffusion of Technology." *Science* 183 (15 February), 620-626.

Vincenti, Walter G. (1990). *What Engineers Know and How They Know It: Analytical Studies From Aeronautical History.* (Baltimore, MD: Johns-Hopkins University Press.)

Wilson, T.D. (1981). "On User Studies and Information Needs." *Journal of Documentation* 37, 3-15.

APPENDIX A

NASA/DoD AEROSPACE KNOWLEDGE DIFFUSION RESEARCH PROJECT

Fact Sheet

The production, transfer, and use of scientific and technical information (STI) is an essential part of aerospace R&D. We define STI production, transfer, and use as *Aerospace Knowledge Diffusion*. Studies tell us that timely access to STI can increase productivity and innovation and help aerospace engineers and scientists maintain and improve their professional skills. These same studies remind us that we know little about aerospace knowledge diffusion or about how aerospace engineers and scientists find and use STI. To learn more about this process, we have organized a research project to study knowledge diffusion. Sponsored by NASA and the Department of Defense (DoD), the NASA/DoD Aerospace Knowledge Diffusion Research Project is being conducted by researchers at the NASA Langley Research Center, the Indiana University Center for Survey Research, and Rensselaer Polytechnic Institute. This research is endorsed by several aerospace professional societies including the AIAA, RAeS, and DGLR and has been sanctioned by the AGARD and AIAA Technical Information Panels.

This 4-phase project is providing descriptive and analytical data regarding the flow of STI at the individual, organizational, national, and international levels. It is examining both the channels used to communicate STI and the social system of the aerospace knowledge diffusion process. Phases 1 investigates the information-seeking habits and practices of U.S. aerospace engineers and scientists and places particular emphasis on their use of government funded aerospace STI. Phase 2 examines the industry-government interface and places special emphasis on the role of the information intermediary in the knowledge diffusion process. Phase 3 concerns the academic-government interface and places specific emphasis on the information intermediary-faculty-student interface. Phase 4 explores the information-seeking behavior of non-U.S. aerospace engineers and scientists from Brazil, Western Europe, India, Israel, Japan, and the Soviet Union.

The results will help us to understand the flow of STI at the individual, organizational, national, and international levels. The results of our research will contribute to increasing productivity and to improving and maintaining the professional competence of aerospace engineers and scientists. They can be used to identify and correct deficiencies, to improve access and use, to plan new aerospace STI systems, and should provide useful information to R&D managers, information managers, and others concerned with improving access to and utilization of STI. The results of our research are being shared freely with those who participate in the study. You can get copies of the project publications by contacting Dr. Pinelli.

Dr. Thomas E. Pinelli
Mail Stop 180A
NASA Langley Research Center
Hampton, VA 23665
(804) 864-2491
Fax (804) 864-8311
tompin@teb.larc.nasa.gov

Dr. John M. Kennedy
Center for Survey Research
Indiana University
Bloomington, IN 47405
(812) 855-2573
Fax (812) 855-2818
kennedy@ismail.soc.indiana.edu

Rebecca O. Barclay
Dept. of Language, Literature & Communication
Rensselaer Polytechnic Institute
Troy, NY 12180
(518) 276-8983
Fax (518) 276-6783

APPENDIX B

NASA/DoD AEROSPACE KNOWLEDGE DIFFUSION RESEARCH PROJECT PUBLICATIONS

REPORTS

Report No.

1 PART 1 Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communications in Aerospace: Results of Phase 1 Pilot Study.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101534. February 1989. 106 p. (Available from NTIS 89N26772.)

1 PART 2 Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communications in Aerospace: Results of a Phase 1 Pilot Study.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101534. February 1989. 83 p. (Available from NTIS 89N26773.)

2 Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communication in Aerospace: Results of Phase 1 Pilot Study -- An Analysis of Managers' and Nonmanagers' Responses.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101625. August 1989. 58 p. (Available from NTIS 90N11647.)

3 Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communication in Aerospace: Results of Phase 1 Pilot Study -- An Analysis of Profit Managers' and Nonprofit Managers' Responses.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101626. October 1989. 71 p. (Available from NTIS 90N15848.)

4 Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 1 Respondents.** Washington, DC: National Aeronautics and Space Administration. NASA TM-102772. January 1991. 8 p. (Available from NTIS 91N17835.)

5 Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 1 Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-102773. January 1991. 53 p. (Available from NTIS 91N20988.)

6 Pinelli, Thomas E. **The Relationship Between the Use of U.S. Government Technical Reports by U.S. Aerospace Engineers and Scientists and Selected Institutional and Sociometric Variables.** Washington, DC: National Aeronautics and Space Administration. NASA TM-102774. January 1991. 350 p. (Available from NTIS 91N18898.)

7 Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 2 Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104063. March 1991. 42 p. (Available from NTIS 91N22931.)

8 Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 3 Faculty and Student Respondents.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104085. June 1991. 8 p. (Available from NTIS 91N24943.)

9 Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 3 Faculty and Student Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104086. June 1991. 42 p. (Available from NTIS 91N25950.)

10 Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 3 Academic Library Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104095. August 1991. 42 p. (Available from NTIS 91N33013.)

11 Pinelli, Thomas E.; Madeline Henderson; Ann P. Bishop; and Philip Doty. **Chronology of Selected Literature, Reports, Policy Instruments, and Significant Events Affecting Federal Scientific and Technical Information (STI) in the United States.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101662. January 1992. 130 p. (Available from NTIS 92N17001.)

12 Glassman, Nanci A. and Thomas E. Pinelli. **An Initial Investigation Into the Production and Use of Scientific and Technical Information (STI) at Five NASA Centers: Results of a Telephone Survey.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104173. June 1992. 80 p. (Available from NTIS 92N27170.)

13 Pinelli, Thomas E. and Nanci A. Glassman. **Source Selection and Information Use by U.S. Aerospace Engineers and Scientists: Results of a Telephone Survey.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107658. September 1992. 27 p. (Available from NTIS 92N33299.)

14 Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Engineering Work and Information Use in Aerospace: Results of a Telephone Survey.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107673. October 1992. 25 p. (Available from NTIS 92N34233.)

15 Pinelli, Thomas E.; Nanci A. Glassman; Linda O. Affelder; Laura M. Hecht and John M. Kennedy; and Rebecca O. Barclay **Technical Uncertainty and Project Complexity as Correlates of Information Use by U.S. Industry-Affiliated Aerospace Engineers and Scientists: Results of an Explanatory Investigation.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107693. September 1993. 68 p. (NTIS pending.)

16 Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. **A Comparison of the Technical Communications Practices of Russian and U.S. Aerospace Engineers and Scientists.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107714. January 1993. 56 p. (Available from NTIS 93N18160.)

17 Barclay, Rebecca O.; Thomas E. Pinelli; and John M. Kennedy. **A Comparison of the Technical Communication Practices of Dutch and U.S. Aerospace Engineers and Scientists.** Washington, DC: National Aeronautics and Space Administration. NASA TM-108987. July 1993. 69 p. (NTIS pending.)

18 Pinelli, Thomas E.; Rebecca O. Barclay; and John M. Kennedy. **A Comparison of the Technical Communication Practices of Aerospace Engineers and Scientists in India and the United States.** Washington, DC: National Aeronautics and Space Administration. NASA TM-109006. September 1993. 68 p. (NTIS pending.)

PAPERS

Paper No.

1 Pinelli, Thomas E.; Myron Glassman; Rebecca O. Barclay; and Walter E. Oliu. **The Value of Scientific and Technical Information (STI), Its Relationship to Research and Development (R&D), and Its Use by U.S. Aerospace Engineers and Scientists.** Paper presented at the European Forum "External Information: A Decision Tool" January 19, 1990, Strasbourg, France. (Available from AIAA 90A21931.)

2 Blados, Walter R.; Thomas E. Pinelli; John M. Kennedy; and Rebecca O. Barclay. **External Information Sources and Aerospace R&D: The Use and Importance of Technical Reports by U.S. Aerospace Engineers and Scientists.** Paper prepared for the 68th AGARD National Delegates Board Meeting, 29 March 1990, Toulouse, France. (Available from NTIS 90N30132.)

3 Kennedy, John M. and Thomas E. Pinelli. **The Impact of a Sponsor Letter on Mail Survey Response Rates.** Paper presented at the Annual Meeting of the American Association for Public Opinion Research, May 1990, Lancaster, PA. (Available from NTIS 92N28112.)

4 Pinelli, Thomas E.; Rebecca O. Barclay; John M. Kennedy; and Myron Glassman. **Technical Communications in Aerospace: An Analysis of the Practices Reported by U.S. and European Aerospace Engineers and Scientists.** Paper presented at the International Professional Communication Conference (IPCC), Post House Hotel, Guilford, England, 14 September 1990. (Available from NTIS 91N14079; and AIAA 91A19799.)

5 Pinelli, Thomas E. and John M. Kennedy. **Aerospace Librarians and Technical Information Specialists as Information Intermediaries: A Report of Phase 2 Activities of the NASA/DoD Aerospace Knowledge Diffusion Research Project.** Paper presented at the Special Libraries Association, Aerospace Division - 81st Annual Conference, Pittsburgh, PA, June 13, 1990. (Available from AIAA 91A19804.)

6 Pinelli, Thomas E. and John M. Kennedy. **Aerospace Knowledge Diffusion in the Academic Community: A Report of Phase 3 Activities of the NASA/DoD Aerospace Knowledge Diffusion Research Project.** Paper presented at the 1990 Annual Conference of the American Society for Engineering Education - Engineering Libraries Division, Toronto, Canada, June 27, 1990. (Available from AIAA 91A19803.)

7 Pinelli, Thomas E. and John M. Kennedy. **The NASA/DoD Aerospace Knowledge Diffusion Research Project: The DoD Perspective.** Paper presented at the Defense Technical Infoımation Center (DTIC) 1990 Annual Users Training Conference, Alexandria, VA, November 1, 1990. (Available from AIAA 91N28033.)

8 Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. **The Role of the Information Intermediary in the Diffusion of Aerospace Knowledge.** Reprinted from *Science and Technology Libraries,* Volume 11, No. 2 (Winter), 1990: 59-76. (Available from NTIS 92N28113.)

9 Eveland, J.D. and Thomas E. Pinelli. **Information Intermediaries and the Transfer of Aerospace Scientific and Technical Information (STI): A Report From the Field.** Paper commissioned for presentation at the 1991 NASA STI Annual Conference held at the NASA Marshall Space Flight Center, Huntsville, AL, April 9, 1991. (Available from NTIS 91N21959.)

10 Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. **The NASA/DoD Aerospace Knowledge Diffusion Research Project.** Reprinted from *Government Information Quarterly,* Volume 8, No. 2 (1991): 219-233. (Available from AIAA 91A35455.)

11 Pinelli, Thomas E. and John M. Kennedy. **The Voice of the User -- How U.S. Aerospace Engineers and Scientists View DoD Technical Reports.** Paper presented at the 1991 Defense Technical Information Center's (DTIC) Managers Planning Conference, Solomon's Island Holiday Inn, MD, May 1, 1991. (Available from AIAA 91A41123.)

12 Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. **The Diffusion of Federally Funded Aerospace Research and Development (R&D) and the Information-Seeking Behavior of U.S. Aerospace Engineers and Scientists.** Paper presented at the Special Libraries Association (SLA) 82nd Annual Conference, San Antonio, TX, June 11, 1991. (Available from AIAA 92A29652.)

13 Pinelli, Thomas E. **The Information-Seeking Habits and Practices of Engineers.** Reprinted from *Science & Technology Libraries,* Volume 11, No. 3, (Spring) 1991: 5-25. (Available from NTIS 92N28114.)

14 Barclay, Rebecca O.; Thomas E. Pinelli; David Elazar; and John M. Kennedy. **An Analysis of the Technical Communications Practices Reported by Israeli and U.S. Aerospace Engineers and Scientists.** Paper presented at the International Professional Communication Conference (IPCC), The Sheraton World Resort, Orlando, FL, November 1, 1991. (Available from NTIS 92N28183.)

15 Barclay, Rebecca O.; Thomas E. Pinelli; Michael L. Keene; John M. Kennedy; and Myron Glassman. **Technical Communications in the International Workplace: Some Implications for Curriculum Development.** Reprinted from *Technical Communication*, Volume 38, No. 3 (Third Quarter, August 1991): 324-335. (Available from NTIS 92N28116.)

16 Pinelli, Thomas E.; John M. Kennedy; Rebecca O. Barclay; and Terry F. White. **Aerospace Knowledge Diffusion Research.** Reprinted from *World Aerospace Technology '91: The International Review of Aerospace Design and Development*, Volume 1 (1991): 31-34. (Available from NTIS 92N28220.)

17 Pinelli, Thomas E.; Rebecca O. Barclay; John M. Kennedy; Nanci Glassman; and Loren Demerath. **The Relationship Between Seven Variables and the Use of U.S. Government Technical Reports by U.S. Aerospace Engineers and Scientists.** Paper presented at the 54th Annual Meeting of the American Society for Information Science (ASIS), The Washington Hilton & Towers, Washington, DC, October 30, 1991. (Available from NTIS 92N28115.)

18 Hernon, Peter and Thomas E. Pinelli. **Scientific and Technical Information (STI) Policy and the Competitive Position of the U.S. Aerospace Industry.** Paper presented at the 30th Aerospace Meeting of the American Institute of Aeronautics and Astronautics (AIAA), Bally's Grand Hotel, Reno, NV, January 1992. (Available from AIAA 92A28233.)

19 Pinelli, Thomas E.; John M. Kennedy; Rebecca O. Barclay; and Ann P. Bishop. **Computer and Information Technology and Aerospace Knowledge Diffusion.** Paper presented at the Annual Meeting of the American Association for the Advancement of Science (AAAS), The Hyatt Regency Hotel, Chicago, IL, February 8, 1992. (Available from NTIS 92N28211.)

20 Holland, Maurita P.; Thomas E. Pinelli; Rebecca O. Barclay; and John M. Kennedy. **Engineers As Information Processors: A Survey of U.S. Aerospace Engineering Faculty and Students.** Reprinted from the *European Journal of Engineering Education*, Volume 16, No. 4 (1991): 317-336. (Available from NTIS 92N28155.)

21 Pinelli, Thomas E.; Rebecca O. Barclay; Maurita P. Holland; Michael L. Keene; and John M. Kennedy. **Technological Innovation and Technical Communications: Their Place in Aerospace Engineering Curricula. A Survey of European, Japanese, and U.S. Aerospace Engineers and Scientists.** Reprinted from the *European Journal of Engineering Education*, Volume 16, No. 4 (1991): 337-351. (Available from NTIS 92N28184.)

22 Pinelli, Thomas E. **Establishing a Research Agenda for Scientific and Technical Information (STI): Focus on the User.** Paper presented at the "Research Agenda in Information Science" workshop sponsored by the Advisory Group for Aerospace Research and Development (AGARD), April 7-9 1992, Lisbon, Portugal. (Available from NTIS 92N28117.)

23 Pinelli, Thomas E.; Rebecca O. Barclay; Ann P. Bishop; and John M. Kennedy. **Information Technology and Aerospace Knowledge Diffusion: Exploring the Intermediary-End User Interface in a Policy Framework.** Reprinted from *Electronic Networking: Research, Applications and Policy.* 2:2 (Summer 1992): 31-49. (Available from NTIS 93N12007.)

24 Brinberg, Herbert R. and Thomas E. Pinelli. **A General Approach to Measuring the Value of Aerospace Information Products and Services.** Paper presented at the 31st Aerospace Sciences Meeting and Exhibits of the American Institute of Aeronautics and Astronautics (AIAA), Bally's Grand Hotel, Reno, Nevada, January 11-13, 1993. (Available from AIAA 93A17511.)

25 Kohl, John R.; Rebecca O. Barclay; Thomas E. Pinelli; Michael L. Keene; and John M. Kennedy. **The Impact of Language and Culture on Technical Communication in Japan.** Reprinted from *Technical Communication*, Volume 40, No. 1 (First Quarter, February 1993): 62-73. (Available from NTIS 93N17592.)

26 Pinelli, Thomas E.; Rebecca O. Barclay; and John M. Kennedy. **The Relationship Between Technology Policy and Scientific and Technical Information Within the U.S. and Japanese Aerospace Industries.** Paper presented at the Third Annual JICST/NTIS Conference on *How to Locate and Acquire Japanese Scientific and Technical Information*, The Nikko Hotel, San Francisco, California, March 18, 1993. (Available from NTIS 93N20111).

27 Pinelli, Thomas E.; Rebecca O. Barclay; Stan Hannah; Barbara Lawrence; and John M. Kennedy. **Knowledge Diffusion and U.S. Government Technology Policy: Issues and Opportunities for Sci/Tech Librarians.** Reprinted from *Science and Technology Libraries*, Volume 13, Number 1 (1992): 33-55. (Available from NTIS 93N20110 and A9329922.)

28 Pinelli, Thomas E.; Rebecca O. Barclay; Michael L. Keene; Madelyn Flammia; and John M. Kennedy. **The Technical Communication Practices of Russian and U. S. Aerospace Engineers and Scientists.** Reprinted from *IEEE Transactions on Professional Communication*, Volume 36, No. 2 (June 1993): 95-104 (Available from NTIS N9328948).

29 Pinelli, Thomas E.; Rebecca O. Barclay; and John M. Kennedy. **The U.S. Government Technical Report and the Transfer of Federally Funded Aerospace R&D.** Reprinted from *Government Publications Review*, Volume 20, No. 3 (July/August 1993): 393-411. (NTIS pending.)

30 Pinelli, Thomas E.; Ann P. Bishop; Rebecca O. Barclay; and John M. Kennedy. **The Electronic Transfer of Information and Aerospace Knowledge Diffusion.** Reprinted from the *International Forum on Information and Documentation*, Volume 17, No. 4 (October 1992): 8-16. (Available from NTIS N9330036.)

31 Pinelli, Thomas E.; Ann P. Bishop; Rebecca O. Barclay; and John M. Kennedy. **The Information - Seeking Behavior of Engineers.** Reprinted from the *Encyclopedia of Library and Information Science*, Volume 52, Supplement 15 (1993): 167-201. (NTIS pending.)

3 2 Flammia, Maselyn; Rebecca O. Barclay; Thomas E. Pinelli; Michael L. Keene; Robert H. Burger; and John M. Kennedy. **A New Era in International Technical Communication: American-Russian Collaboration**. Reprinted from the *Proceedings of the International Professional Communication Conference (IPCC), Philadelphia, PA, October 5-8, 1993; 217-221.* (NTIS pending.)

3 3 Barclay, Rebecca O.; Thomas E. Pinelli; Axel S. T. Tan; and John M. Kennedy. **Technical Communications Practices and the Use of Information Technologies as Reported by Dutch and U.S. Aerospace Engineers and Scientists.** Reprinted from the *Proceedings of the International Professional Conference (IPCC)*, Philadelphia, PA, October 5-8, 1993: 221-226. (NTIS pending.)

3 4 Pinelli, Thomas E.; Rebecca O. Barclay; and John M. Kennedy. **Users and Uses of DoD Technical Reports: A Report From the Field.** *Paper presented at the 1993 Military Librarians Workshop, Albuquerque, NM, November 15-19, 1993.* (NTIS pending.)

APPENDIX C
SAE TELEPHONE INSTRUMENT

1. **Think of the most important job-related project, task, or problem you have worked on in the past 6 months. Which category __best__ describes this work? (Check __ONLY ONE__ Box)**

☐ Educational (e.g., for professional development or preparation of a lecture)

☐ Research (either basic or applied)

☐ Design

☐ Development

☐ Manufacturing

☐ Production

☐ Computer applications

☐ Management (e.g., planning, budgeting, and managing research)

☐ Other (specify)____

2. **How would you describe the overall complexity of the technical project, task, or problem you categorized in Q.1? (Circle Number)**

Very Simple 1 2 3 4 5 **Very Complex**

3. **How would you rate the amount of technical uncertainty that you faced when you started the technical project, task, or problem categorized in Q.1? (Circle Number)**

Little Uncertainty 1 2 3 4 5 **Great Uncertainty**

4. **While you were involved in the technical project, task, or problem, did you work alone or with others? (Check Box)**

☐ **Alone** ☐ **With others** → In how many groups did you work? ____________

About how many people were in each group? ______

5. **Which of the following best describes the kinds of duties you performed while working on the project? (Check Box)**

☐ Engineering ☐ Science ☐ Management ☐ Other (specify)____________________

6. **What steps did you follow to get the __information you needed__ for this project, task, or problem? Please sequence these items (e.g., #1, #2, #3, #4, #5) or put an __X__ beside the steps you did not use.**

__**Sequence**__

____ Used my personal store of technical information, including sources I keep in my office

____ Spoke with co-workers or people __inside__ my organization

____ Spoke with colleagues __outside__ my organization

____ Spoke with a librarian or technical information specialist

____ Used literature resources (e.g., conference papers, journals, technical reports) found in my organization's library

(If you used none of the above steps, check here____)

7. **Do you use the results of federally funded aerospace R&D in your work? (Check Box)**

☐ **Yes** ☐ **No (Skip to Q.12)**

7a. **How often do you learn about the results of federally funded aerospace R&D from the following sources? (Check Box)**

	Never	Seldom	Sometimes	Frequently
Co-workers <u>inside</u> my organization	☐	☐	☐	☐
Colleagues <u>outside</u> my organization	☐	☐	☐	☐
NASA and DoD contacts	☐	☐	☐	☐
Publications such as NASA STAR	☐	☐	☐	☐
NASA and DoD sponsored and co-sponsored conferences & workshops	☐	☐	☐	☐
NASA and DoD technical reports	☐	☐	☐	☐
Professional and society journals	☐	☐	☐	☐
Librarians <u>inside</u> my organization	☐	☐	☐	☐
Trade journals	☐	☐	☐	☐
Searches of computerized data bases	☐	☐	☐	☐
Professional and society meetings	☐	☐	☐	☐
Visits to NASA and DoD facilities	☐	☐	☐	☐

8. **Did you use the results of federally funded aerospace R&D in completing the project, task, or problem, you categorized in Q.1? (Check Box)**

☐ **Yes** ☐ **No**

9. **Were these results published in either a NASA or DoD technical report? (Check Box)**

☐ **Yes** ☐ **No**

10. **How important were these results in completing the project, task, or problem, you categorized in Q.1? (Check Box)**

Very Unimportant ☐ ☐ ☐ ☐ ☐ **Very Important**

11. **Which, if any, of the following problems were associated with using these results? (Check <u>All</u> Boxes that Apply)**

☐ The time and effort it took to locate the results

☐ No problems

☐ The time and effort it took to physically obtain the results

☐ The accuracy, precision, and reliability of the results

☐ The legibility or readability of the results

☐ The organization or format of the results

☐ The distribution limitations or security restrictions of the results

12. **In your work, how important is it for you to communicate (e.g., producing written materials or oral discussions) technical information effectively? (Check Box)**

Very Unimportant ☐ ☐ ☐ ☐ ☐ **Very Important**

13. **In the past 6 months, about how many hours did you spend each week communicating technical information?**

(output)

_________hours per week writing

_________hours per week communicating orally

14. **Compared to 5 years ago, how has the amount of time you have spent communicating technical information changed? (Check Box)**

☐ Increased ☐ Stayed the same ☐ Decreased

15. **In the past 6 months, about how many hours did you spend each week working with technical information received from others?**

(input)

_________hours per week working with written information

_________hours per week receiving information orally

16. **As you have advanced professionally, how has the amount of time you have spent working with technical information received from others changed? (Check Box)**

☐ Increased ☐ Stayed the same ☐ Decreased

17. **What percentage of your written technical communications involve:**

Writing alone _____% ⟶ (If 100% alone, skip to Q.20)
Writing with one other person _____%
Writing with a group of 2 to 5 persons _____%
Writing with a group of more than 5 _____%
100%

18. **In general, do you find writing as part of a group more or less productive (i.e., quantity/quality) than writing alone? (Check Box)**

☐ A group is more productive than writing alone ☐ A group is about as productive as writing alone ☐ A group is less productive than writing alone

19. **In the past 6 months, did you work with the same group of people when producing written technical communications? (Check Box)**

☐ **Yes** ⟶ About how many people were in the group: _____number of people

☐ **No** ⟶ With about how many groups did you work: _____number of groups

↓ About how many people were in each group: _____number of people

20. **Approximately how many times in the past 6 months did you write or prepare the following alone or in a group? (If in a group, how many people were in each group?)**

Times in Past 6 Months Produced

	Alone		In a group		Average No. of People
a Abstracts	______	times	______	times →	______
b Journal articles	______		______		______
c Conference/Meeting papers	______		______		______
d Trade/Promotional literature	______		______		______
e Drawings/Specifications	______		______		______
f Audio/Visual materials	______		______		______
g Letters	______		______		______
h Memoranda	______		______		______
i Technical proposals	______		______		______
j Technical manuals	______		______		______
k Computer program documentation	______		______		______
l AGARD technical reports	______		______		______
m U.S. Government technical reports	______		______		______
n In-house technical reports	______		______		______
o Technical talks/Presentations	______		______		______

21. **Approximately how many times in the past 6 months did you <u>use</u> the following?**

	Times used in 6 months
a Abstracts	______
b Journal articles	______
c Conference/Meeting papers	______
d Trade/Promotional literature	______
e Drawings/Specifications	______
f Audio/Visual materials	______
g Letters	______
h Memoranda	______
i Technical proposals	______
j Technical manuals	______
k Computer program documentation	______
l AGARD technical reports	______
m U.S. Government technical reports	______
n In-house technical reports	______
o Technical talks/Presentations	______

22. (Even if you don't use them...) What is your opinion of JOURNAL ARTICLES? (Circle Number)

They are easy to physically obtain	1	2	3	4	5	They are difficult to physically obtain
They are easy to use or to read	1	2	3	4	5	They are difficult to use or to read
They are inexpensive	1	2	3	4	5	They are expensive
They are of good technical quality	1	2	3	4	5	They are of poor technical quality
They have comprehensive data and information	1	2	3	4	5	They have incomplete data and information
They are relevant to my work	1	2	3	4	5	They are irrelevant to my work
They can be obtained at a nearby location or source	1	2	3	4	5	They must be obtained from a distant location or source
I've had good prior experiences using them	1	2	3	4	5	I've had bad prior experiences using them

23. If you were deciding whether or not to use JOURNAL ARTICLES in your work, how important would the following factors be? (Check Box)

	Very Unimportant Factor				Very Important Factor
Are easy to physically obtain	☐	☐	☐	☐	☐
Are easy to use or to read	☐	☐	☐	☐	☐
Are inexpensive	☐	☐	☐	☐	☐
Have good technical quality	☐	☐	☐	☐	☐
Have comprehensive data and information	☐	☐	☐	☐	☐
Are relevant to my work	☐	☐	☐	☐	☐
Can be obtained at a nearby location or source	☐	☐	☐	☐	☐
Had good prior experiences using them	☐	☐	☐	☐	☐

24. In your work, how important is it for you to use JOURNAL ARTICLES? (Circle Number)

Very Unimportant 1 2 3 4 5 **Very Important**

25. Do you use JOURNAL ARTICLES in your work? (Check Box)

☐ **Yes** ☐ **No (Skip to Q.27)**

26. How many times in the past 6 months have you used JOURNAL ARTICLES?

__________**Times in the Past 6 Months**

27. (Even if you don't use them...) What is your opinion of CONFERENCE or MEETING PAPERS? (Circle Number)

They are easy to physically obtain	1	2	3	4	5	They are difficult to physically obtain
They are easy to use or to read	1	2	3	4	5	They are difficult to use or to read
They are inexpensive	1	2	3	4	5	They are expensive
They are of good technical quality	1	2	3	4	5	They are of poor technical quality
They have comprehensive data and information	1	2	3	4	5	They have incomplete data and information
They are relevant to my work	1	2	3	4	5	They are irrelevant to my work
They can be obtained at a nearby location or source	1	2	3	4	5	They must be obtained from a distant location or source
I've had good prior experiences using them	1	2	3	4	5	I've had bad prior experiences using them

28. If you were deciding whether or not to use CONFERENCE or MEETING PAPERS in your work, how important would the following factors be? (Check Box)

	Very Unimportant Factor				Very Important Factor
Are easy to physically obtain	☐	☐	☐	☐	☐
Are easy to use or to read	☐	☐	☐	☐	☐
Are inexpensive	☐	☐	☐	☐	☐
Have good technical quality	☐	☐	☐	☐	☐
Have comprehensive data and information	☐	☐	☐	☐	☐
Are relevant to my work	☐	☐	☐	☐	☐
Can be obtained at a nearby location or source	☐	☐	☐	☐	☐
Had good prior experiences using them	☐	☐	☐	☐	☐

29. In your work, how important is it for you to use CONFERENCE or MEETING PAPERS? (Circle Number)

Very Unimportant 1 2 3 4 5 **Very Important**

30. Do you use CONFERENCE or MEETING PAPERS in your work? (Check Box)

☐ **Yes** ☐ **No (Skip to Q.32)**

31. How many times in the past 6 months have you used CONFERENCE or MEETING PAPERS?

__________Times in the Past 6 Months

32. (Even if you don't use them...) What is your opinion of IN-HOUSE TECHNICAL REPORTS? (Circle Number)

They are easy to physically obtain	1	2	3	4	5	They are difficult to physically obtain
They are easy to use or to read	1	2	3	4	5	They are difficult to use or to read
They are inexpensive	1	2	3	4	5	They are expensive
They are of good technical quality	1	2	3	4	5	They are of poor technical quality
They have comprehensive data and information	1	2	3	4	5	They have incomplete data and information
They are relevant to my work	1	2	3	4	5	They are irrelevant to my work
They can be obtained at a nearby location or source	1	2	3	4	5	They must be obtained from a distant location or source
I've had good prior experiences using them	1	2	3	4	5	I've had bad prior experiences using them

33. If you were deciding whether or not to use IN-HOUSE TECHNICAL REPORTS in your work, how important would the following factors be? (Check Box)

	Very Unimportant Factor				Very Important Factor
Are easy to physically obtain	☐	☐	☐	☐	☐
Are easy to use or to read	☐	☐	☐	☐	☐
Are inexpensive	☐	☐	☐	☐	☐
Have good technical quality	☐	☐	☐	☐	☐
Have comprehensive data and information	☐	☐	☐	☐	☐
Are relevant to my work	☐	☐	☐	☐	☐
Can be obtained at a nearby location or source	☐	☐	☐	☐	☐
Had good prior experiences using them	☐	☐	☐	☐	☐

34. In your work, how important is it for you to use IN-HOUSE TECHNICAL REPORTS? (Circle Number)

Very Unimportant 1 2 3 4 5 **Very Important**

35. Do you use IN-HOUSE TECHNICAL REPORTS in your work? (Check Box)

☐ **Yes** ☐ **No (Skip to Q.37)**

36. How many times in the past 6 months have you used IN-HOUSE TECHNICAL REPORTS?

__________**Times in the Past 6 Months**

37. (Even if you don't use them...) What is your opinion of AGARD TECHNICAL REPORTS? (Circle Number)

They are easy to physically obtain	1	2	3	4	5	They are difficult to physically obtain
They are easy to use or to read	1	2	3	4	5	They are difficult to use or to read
They are inexpensive	1	2	3	4	5	They are expensive
They are of good technical quality	1	2	3	4	5	They are of poor technical quality
They have comprehensive data and information	1	2	3	4	5	They have incomplete data and information
They are relevant to my work	1	2	3	4	5	They are irrelevant to my work
They can be obtained at a nearby location or source	1	2	3	4	5	They must be obtained from a distant location or source
I've had good prior experiences using them	1	2	3	4	5	I've had bad prior experiences using them

38. If you were deciding whether or not to use AGARD TECHNICAL REPORTS in your work, how important would the following factors be? (Check Box)

	Very Unimportant Factor				Very Important Factor
Are easy to physically obtain	☐	☐	☐	☐	☐
Are easy to use or to read	☐	☐	☐	☐	☐
Are inexpensive	☐	☐	☐	☐	☐
Have good technical quality	☐	☐	☐	☐	☐
Have comprehensive data and information	☐	☐	☐	☐	☐
Are relevant to my work	☐	☐	☐	☐	☐
Can be obtained at a nearby location or source	☐	☐	☐	☐	☐
Had good prior experiences using them	☐	☐	☐	☐	☐

39. In your work, how important is it for you to use AGARD TECHNICAL REPORTS? (Circle Number)

Very Unimportant 1 2 3 4 5 **Very Important**

40. Do you use AGARD TECHNICAL REPORTS in your work? (Check Box)

☐ **Yes** ☐ **No (Skip to Q.42)**

41. How many times in the past 6 months have you used AGARD TECHNICAL REPORTS?

__________Times in the Past 6 Months

42. (Even if you don't use them...) What is your opinion of DoD TECHNICAL REPORTS? (Circle Number)

They are easy to physically obtain	1	2	3	4	5	They are difficult to physically obtain
They are easy to use or to read	1	2	3	4	5	They are difficult to use or to read
They are inexpensive	1	2	3	4	5	They are expensive
They are of good technical quality	1	2	3	4	5	They are of poor technical quality
They have comprehensive data and information	1	2	3	4	5	They have incomplete data and information
They are relevant to my work	1	2	3	4	5	They are irrelevant to my work
They can be obtained at a nearby location or source	1	2	3	4	5	They must be obtained from a distant location or source
I've had good prior experiences using them	1	2	3	4	5	I've had bad prior experiences using them

43. If you were deciding whether or not to use DoD TECHNICAL REPORTS in your work, how important would the following factors be? (Check Box)

	Very Unimportant Factor				Very Important Factor
Are easy to physically obtain	☐	☐	☐	☐	☐
Are easy to use or to read	☐	☐	☐	☐	☐
Are inexpensive	☐	☐	☐	☐	☐
Have good technical quality	☐	☐	☐	☐	☐
Have comprehensive data and information	☐	☐	☐	☐	☐
Are relevant to my work	☐	☐	☐	☐	☐
Can be obtained at a nearby location or source	☐	☐	☐	☐	☐
Had good prior experiences using them	☐	☐	☐	☐	☐

44. In your work, how important is it for you to use DoD TECHNICAL REPORTS? (Circle Number)

Very Unimportant 1 2 3 4 5 **Very Important**

45. Do you use DoD TECHNICAL REPORTS in your work? (Check Box)

☐ **Yes** ☐ **No (Skip to Q.47)**

46. How many times in the past 6 months have you used DoD TECHNICAL REPORTS?

__________Times in the Past 6 Months

47. (Even if you don't use them...) What is your opinion of NASA TECHNICAL REPORTS? (Circle Number)

They are easy to physically obtain	1	2	3	4	5	They are difficult to physically obtain
They are easy to use or to read	1	2	3	4	5	They are difficult to use or to read
They are inexpensive	1	2	3	4	5	They are expensive
They are of good technical quality	1	2	3	4	5	They are of poor technical quality
They have comprehensive data and information	1	2	3	4	5	They have incomplete data and information
They are relevant to my work	1	2	3	4	5	They are irrelevant to my work
They can be obtained at a nearby location or source	1	2	3	4	5	They must be obtained from a distant location or source
I've had good prior experiences using them	1	2	3	4	5	I've had bad prior experiences using them

48. If you were deciding whether or not to use NASA TECHNICAL REPORTS in your work, how important would the following factors be? (Check Box)

	Very Unimportant Factor				Very Important Factor
Are easy to physically obtain	☐	☐	☐	☐	☐
Are easy to use or to read	☐	☐	☐	☐	☐
Are inexpensive	☐	☐	☐	☐	☐
Have good technical quality	☐	☐	☐	☐	☐
Have comprehensive data and information	☐	☐	☐	☐	☐
Are relevant to my work	☐	☐	☐	☐	☐
Can be obtained at a nearby location or source	☐	☐	☐	☐	☐
Had good prior experiences using them	☐	☐	☐	☐	☐

49. In your work, how important is it for you to use NASA TECHNICAL REPORTS? (Circle Number)

Very Unimportant 1 2 3 4 5 **Very Important**

50. Do you use NASA TECHNICAL REPORTS in your work? (Check Box)

☐ **Yes** ☐ **No (Skip to Q.52)**

51. How many times in the past 6 months have you used NASA TECHNICAL REPORTS?

__________Times in the Past 6 Months

over ⟶

The following data will be used to determine whether people with different backgrounds have different technical communication practices.

52. **Please list all of your degrees.**

- ☐ No degree
- ☐ Bachelors in ____________
- ☐ Masters in ____________
- ☐ M B A
- ☐ J D
- ☐ Doctorate in ____________
- ☐ Other (specify) ____________

53. **Your years of professional aerospace work experience:** ________ Years

54. **The type of organization where you work: (Check ONLY ONE Box)**

- ☐ Academic ☐ Industry ☐ Government ☐ Not-for-profit
- ☐ Other (specify) ____________

55. **Which of the following BEST describes your primary professional duties? (Check ONLY ONE Box)**

- ☐ Research
- ☐ Administration/Mgt (private sector)
- ☐ Administration/Mgt (not-for-profit)
- ☐ Design/Development
- ☐ Teaching/Academic (may include research)
- ☐ Manufacturing/Production
- ☐ Private consultant
- ☐ Service/Maintenance
- ☐ Marketing/Sales
- ☐ Other (specify) ____________

56. **Your academic preparation was as a(n):**

- ☐ Engineer ☐ Scientist ☐ Other (specify) ____________

57. **In your present job, you consider yourself primarily a(n):**

- ☐ Engineer ☐ Scientist ☐ Other (specify) ____________

58. **The SAE aerospace membership categories are listed below. Please check the ONE box that best classifies your organization.**

- ☐ Airplanes
- ☐ Helicopters
- ☐ Space vehicles (incls. missiles & satellites)
- ☐ Parts, accessories, & component mfg.
- ☐ Operations & maintenance
- ☐ Avionics, electronic, and electrical systems
- ☐ Ground support
- ☐ Air transportation - trunk, regional & int'l
- ☐ Air transportation - business & general aviation
- ☐ Other (specify) ____________

Project Number :

Reply to: **NASA Langley Research Center**
Mail Stop 180 A
Hampton, VA 23665-5225

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
September 1993

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
Technical Uncertainty and Project Complexity as Correlates of Information Use by U.S. Industry-Affiliated Aerospace Engineers and Scientists: Results of an Exploratory Investigation

5. FUNDING NUMBERS
WU 505-90

6. AUTHOR(S)
Thomas E. Pinelli, Nanci A. Glassman, Linda O. Affelder, Laura M. Hecht, John M. Kennedy, and Rebecca O. Barclay

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23681-0001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM-107693

11. SUPPLEMENTARY NOTES
*Report number 15 under the NASA/DoD Aerospace Knowledge Diffusion Research Project. Thomas E. Pinelli: Langley Research Center, Hampton, VA; Nanci A. Glassman and Linda O. Affelder: Continental Research, Norfolk, VA; Laura M. Hecht and John M. Kennedy: Indiana University, Bloomington, IN; Rebecca O. Barclay: RPI, Troy, NY.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified–Unlimited

Subject Category 82

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
An exploratory study was conducted that investigated the influence of technical uncertainty and project complexity on information use by U.S. industry-affiliated aerospace engineers and scientists. The study utilized survey research in the form of a self-administered mail questionnaire. U.S. aerospace engineers and scientists on the Society of Automotive Engineers (SAE) mailing list served as the study population. The adjusted response rate was 67 percent. The survey instrument is appendix C to this report. Statistically significant relationships were found to exist between technical uncertainty, project complexity, and information use. Statistically significant relationships were found to exist between technical uncertainty, project complexity, and the use of federally funded aerospace R&D. The results of this investigation are relevant to researchers investigating information-seeking behavior of aerospace engineers. They are also relevant to R&D managers and policy planners concerned with transferring the results of federally funded aerospace R&D to the U.S. aerospace industry.

14. SUBJECT TERMS
Knowledge diffusion; Engineer; Information use; Technical uncertainty; Project complexity

15. NUMBER OF PAGES
70

16. PRICE CODE
A04

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL