NASA/DoD Aerospace Knowledge Diffusion Research Project

NASA Technical Memorandum 110181

Report Number 34

How Early Career-Stage U.S. Aerospace Engineers and Scientists Produce and Use Information

NASA-TM-110181 19960000999

Thomas E. Pinelli
NASA Langley Research Center
Hampton, Virginia

Rebecca O. Barclay
Rensselaer Polytechnic Institute
Troy, New York

John M. Kennedy
Indiana University
Bloomington, Indiana

September 1995

National Aeronautics and Space Administration

Department of Defense

INDIANA UNIVERSITY

HOW EARLY CAREER-STAGE U.S. AEROSPACE ENGINEERS AND SCIENTISTS PRODUCE AND USE INFORMATION

Thomas E. Pinelli, Rebecca O. Barclay, and John M. Kennedy

ABSTRACT

The U.S. government technical report is a primary means by which the results of federally funded research and development (R&D) are transferred to the U.S. aerospace industry. However, little is known about this information product in terms of its actual use, importance, and value in the transfer of federally funded R&D. Little is also known about the intermediary-based system that is used to transfer the results of federally funded R&D to the U.S. aerospace industry. To help establish a body of knowledge, the U.S. government technical report is being investigated as part of the *NASA/DoD Aerospace Knowledge Diffusion Research Project.* In this report, we summarize the literature on technical reports, present a model that depicts the transfer of federally funded aerospace R&D via the U.S. government technical report, and present the results of research that investigated aerospace knowledge diffusion vis-à-vis U.S. aerospace engineers and scientists who had changed their American Institute of Aeronautics and Astronautics (AIAA) membership from student to professional in the past five years.

INTRODUCTION

NASA and the DoD maintain scientific and technical information (STI) systems for acquiring, processing, announcing, publishing, and transferring the results of government-performed and government-sponsored research. Within both the NASA and DoD STI systems, the U.S. government technical report is considered a primary mechanism for transferring the results of this research to the U.S. aerospace community. However, McClure (1988) concludes that we actually know little about the role, importance, and impact of the technical report in the transfer of federally funded R&D because little empirical information about this product is available.

We are examining the system(s) used to diffuse the results of federally funded aerospace R&D as part of the *NASA/DoD Aerospace Knowledge Diffusion Research Project.* This project investigates, among other things, the information-seeking behavior of U.S. aerospace engineers and scientists, the factors that influence the use of STI, and the role played by U.S. government technical reports in the diffusion of federally funded aerospace STI (Pinelli, Kennedy, and Barclay, 1991; Pinelli, Kennedy, Barclay, and White, 1991). The results of this investigation could (1) advance 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 R&D to the U.S. aerospace community. The project fact sheet is Appendix A.

In this report, we summarize the literature on technical reports, provide a model that depicts the transfer of federally funded aerospace R&D through the U.S. government technical report, and present the results of the Phase 1 survey of early career-stage U.S. aerospace engineers and scientists. We summarize the findings of our investigation into the production and use of information by U.S. aerospace engineers and scientists who had changed their American Institute of Aeronautics and Astronautics (AIAA) membership from student to professional in the past five years.

THE U.S. GOVERNMENT TECHNICAL REPORT

Although they have the potential for increasing technological innovation, productivity, and competitiveness, U.S. government technical reports may not be utilized because of limitations in the existing transfer mechanism. According to Ballard, et al., (1986), the current system "virtually guarantees that much of the Federal investment in creating STI will not be paid back in terms of tangible products and innovations." They further state that "a more active and coordinated role in STI transfer is needed at the Federal level if technical reports are to be better utilized."

Characteristics of Technical Reports

The definition of the technical report varies because the report serves different roles in communication within and between organizations. The technical report has been defined etymologically, according to report content and method (U.S. Department of Defense, 1964); behaviorally, according to the influence on the reader (Ronco, et al., 1964); and rhetorically, according to the function of the report within a system for communicating STI (Mathes and Stevenson, 1976). The boundaries of technical report literature are difficult to establish because of wide variations in the content, purpose, and audience being addressed. The nature of the report -- whether it is informative, analytical, or assertive -- contributes to the difficulty.

Fry (1953) points out that technical reports are heterogenous, appearing in many shapes, sizes, layouts, and bindings. According to Smith (1981), "Their formats vary; they might be brief (two pages) or lengthy (500 pages). They appear as microfiche, computer printouts or vugraphs, and often they are loose leaf (with periodic changes that need to be inserted) or have a paper cover, and often contain foldouts. They slump on the shelf, their staples or prong fasteners snag other documents on the shelf, and they are not neat."

Technical reports may exhibit some or all of the following characteristics (Gibb and Phillips, 1979; Subramanyam, 1981):

- Publication is not through the publishing trade.
- Readership/audience is usually limited.
- Distribution may be limited or restricted.

- Content may include statistical data, catalogs, directions, design criteria, conference papers and proceedings, literature reviews, or bibliographies.

- Publication may involve a variety of printing and binding methods.

The SATCOM report (National Academy of Sciences - National Academy of Engineering, 1969) lists the following characteristics of the technical report:

- It is written for an individual or organization that has the right to require such reports.

- It is basically a stewardship report to some agency that has funded the research being reported.

- It permits prompt dissemination of data results on a typically flexible distribution basis.

- It can convey the total research story, including exhaustive exposition, detailed tables, ample illustrations, and full discussion of unsuccessful approaches.

History and Growth of the U.S. Government Technical Report

The development of the [U.S. government] technical report as a major means of communicating the results of R&D, according to Godfrey and Redman (1973), dates back to 1941 and the establishment of the U.S. Office of Scientific Research and Development (OSRD). Further, the growth of the U.S. government technical report coincides with the expanding role of the Federal government in science and technology during the post World War II era. However, U.S. government technical reports have existed for several decades. The Bureau of Mines *Reports of Investigation* (Redman, 1965/66), the *Professional Papers of the United States Geological Survey*, and the *Technological Papers of the National Bureau of Standards* (Auger, 1975) are early examples of U.S. government technical reports. Perhaps the first U.S. government publications officially created to document the results of federally funded (U.S.) R&D were the technical reports first published by the National Advisory Committee for Aeronautics (NACA) in 1917.

Auger (1975) states that "the history of technical report literature in the U.S. coincides almost entirely with the development of aeronautics, the aviation industry, and the creation of the NACA, which issued its first report in 1917." In her study, *Information Transfer in Engineering*, Shuchman (1981) reports that 75% of the engineers she surveyed used technical reports; that technical reports were important to engineers doing applied work; and that aerospace engineers, more than any other group of engineers, referred to technical reports. However, in many of these studies, including Shuchman's, it is often unclear whether U.S. government technical reports, non-U.S. government technical reports, or both are included (Pinelli, 1991a).

The U.S. government technical report is a primary means by which the results of federally funded R&D are made available to the scientific community and are added to the literature of science and technology (President's Special Assistant for Science and Technology, 1962). McClure (1988) points out that "although the [U.S.] government technical report has been variously reviewed, compared, and contrasted, there is no real knowledge base regarding the role, production, use, and importance [of this information product] in terms of accomplishing this task." Our analysis of the literature supports the following conclusions reached by McClure:

- The body of available knowledge is simply inadequate and noncomparable to determine the role that the U.S. government technical report plays in transferring the results of federally funded R&D.

- Further, most of the available knowledge is largely anecdotal, limited in scope and dated, and unfocused in the sense that it lacks a conceptual framework.

- The available knowledge does not lend itself to developing "normalized" answers to questions regarding U.S. government technical reports.

THE TRANSFER OF FEDERALLY FUNDED AEROSPACE R&D AND THE U.S. GOVERNMENT TECHNICAL REPORT

Three paradigms -- appropriability, dissemination, and diffusion -- have dominated the transfer of federally funded (U.S.) R&D (Ballard, et al., 1989; Williams and Gibson, 1990). Whereas variations of them have been tried within different agencies, overall Federal (U.S.) STI transfer activities continue to be driven by a "supply-side," dissemination model.

The Appropriability Model

The **appropriability model** emphasizes the production of knowledge by the Federal government that would not otherwise be produced by the private sector and competitive market pressures to promote the use of that knowledge. This model emphasizes the production of basic research as the driving force behind technological development and economic growth and assumes that the Federal provision of R&D will be rapidly assimilated by the private sector. Deliberate transfer mechanisms and intervention by information intermediaries are viewed as unnecessary. Appropriability stresses the supply (production) of knowledge in sufficient quantity to attract potential users. Good technologies, according to this model, sell themselves and offer clear policy recommendations regarding Federal priorities for improving technological development and economic growth. This model incorrectly assumes that the results of federally funded R&D will be acquired and used by the private sector, ignores the fact that most basic research is irrelevant to technological innovation, and dismisses the process of technological innovation within the firm.

The Dissemination Model

The **dissemination model** emphasizes the need to transfer information to potential users and embraces the belief that the production of quality knowledge is not sufficient to ensure its fullest use. Linkage mechanisms, such as information intermediaries, are needed to identify useful knowledge and to transfer it to potential users. This model assumes that if these mechanisms are available to link potential users with knowledge producers, then better opportunities exist for users to determine what knowledge is available, acquire it, and apply it to their needs. The strength of this model rests on the recognition that STI transfer and use are critical elements of the process of technological innovation. Its weakness lies in the fact that it is passive, for it does not take users into consideration except when they enter the system and request assistance. The **dissemination model** employs one-way, source-to-user transfer procedures that are seldom responsive in the user context. User requirements are seldom known or considered in the design of information products and services.

The Knowledge Diffusion Model

The **knowledge diffusion model** is grounded in theory and practice associated with the diffusion of innovation and planned change research and the clinical models of social research and mental health. Knowledge diffusion emphasizes "active" intervention as opposed to dissemination and access; stresses intervention and reliance on interpersonal communications as a means of identifying and removing interpersonal barriers between users and producers; and assumes that knowledge production, transfer, and use are equally important components of the R&D process. This approach also emphasizes the link between producers, transfer agents, and users and seeks to develop user-oriented mechanisms (e.g., products and services) specifically tailored to the needs and circumstances of the user. It makes the assumption that the results of federally funded R&D will be under utilized unless they are relevant to users and ongoing relationships are developed among users and producers. The problem with the knowledge diffusion model is that (1) it requires a large Federal role and presence and (2) it runs contrary to the dominant assumptions of established Federal R&D policy. Although U.S. technology policy relies on a "dissemination-oriented" approach to STI transfer, other industrialized nations, such as Germany and Japan, are adopting "diffusion-oriented" policies which increase the power to absorb and employ new technologies productively (Branscomb, 1991; Branscomb, 1992).

The Transfer of (U.S.) Federally-Funded Aerospace R&D

A model depicting the transfer of federally funded aerospace R&D through the U.S. government technical report appears in figure 1. The model is composed of two parts -- the **informal** that relies on collegial contacts and the **formal** that relies on surrogates, information producers, and information intermediaries to complete the "producer to user" transfer process.

When U.S. government (i.e., NASA) technical reports are published, the initial or primary distribution is made to libraries and technical information centers. Copies are sent to surrogates for secondary and subsequent distribution. A limited number of copies are set aside to be used by the author for the "scientist-to-scientist" exchange of information at the collegial level.

Surrogates serve as technical report repositories or clearinghouses for the producers and include the Defense Technical Information Center (DTIC), the NASA Center for Aero Space

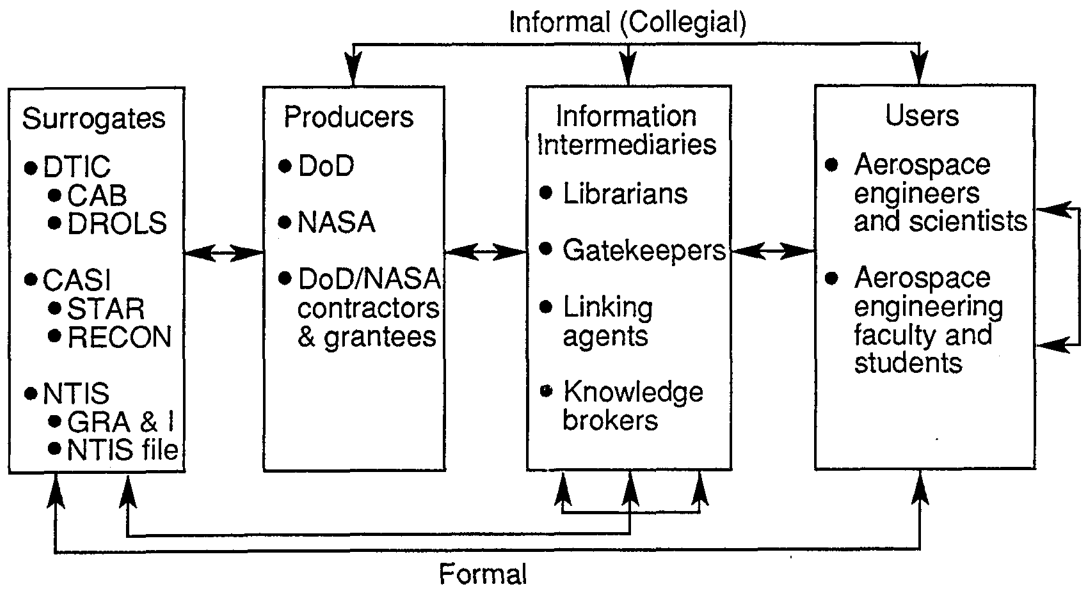


Figure 1. The U.S. Government Technical Report in
a Model Depicting the Dissemination of Federally Funded Aerospace R&D.

Information (CASI), and the National Technical Information Service (NTIS). These surrogates have created a variety of technical report announcement journals such as *CAB* (Current Awareness Bibliographies), *STAR* (Scientific and Technical Aerospace Reports), and *GRA&I* (Government Reports Announcement and Index) and computerized retrieval systems such as *DROLS* (Defense RDT&E Online System), *RECON* (REsearch CONnection), and NTIS *On-line* that permit online access to technical report data bases. Information intermediaries are, in large part, librarians and technical information specialists in academia, government, and industry. Those representing the producers serve as what McGowan and Loveless (1981) describe as "knowledge brokers" or "linking agents." Information intermediaries connected with users act, according to Allen (1977), as "technological entrepreneurs" or "gatekeepers." The more "active" the intermediary, the more effective the transfer process becomes (Goldhor and Lund, 1983). Active intermediaries move information from the producer to the user, often utilizing inter-personal (i.e., face-to-face) communication in the process. Passive information intermediaries, on the other hand, "simply array information for the taking, relying on the initiative of the user to request or search out the information that may be needed" (Eveland, 1987).

The overall problem with the total Federal STI system is that "the present system for transferring the results of federally funded STI is passive, fragmented, and unfocused;" effective knowledge transfer is hindered by the fact that the Federal government "has no coherent or systematically designed approach to transferring the results of federally funded R&D to the user" (Ballard, et al., 1986). In their study of issues and options in Federal STI, Bikson and her colleagues (1984) found that many of the interviewees believed "dissemination activities were afterthoughts, undertaken without serious commitment by Federal agencies whose primary concerns were with [knowledge] production and not with knowledge transfer;" therefore, "much of what has been learned about [STI] and knowledge transfer has not been incorporated into federally supported information transfer activities."

Problematic to the **informal** part of the system is that knowledge users can learn from collegial contacts only what those contacts happen to know. Ample evidence supports the claim that no one researcher can know about or keep up with all the research in his/her area(s) of interest. Like other members of the scientific community, aerospace engineers and scientists are faced with the problem of too much information to know about, to keep up with, and to screen. Further, information is becoming more interdisciplinary in nature and more international in scope.

Two problems exist with the **formal** part of the system. First, the **formal** part of the system employs one-way, source-to-user transmission. The problem with this kind of transmission is that such formal one-way, "supply side" transfer procedures do not seem to be responsive to the user context (Bikson, et al., 1984). Rather, these efforts appear to start with an information system into which the users' requirements are retrofit (Adam, 1975). The consensus of the findings from the empirical research is that interactive, two-way communications are required for effective information transfer (Bikson, et al., 1984).

Second, the **formal** part relies heavily on information intermediaries to complete the knowledge transfer process. However, a strong methodological base for measuring or assessing the effectiveness of the information intermediary is lacking (Beyer and Trice, 1982). In addition, empirical data on the effectiveness of information intermediaries and the role(s) they play in knowledge transfer are sparse and inconclusive. The impact of information intermediaries is likely to be strongly conditional and limited to a specific institutional context.

According to Roberts and Frohman (1978), most Federal approaches to knowledge utilization have been ineffective in stimulating the diffusion of technological innovation. They claim that the numerous Federal STI programs are "highest in frequency and expense yet lowest in impact" and that Federal "information dissemination activities have led to little documented knowledge utilization." Roberts and Frohman also note that "governmental programs start to encourage utilization of knowledge only after the R&D results have been generated" rather than during the idea development phase of the innovation process. David (1986), Mowery (1983), and Mowery and Rosenberg (1979) conclude that successful [Federal] technological innovation rests more with the transfer and utilization of knowledge than with its production.

THE INFORMATION-SEEKING BEHAVIOR OF ENGINEERS

The information-seeking behavior of engineers and scientists has been variously studied by information and social scientists, the earliest studies having been undertaken in the late 1960s (Pinelli, 1991b). 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).

Despite the fact that numerous "information use" studies have been conducted, the information-seeking behavior of engineers and information use in engineering are neither broadly known nor well understood. There are a number of reasons (Berul, et al., 1965): (1) many of the studies were conducted for narrow or specific purposes in unique environments such as experimental laboratories; (2) many, if not most, of them focused on scientists exclusively or engineers working in a research environment; (3) few studies have concentrated on engineers, especially engineers working in manufacturing and production; (4) from an information use standpoint, some engineering disciplines have yet to be studied; (5) most of the studies have concentrated on the users' use of information in terms of a library and/or specific information packages such as professional journals rather than how users produce, transfer, and use information; and (6) many of the studies, as previously stated, were not methodologically sophisticated and few included testable hypotheses or valid procedures for testing the study's hypotheses.

Further, we know very little about the diffusion of knowledge in specific communities such as aerospace. In the past 25 years, few studies have been devoted to understanding the information environment in which aerospace engineers and scientists work, the information-seeking behavior of aerospace engineers and scientists, and the factors that influence the use of federally funded aerospace STI. Presumably, the results of such studies would have implications for current and future aerospace STI systems and for making decisions regarding the transfer and use of federally funded aerospace STI.

RESULTS OF THE PHASE 1 EARLY CAREER-STAGE AIAA MAIL SURVEY

This research was conducted as a Phase 1 activity of the *NASA/DoD Aerospace Knowledge Diffusion Research Project.* Survey participants consisted of U.S. aerospace engineers and scientists who had changed their AIAA membership from student to professional in the past five years. The survey instrument appears as Appendix B.

The Survey

The questionnaire used in this study was jointly prepared by the project team and representatives from the Indiana University Center for Survey Research (CSR). The survey was pretested on a group of U.S. aerospace engineers and scientists. The Indiana University staff prepared an envelope for each individual that contained an 11-page questionnaire, a cover letter, and self-addressed, franked reply envelope. The cover letter provided a toll-free telephone number that respondents could call if they needed additional information. The envelopes were packaged and mailed to NASA Langley Research Center (LaRC) on March 19, 1995, for mailing. The envelopes were mailed from NASA LaRC on April 13, 1995.

The sample size was 700 and consisted of U.S. aerospace engineers and scientists who had changed their AIAA membership from student to professional in the past five years. Between April 25, 1995 and July 19, 1995, we heard from 163 AIAA members who indicated that they were either (1) unemployed, (2) not working in aerospace, or (3) that the survey was not applicable to them. Some surveys were returned bearing the notation "no longer employed or terminated."

By July 27, 1995, the survey cut-off date, 264 usable questionnaires had been received; the adjusted completion rate for the survey was 49%.

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. 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) research, (2) design, (3) development, (4) manufacturing, (5) production, (6) quality assurance/control, (7) computer applications, (8) management, and (9) 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 6 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 used were measured on an interval scale. Use of formal information sources and federally funded aerospace R&D were measured using a nominal scale. Data analysis was based on 264 responses, the total number of useable questionnaires received by the established cut-off date.

DESCRIPTIVE FINDINGS

A total of 264 usable surveys were received by the established cut-off date. Of the respondents, 52% (136 respondents) worked in industry, 32% (83 respondents) worked in government, 9% (24) worked in academia, and 8% (20 respondents) had some other affiliation. Survey demographics for the 264 appear in Table 1. The following "composite" participant profile was developed for the respondents: works in industry (51.7%), has a bachelor's degree (51.9%), has an average of 2.4 years of work experience in aerospace, was educated as and works as an engineer (98.1%, 85.2%), works in design/development (49.4%), and is a male (89%).

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 6 months. The categories and responses are listed in table 2. A majority of the job-related projects, tasks, and problems (45.8%) were categorized as design/development. About 22.1% and 12.6% of the job-related projects, tasks, and problems were categorized as research and other respectively. Most respondents (79.7%) worked with others (did not work alone) in completing their most important job-related project, task, or problem.

Number of Groups and Group Size. On average, respondents worked with 2.1 groups; each group contained an average of 5.4 members (table 2). A majority of respondents (80.8%) performed engineering duties while working on their most important job-related project, task, or problem. About 7% performed management duties.

Project, Task, Problem Complexity and Uncertainty. Respondents were asked to rate the overall complexity of their most important job-related project, task, or problem. The mean complexity score was 3.8 (of a possible 5.0). 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 3.2 (of a possible 5.0).

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 3. 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.

Project, Task, or Problem and Information Use. 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 stores of technical information, (2) spoke with coworkers inside the organization, (3) spoke with colleagues outside of the organization, (4) spoke with a librarian/technical information specialist, (5) used literature resources in the organization's library and (6) searched an electronic data base in the library. They were asked to identify the steps

Table 1. Survey Demographics
[n = 264]

Demographics	Percentage	Number
Do You Currently Work In:		
Industry	51.7	136
Government	31.6	83
Academia	9.1	24
Other	7.6	20
Your Highest Level Of Education:		
No Degree	0.4	1
Bachelor's Degree	51.9	139
Master's Degree	34.1	90
Doctorate	10.6	28
Post-Doctorate	2.7	7
Other Type Of Degree	0.4	1
Your Years In Aerospace:		
Less Than 1	10.0	21
1 - 2	52.1	110
3 - 5	30.3	64
More Than 5	7.6	16
Mean = 2.4 Years Median = 2.0 Years		
Your Education:		
Engineer	98.1	259
Scientist	0.8	2
Other	1.1	3
Your Primary Duties:		
Engineer	85.2	225
Scientist	4.9	13
Other	9.8	26
Is Your Work Best Classified As:		
Teaching/Academic	2.3	6
Research	20.2	53
Management	8.0	21
Design/Development	49.4	130
Manufacturing/Production	3.8	10
Service/Maintenance	0.4	1
Sales/Marketing	1.1	3
Other	14.8	39
Your Gender:		
Female	11.0	29
Male	89.0	235

Table 2. Project, Task, or Problem Categorization

Factors	Percentage	Number
Categories Of Project, Task, Or Problem:		
Research	22.1	58
Design/Development	45.8	120
Manufacturing/Production	5.7	15
Computer Applications	8.4	22
Management	5.3	14
Other	12.6	33
Worked On Project, Task Or Problem:		
Alone	20.3	53
With Others	79.7	208
Mean Number Of Groups = 2.1		
Mean Number of People/Group = 5.4		
Nature Of Duties Performed:		
Engineering	80.8	211
Science	5.4	14
Management	7.3	19
Other	6.5	17

Table 3. Correlation of Project Complexity and Technical Uncertainty by Type of Project, Task, or Problem

Complexity - Uncertainty Correlation	Number	*r*
Overall**	260	0.41*
Education/Research	58	0.27*
Design/Development	118	0.39*
Manufacturing/Production	15	0.75*
Management	14	0.25
Computer Applications	22	0.44*

**r* values are statistically significant at $p \leq 0.05$.
** Overall mean complexity (uncertainty) score = 3.8 (3.2) out of a possible 5.0.

they followed to obtain needed information by sequencing these items (e.g., #1,#2,#3,#4, and #5). (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 4.

Table 4. Information Sources Used to Solve Project, Task, or Problem

Information Source	Used First %	Used Second %	Used Third %	Used Fourth %	Used Fifth %	Used Sixth %	Not Used
Personal Store Of Technical Information	39.3	29.1	16.2	5.7	2.0	0.4	7.3
Spoke With Coworker(s) Inside The Organization	48.8	36.2	9.3	2.0	1.6	0.0	2.0
Spoke With Colleagues Outside Of The Organization	3.7	16.5	32.6	13.6	4.5	2.9	26.0
Used Literature Resources In My Organization's Library	5.4	12.5	19.6	19.6	5.8	2.1	35.0
Spoke With A Librarian/ Technical Information Specialist	0.4	2.6	4.7	6.0	6.8	5.6	73.9
Searched (Or Had Someone Search For Me) An Electronic (Bibliographic) Data Base	3.0	3.8	8.1	11.0	8.9	3.0	62.3

Use of Federally Funded Aerospace R&D. About 57% (148) of the 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 12 sources. They were asked to indicate how they learned about the results of federally funded aerospace R&D from each of the 12 sources (Table 5). 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. NASA and DoD technical reports and NASA and DoD contacts were the exception.

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 6 months. The 45% (115) 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 4.0. Almost two-thirds of those who used federally funded R&D (respondents) responded with an importance rating of "4" or "5". Sixty-three 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.

Table 5. Sources Used to Learn About
the Results of Federally Funded Aerospace R&D
[n = 115]

Source	Percentage*	Number
1. Professional And Society Meetings	25.6	23
2. Coworkers Inside My Organization	95.3	101
3. Trade Journals	17.4	16
4. NASA And DoD Technical Reports	65.7	65
5. Colleagues Outside My Organization	62.0	62
6. NASA And DoD Contacts	56.3	54
7. Professional And Society Meetings	48.5	47
8. Searches Of Computerized Data Bases	41.5	39
9. NASA And DoD Sponsored Conferences And Workshops	25.0	23
10. Visits To NASA And DoD Facilities	34.8	31
11. Publications Such As *STAR*	6.8	6

*Includes combined "frequently" and "sometimes" responses.

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 6). Respondents were given a list of six problems from which to choose. About 46% indicated that the "time and effort it took to locate the results" was a problem. About 43% reported that the "time and effort it took to physically obtain the results" was a problem. About 17% indicated that "accuracy, precision, and reliability of the results" was a problem, and about 24% reported that "distribution limitations or security restrictions" constituted a problem. About 18%/14% indicated that "organization or format"/"legibility or readability" of the results constituted a problem.

Technical Communications Practices

Data which describe factors concerning the production and use of technical information are summarized in table 7. 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).

Importance and Time Spent. The mean importance rating was 4.6; approximately 92% 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 had spent communicating technical information, both in written form and orally, during the past 6 months. Respondents reported spending slightly more time on producing oral discussions (an average of

Table 6. Problems Related to Use of Federally-Funded Aerospace R&D
[n = 115]

Problem	Percentage	Number
Time And Effort To Locate Results	46.1	53
Time And Effort To Obtain Results	42.6	49
Accuracy, Precision And Reliability Of Results	16.5	19
Distribution Limitations Or Security Restrictions Of Results	24.3	28
Organization Or Format Of Results	18.3	21
Legibility Or Readability Of Results	13.9	16

10.5 hours/week) than written materials (an average of 9.7 hours/week). Approximately 72% of the respondents indicated that the amount of time they spent communicating technical information to others had increased over the past 5 years. About 6% indicated a decrease in the amount of time spent communicating technical information to others over the same period.

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 slightly more time working with written technical information received from others (an average of 9.9 hours/week) than with technical information received orally from others (an average of 8.0 hours/week). Approximately 66% of the respondents indicated that, as they have advanced professionally, the amount of time spent working with technical information received from others had increased. About 5% indicated a decrease in the amount of time they spent working with technical information when compared with 5 years ago.

Collaborative Writing. An attempt was made to determine the amount of writing in U. S. aerospace that is collaborative. Survey participants were asked to indicate the percentage of their written technical communications in the past 6 months that involved writing alone, with one other person, with a group of two to five people, and with a group of more than five people. About 30% of the survey respondents indicated that about 100% of the written technical communications they prepared involved writing alone. [The mean percent was ($\bar{X}$ = 71.2) and the median percent was 80.0.] About 58% indicated that their written technical communications involved writing with one other person. [The mean percent was ($\bar{X}$ = 14.1) and the median percent was 10.0.] About 44% indicated that their written technical communications involved writing with a group of two to five people. [The mean percent was ($\bar{X}$ = 11.2) and the median percent was 0.0.] About 13% indicated that their written technical communications involved writing with a group of more than five people. [The mean percent was ($\bar{X}$ = 3.2) and the median percent was 0.0.]

Table 7. Technical Communications: Importance, Time Spent, and Change Over Time
[n = 264]

Communication And Receipt Of Information	Percentage	Number
Importance Of Communicating Technical Information:		
Unimportant	2.7	7
Neither important Nor Unimportant	5.3	14
Important	92.0	243
Mean = 4.6 Median = 5.0		
Time Spent Producing Written Technical Information:		
0 Hours Per Week	1.6	4
1 Through 5 Hours Per Week	39.7	102
6 Through 10 Hours Per Week	29.6	76
11 Through 15 Hours Per Week	11.3	29
16 Through 20 Hours Per Week	12.5	32
21 Or More Hours Per Week	5.2	14
Mean = 9.7 Median = 8.0		
Time Spent Communicating Technical Information Orally:		
0 Hours Per Week	2.0	5
1 Through 5 Hours Per Week	33.7	85
6 Through 10 Hours Per Week	31.7	80
11 Through 15 Hours Per Week	11.1	28
16 Through 20 Hours Per Week	16.3	41
21 Or More Hours Per Week	5.2	13
Mean = 10.5 Median = 10.0		
Change Over Past 5 Years In The Amount Of Time Spent Communicating Technical Information To Others:		
Increased	71.5	181
Stayed The Same	22.5	57
Decreased	6.0	15
Time Spent Working With Written Technical Information Received From Others:		
0 Hours Per Week	0.8	2
1 Through 5 Hours Per Week	40.7	103
6 Through 10 Hours Per Week	31.2	79
11 Through 15 Hours Per Week	11.9	30
16 Through 20 Hours Per Week	8.7	22
21 Or More Hours Per Week	6.7	17
Mean = 9.9 Median = 8.0		
Time Spent Working with Technical Information Received Orally From Others:		
0 Hours Per Week	2.0	5
1 Through 5 Hours Per Week	49.3	124
6 Through 10 Hours Per Week	33.7	84
11 Through 15 Hours Per Week	4.4	11
16 Through 20 Hours Per Week	6.0	15
21 Or More Hours Per Week	4.0	10
Mean = 8.0 Median = 5.0		
Professional Advancement And Changes In Amount Of Time Spent Working With Technical Information Received From Others:		
Increased	65.5	167
Stayed The Same	29.0	74
Decreased	5.5	14

Survey participants who write collaboratively were asked if they find writing as part of a group more or less productive (i.e., producing more written products or producing better written products) than writing alone. The responses appear in table 8. Overall, more of the respondents indicated that writing with a group is more productive than writing alone. About 39% indicated that a group is more productive and about 12% indicated that a group is less productive. About 19% indicated that a group is about as productive as writing alone.

Table 8. Influence of Group Participation on Writing Productivity
[n =181]

How Productive	Percentage	Number
A Group Is More Productive Than Writing Alone	38.5	99
A Group Is About As Productive As Writing Alone	19.1	49
A Group Is Less Productive Than Writing Alone	11.7	30
I Write Alone (Only)	30.7	79

Survey participants were asked if, during that 6 month period, they had worked with the same group of people when producing written technical communications. About 44% (112 respondents) indicated "yes" they had worked with the same group, and about 24% indicated that they had worked with various groups and 31% indicated that they only write alone. Of those who indicated that they had worked in the same group, these respondents were asked how many people were in the group. About 83% (93 respondents) indicated a group size of 2-5 people and about 13% (14 respondents) indicated a group size of 6-10 people. The mean number of people in the group was $\bar{X}$ = 3.6 and the median was 3.0.

Those 61 respondents who indicated "no," meaning that they did not work with the same group during the past 6 months, were asked with about how many groups they had worked. About 32% (19 respondents) reported working with 2 groups, about 42% (25 respondents) reported working with 3 groups, about 12% (7 respondents) reported working with 4 groups, about 7% (4 respondents) reported working with 5 groups, and about 3% (2 respondents) reported working with 6-10 groups. The average (mean) number of groups was $\bar{X}$ = 3.0 and the median number of groups was 3.0. The number of people in each group varied. About 90% of the respondents reported working with a group of 2-5 people and about 5% reported working with a group of 6-10 people. The average (mean) number of people per group was $\bar{X}$ = 3.4 and the median number of people per group was 3.0.

Technical Information Products Produced. Survey participants were given a list of technical information products. They were asked to indicate the number of these products they had written or otherwise prepared in the past 6 months and if those products had been written or prepared as part of a group. The 10 most frequently produced (alone) technical information products appear in table 9.

Survey participants were also asked to indicate the number of these products they had written or otherwise prepared in the past 6 months as part of a group. The 10 most frequently prepared (as part of a group) technical information products appear in table 10. Data shown in table 10 include the number of products produced (mean and median) and the average (mean and median) numbers of people per group.

Table 9. Technical Information Products Written or Produced Alone in the Past 6 Months
[n = 115]

Products	Mean	Median
Memoranda	8.9	3.0
Letters	8.7	2.0
Drawings/Specifications	9.3	0.0
Abstracts	0.6	0.0
Audio/Visual Materials	2.2	0.0
Technical Manuals	1.1	0.0
Computer Program Documentation	2.9	0.0
Conference/Meeting Papers	1.2	0.0
Technical Talks/Presentations	2.5	1.0
Technical Proposals	1.0	0.0

A comparison of the data contained in tables 9 and 10 reveals more similarities than differences. The production numbers vary somewhat but the products included on both lists (products produced alone or as part of a group) are essentially identical. With the exception of the "group size" for technical proposals, the average numbers of people per group for the various products produced are fairly similar in size.

Survey participants were given a list of technical information products. They were asked to indicate approximately how many times in the past 6 months they had used each of them. The 10 most frequently used technical information products appear in table 11. A comparison of the data contained in tables 9 (production) and 11 (use) reveals two differences. First, on average, more products are used than are produced. Second, there are slight differences in the types or kinds of products produced and used.

Table 10. Technical Information Products Written or Produced as Part of a Group in the Past 6 Months
[n = 264]

Information Products	In A Group		Average Number of People Per Group	
	Mean	Median	Mean	Median
Drawings/Specifications	2.7	0.0	3.1	3.0
Letters	0.5	0.0	2.4	2.0
Memoranda	0.6	0.0	2.7	2.0
Audio/Visual Material	0.5	0.0	3.1	3.0
Conference/Meeting Papers	0.4	0.0	2.7	2.0
Abstracts	0.3	0.0	2.8	3.0
Technical Talks/Presentations	1.1	0.0	4.0	3.0
Computer Programs and Documentation	0.3	0.0	3.4	3.0
Technical Manuals	0.4	0.0	4.1	3.0
Technical Proposals	1.1	0.0	3.7	3.0

Table 11. Technical Information Products Used in the Past 6 Months
[n = 264]

Information Products	Mean	Median
Drawings/Specifications	45.7	6.0
Memoranda	14.6	5.0
Letters	10.5	2.0
Trade/Promotional Literature	4.8	0.0
Technical Manuals	19.4	3.0
Conference Papers	4.0	0.0
Technical Talks/Presentations	6.2	1.0
Journal Articles	6.0	0.0
Audio/Visual Materials	5.0	0.0
Computer Programs And Documentation	12.8	2.0

Communications Skills

The literature on engineering education establishes the importance of effective communications skills to professional success (Black, 1994; Morrow, 1994; Evans, et. al., 1993; Katz, 1993; Garry, 1986; Devon, 1985). Survey respondents were asked to assess the importance of selected communications skills to professional success, to indicate if they had received instruction in these skills, and to rate the helpfulness (usefulness) of that instruction.

Respondents were asked to rate the importance of six communications skills to professional career success (table 12). Survey respondents assigned the highest importance ratings to the ability to use computer, communication and information technology ($\bar{X} = 6.3$). Oral and written technical communications skills received the next highest importance ratings. The mean ratings for these skills were about 6.2. Having a knowledge and understanding of engineering/science information resources and materials also received a mean importance rating of about 5.7.

Table 12. Importance of Communications Skills to Professional Success

Skills	Mean[a]	Number
Effectively Communicate Technical Information In Writing	6.2	262
Effectively Communicate Technical Information Orally	6.2	263
Have A Knowledge And Understanding Of Engineering\Science Resources And Materials	5.7	263
Be Able To Search Electronic (Bibliographic) Data Bases	4.3	259
Know How To Use A Library That Contains Engineering\Science Resources And Materials	4.6	262
Effectively Use Computer, Communication And Information Technology	6.3	262

[a]Survey respondents used a 7-point scale to rate importance, where 7 indicates the highest rating.

Table 13 shows the percentage of respondents who have received communications skills instruction. About 84.4% of survey respondents have received instruction in the use of computer, communication, and information technology. Approximately 84.8% of the respondents have had technical writing instruction. About 74.5% of respondents have received instruction in speech/oral communication, using engineering/science information resources and materials, or using a library that contains engineering/science information resources and materials.

Survey respondents who had received communications skills instruction were asked to rate the helpfulness (usefulness) of that instruction (table 14). For the most part, respondents reported that the instruction was helpful. Respondents assigned the highest ratings to instruction in using computer, communication, and information technology.

Table 13. Communications Skills Instruction

Skills	Percentage	Number
Technical Writing\Communication	84.4	224
Speech/Oral Communication	75.4	199
Using Engineering\Science Information Resources And Materials	80.6	212
Searching Electronic (Bibliographic) Data Bases	60.8	160
Using A Library Containing Engineering\Science Information Resources and Materials	75.3	198
Using Computer, Communication And Information Technology	84.4	222

Table 14. Helpfulness of Communications Skills Instruction[a]

Skills	Mean[b]	Number
Technical Writing\Communication	5.5	224
Speech/Oral Communication	5.6	201
Using Engineering\Science Information Resources And Materials	5.1	212
Searching Electronic (Bibliographic) Data Bases	4.6	167
Using A Library Containing Engineering\Science Information Resources and Materials	4.8	201
Using Computer, Communication, and Information Technology	6.1	225

[a]Includes ratings only for those respondents who received training in each communication skill.

[b]Helpfulness was rated using a 7-point scale, where 7 indicates the highest rating.

Impediments to Preparing Written Technical Communications

We asked respondents the extent to which a lack of knowledge/skill about certain communications principles impedes their ability to write (table 15). Overall, respondents did not report serious problems with their writing skills, at least to the point that any deficiencies might impede the technical writing process.

Table 15. Impediments to the Production of Written Technical Communications

Principles	Mean[a]	Number
Defining The Purpose Of The Communication	3.6	239
Assessing The Needs Of The Reader	3.9	238
Preparing/Presenting Information In An Organized Manner	4.0	241
Developing Paragraphs (Introductions, Transitions, Conclusions)	3.4	243
Writing Grammatically Correct Sentences	3.3	243
Notetaking And Quoting	2.8	230
Editing And Revising	3.5	237

[a]The extent to which each principle impedes was measured using a 7-point scale, where 7 indicates the highest rating.

Survey respondents appear to have the least difficulty with those writing skills that most respondents have the opportunity to use frequently. Grammar skills, notetaking and quoting, and skills related to editing and revising received the lowest "impedance" scores (means range closely around 3.2). Skill areas where the survey respondents report the most difficulty are in assessing the needs of the reader and problems presenting information in an organized manner. The mean difficulty scores for these skill areas is just under 4.0. Areas in which respondents report mid-range difficulties (mean scores less than $\bar{X} = 3.8$) include defining the purpose of the communication and developing paragraphs.

Collaborative Writing

Most of the respondents in this study have experience in collaborative writing. Over 75% of the survey respondents report that they have produced written technical information as part of a group (table 16). Table 16 also indicates the percentage of writing that is required to be collaborative. Just over 33% of writing projects assigned to survey respondents is required to be collaborative.

Table 16. Percentage of Writing that is Collaborative

Group Writing	Mean %	Number
Writing Done In Groups	28.8	253
Writing Required To Be Collaborative	33.1	176

We also asked survey respondents who write collaboratively to compare the productivity of group writing to the productivity of writing alone. A high percentage of respondents indicated that group writing is more productive than writing alone (table 17). Over 43% of survey respondents reported that writing in a group is more productive than writing alone. Less than 18% of all respondents reported that group writing is less productive, and about 39% reported that group writing was as productive as writing alone.

Table 17. Productivity of Collaborative Writing

Productivity of Group Writing	Percentage	Number
More Productive Than Writing Alone	43.3	84
About the Same As Writing Alone	39.5	76
Less Productive Than Writing Alone	17.5	34

Use and Importance of Libraries and Technical Reports

This section examines the use and importance of libraries and the use of domestically and foreign produced technical reports. We examine the frequency of the survey respondents' library use, their reasons for not using a library, and the effectiveness of the information obtained from the library in meeting their engineering/science information needs. Table 18 reports the frequency of library use during the past 6 months. Nearly 29% of the survey respondents indicated that they had not used the library at all. Overall, survey respondents averaged 7.3 trips to the library during the past 6 months.

Table 18. Use of A Library in the Past 6 Months

Visits		Percentage	Number
0	Times	28.4	63
1 - 5	Times	40.9	105
6 - 10	Times	14.8	38
11 - 25	Times	10.1	26
26 - 50	Times	3.9	10
51 Or More	Times	1.9	5
Mean		7.3	
Median		3.0	

We also asked respondents who had not used a library during the past 6 months to indicate their reasons for non-use. The percentages of non-users by the reason for not using a library appear in table 19. About 51% of non-users reported that they had no information needs. About 87% of non-users indicated that their information needs were more easily met by sources other than the library, and about 15% of non-users reported that they had tried the library before but had difficulty finding the information they needed.

Table 19. Reasons Respondents Did Not Use A Library in the Past 6 Months

Reasons	Percentage	Number
I Had No Information Needs	50.7	34
My Information Needs Were More Easily Met Some Other Way	86.8	59
Tried The Library Once Or Twice Before But I Couldn't Find The Information I Needed	14.8	9
The Library Is Physically Too Far Away	28.3	17
The Library Staff Is Not Cooperative Or Helpful	3.5	2
The Library Staff Does Not Understand My Information Needs	3.5	14
The Library Did Not Have The Information I Need	25.5	19
I Have My Own Personal Library And Do Not Need Another Library	32.8	19
The Library Is Too Slow In Getting The Information I Need	10.5	6
We Have To Pay To Use The Library	3.4	2
We Are Discouraged From Using The Library	3.4	2

Effectiveness of Information

Respondents who had used the library during the past 6 months were asked to rate the effectiveness of the information obtained in the library for meeting their engineering and science information needs (table 20). Effectiveness was measured using a 7-point scale, where 7 was very effective. Almost 35% of the respondents indicated that the information was very effective.

Table 20. Effectiveness of Information Obtained From the Library in Meeting Engineering/Science Information Needs

Effectiveness	Percentage	Number
Very Effective	34.4	64
Neither Effective Nor Ineffective	62.3	116
Very Ineffective	3.2	6
Mean	5.0	

Survey respondents were whether they use technical reports produced in the U.S. and foreign counties (table 21). Almost 60% of respondents reported using U.S. technical reports. Less than 20% reported using technical reports produced in the foreign countries.

Table 21. Use of Foreign and Domestically Produced Technical Reports

Country/Organization	Percentage[a]	Number
NATO AGARD Reports	19.2	40
British ARC And RAE Reports	14.0	29
Dutch NLR Reports	5.0	10
ESA (European Space Agency) Reports	12.6	26
Indian NAL Reports	0.5	1
French ONERA Reports	8.9	18
German DFVLR, DLR, And MBB Reports	8.4	17
Japanese NAL Reports	2.5	5
Russian TsAGI Reports	5.5	11
U.S. NASA Reports	59.2	142

[a]Percentages exclude respondents who indicated that they do not have access to technical reports from each given country.

Use of Computer and Information Technology

The use of use computer technology to prepare (written) technical communications was investigated. Survey respondents were asked about their current and anticipated use of selected information technologies. Specifically, respondents were asked about their use of electronic networks, their use of electronic networks for specific purposes, and their use of electronic networks to exchange messages and files.

Use of Computers to Prepare Written Technical Communications

Nearly all of the respondents (98.9%) we surveyed use computers when they prepare written technical communications. Survey respondents who do not use computer technology to prepare written technical communication most often (66.7%) gave lack of access to computer technology as the reason for "non-use".

Table 22. Use and Non-use of a Computer to Prepare Written Technical Communications

Factor	Percentage	Number
Do You Use A Computer To Prepare Written Technical Communication?		
Never	1.1	3
Yes	98.9	260
Sometimes	6.8	18
Frequently	17.5	46
Always	74.5	196
Your Reason(s) For Not Using A Computer		
No/Limited Computer Access	66.7	2
Lack of Knowledge/Skill Using A Computer	---	--
Prefer Not To Use A Computer	---	--
Other	33.3	1

Use of Selected Information Technologies

Survey respondents were asked about their use and non-use of a wide range of information technologies (table 23). Specifically, they were asked to indicate if they "already use it," "don't use it but may in the future," and "don't use it and doubt if I will." Respondents reported the greatest use of computer-based information technologies such as electronic publishing, electronic mail, desktop publishing, FAX/TELEX, and electronic data bases.

Table 23. Use, Non-Use, and Potential Use of Information Technologies

Information Technologies	Already Use It		Don't Use It, But May In Future		Don't Use It, And Doubt If Will	
	%	(n)	%	(n)	%	(n)
Audio Tapes And Cassettes	6.2	16	17.4	45	76.4	197
Motion Picture Films	3.5	9	27.0	69	69.5	178
Videotape	36.2	93	44.7	115	19.1	49
Desktop/Electronic Publishing	87.8	230	9.9	26	2.3	6
Computer Cassettes/Cartridge Tapes	35.2	90	30.1	77	34.8	89
Electronic Mail	82.8	217	16.8	44	0.4	1
Electronic Bulletin Boards	47.3	122	47.3	122	5.4	14
FAX or TELEX	92.7	240	6.6	17	0.8	2
Electronic Data Bases	71.7	185	26.7	69	1.6	4
Video Conferencing	20.2	52	68.1	175	11.7	30
Computer Conferencing	10.9	28	76.3	196	12.8	33
Micrographics And Microforms	33.6	86	35.2	90	31.3	80

Use of Electronic (Computer) Networks

Nearly all the respondents surveyed have access to electronic (computer) networks. Almost 85% of the survey respondents indicated that they use electronic (computer) networks (see table 24). Approximately 4% of the respondents use networks through an intermediary. Survey respondents for a variety of purposes (see table 25.) About 56% of survey respondents use networks for logging onto bulletin boards or conferences and for information search and data retrieval (75%).

Table 24. Use of Electronic (Computer) Networks

Factor	Percentage	Number
Yes, I Personally Use Them	85.4	223
Yes, I Use Them But Through An Intermediary	3.8	10
No	1.9	5
No, Because I Do Not Have Access To Electronic Networks	3.4	9
No, But I May Use Them In The Future	5.4	14

Table 25. Use of Electronic Networks for Specific Purposes

Purpose	Percentage	Number
Connect To Geographically Distant Sites	78.6	180
Electronic Mail	94.8	219
Electronic Bulletin Boards Or Conferences	55.7	128
Log On To Remote Computers	94.4	218
Control Remote Equipment	67.4	155
Access/Search The Library's Catalog	19.4	44
Order Documents From The Library	61.9	143
Search Electronic (Bibliographic) Data Bases	24.8	57
Information Search And Data Retrieval	74.5	172
Prepare Scientific And Papers With Colleagues At Geographically Distant Sites	26.6	61

Survey participants who used electronic networks were asked to identify the groups with whom they exchanged messages or files (table 26). About 86% of the survey respondents used electronic networks to exchange files with members of their own work group, others in their organization but not in their work group, and people outside their organization.

Table 26. Use of Electronic Networks to Exchange Messages or Files

Exchange With --	Percentage	Number
Members Of Own Work Group	85.8	199
Others In Your Organization But Not In Your Work Group	82.3	190
Others In Your Organization, Not In Your Work Group, At A Geographically Different Site	68.7	158
People Outside Your Work Group	83.5	193

Professional Aspirations

Survey respondents were asked to rate the importance of 15 goals to a successful career. The list includes aspirations that are classified as either engineering, science, or management goals. Table 27 shows the mean importance ratings for each goal. The majority of survey respondents reported that engineering goals are most important to a successful career.

Table 27. Importance of Career Goals and Aspirations

Goals	Percentage[a]	Number
Engineering		
Have The Opportunity To Explore New Ideas About Technology Or Systems	76.1	198
Attain A High Level Staff Technical Position	44.1	114
Have The Opportunity To Work On Complex Technological Knowledge	78.9	181
Work On Projects That Require Learning New Technical Knowledge	70.0	184
Work On Projects That Utilize The Latest Theoretical Results	39.4	103
Science		
Establish Professional Reputation Outside Of The Organization	49.8	129
Receive Patents For Your Ideas	15.6	40
Be Evaluated On The Basis Of Your Technical Ideas	54.0	141
Publish Articles In Technical Journals	26.1	67
Communicate Your Ideas To Others In Your Profession By Presenting Papers At Professional Meetings	29.7	76
Management		
Be A Technical Leader Of A Group Of Less Experienced Professionals	48.1	125
Plan And Coordinate The Work Of Others	39.5	103
Become A Manager Or Director	39.1	101
Plan Projects Or Make Decisions Affecting The Organization	46.8	121
Advance To A Policy-Making-Position In Management	32.5	83

[a]Survey respondents used a 7-point scale to rate importance, where 7 indicates the highest rating. The percentages listed are the respondents who rated the factor as either a "6" or a "7".

FINDINGS

1. The "average" participant works in industry (51.7%), has a bachelor's degree (51.9%), has an average of 2.4 years of work experience in aerospace, was educated as and works as an engineer (98.1%, 85.2%), works in design/development (49.4%), and is male (89%).

2. Their most important job-related project, task, or problem worked on in the past 6 months was categorized as design/development (45.8%); 79.7% of the participants worked on this project, task, or problem with others. The mean number of groups involved was 2.1, and the mean number of people in a work group was 5.4. Engineering duties predominated (73%) followed by management duties (7.3%) in the completion of the most important job-related project, task, or problem worked on in the past 6 months.

3. A positive and significant correlation was found between the overall complexity and technical uncertainty of the most important job-related project, task, or problem that respondents had worked on in the past 6 months.

4. To complete their most important job-related project, task, or problem, respondents first and second, spoke with coworker(s) inside the organization (48.8%, 36.2%); third, spoke with colleagues outside of the organization (32.6%); fourth, used literature resources in the organization's library (19.6%); fifth, searched an electronic data base in the library (8.9%); and sixth, spoke with a librarian/technical information specialist (5.6%).

5. Approximately 57% of the respondents reported using the results of federally funded aerospace R&D in their work. Of the four sources most frequently used to find out about the results of federally funded aerospace R&D, three involve interpersonal communication and one involves formal (written) communication. Three of five "federal initiatives" were the sources used least to learn about the results of federally funded aerospace R&D. NASA and DoD technical reports and NASA and DoD contacts were the exception.

6. About 45% of the respondents had used the results of federally funded aerospace R&D to complete their most important job-related project, task, or problem during the last 6 months. About two-thirds of this group indicated that federally funded aerospace R&D was "important" or "very important" for completing this work. About 63% (72) 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.

7. Of the respondents who used the results of federally funded aerospace R&D in completing their most important job-related project, task, or problem, 46% indicated that the "time and effort it took to locate the results" was a problem, and 43% reported that the "time and effort it took to obtain the results" was a problem.

8. About 92% of the respondents indicated that it was important to communicate technical information effectively; respondents spent an average of 9.7 hours per week producing written material and 10.5 hours per week communicating information orally. Over the past 5 years approximately 72% have increased the amount of time they spend communicating information to others. Survey respondents reported spending an average of 9.9 hours per week working with written information received from others and an average of 8.0 hours per week working with information received orally from others. More than 65% of the respondents indicated that the amount of time they spend receiving technical information from others has increased over the past 5 years.

9. About 30% of the respondents reported that all of the written technical communications they prepared involved writing alone. About 58% indicated that their written technical communications involved writing with one other person. About 44% indicated that their written technical communications involved writing with a group of two to five people. About 13% indicated that their written technical communications involved writing with a group of more than five people.

10. In terms of the perceived productivity of collaborative writing, slightly more of the respondents indicated that writing with a group is more productive than writing alone. About 39% indicated that a group is more productive and about 12% indicated that a group is less productive. About 19% indicated that a group is about as productive as writing alone.

11. A comparison of the technical information products produced and used reveals that on average, the survey respondents used more products than they produce. There are also slight differences in the types of technical information products produced and used.

12. Survey respondents indicated that the six communication skills were important to professional success, most respondents had received communications skills training, and most found the training to be helpful.

13. Survey respondents reported "preparing/presenting information in a organized manner" and assessing the needs of the reader" as the greatest impediments to producing written technical communication.

14. Survey respondents reported using a library about 7.3 times in a six month period. My information needs were more easily met some other way was the reason given most often for not using a library. About 62% of the respondents reported that the information they received from the library was neither effective nor ineffective in meeting their engineering/science information needs.

15. Overall use of foreign produced technical reports by survey respondents was low.

16. About 99% of the respondents use a computer to prepare written technical communications. About an equal number use electronic (computer) networks; most use them for electronic mail.

REFERENCES

Adam, R. 1975 — "Pulling the Minds of Social Scientists Together: Towards a Science Information System." *International Social Journal* 27(3): 519-531.

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

Auger, C. P. 1975 — *Use of Technical Reports Literature.* Hamden, CT: Archon Books.

Ballard, S., et. al. 1989 — *Innovation Through Technical and Scientific Information: Government and Industry Cooperation.* Westport, CT: Quorum Books.

Ballard, S., et. al. 1986 — *Improving the Transfer and Use of Scientific and Technical Information. The Federal Role: Volume 2 - Problems and Issues in the Transfer and Use of STI.* Washington, DC: National Science Foundation. (Available from NTIS, Springfield, VA; PB-87-14923.)

Berul, L. H., et. al. 1965 — *DoD User-Needs Study, Phase 1. Volume 1: Management Report, Conduct of the Study, and Analysis of Data.* Philadelphia, PA: Auerbach Corporation. (Available from NTIS, Springfield, VA; AD-615 501.

Beyer, J. M. and H.M. Trice 1982 — "The Utilization Process: A Conceptual Framework and Synthesis of Empirical Findings." *Administrative Science Quarterly* 27: 591-622.

Bikson, T. K., B. E. Quint, and L. L. Johnson 1984 — *Scientific and Technical Information Transfer: Issues and Option.* Washington, DC: National Science Foundation. (Available from NTIS, Springfield, VA; PB-85-150357; also available as Rand Note 2131.)

Black, K. M. 1994 — "An Industry View of Engineering Education." *Journal of Engineering Education*, 83:1, 26-28.

Branscomb, L. G. 1992 — "America's Emerging Technology Policy." *Minerva* 30:3 (August): 317-336.

Branscomb, L. G. 1991 — "Toward a U.S. Technology Policy." *Issues in Science and Technology* 7:4 (Fall): 50-55.

David, P. A. 1986 — "Technology Diffusion, Public Policy, and Industrial Competitiveness." In *The Positive Sum Strategy: Harnessing Technology for Economic Growth.* R. Landau and N. Rosenberg, eds. Washington, DC: National Academy Press.

Devon, R. 1985 — "Industry's Advice for the First Two Years." *Engineering Education*, 76:2, 112-114.

Evans, D. L., G. C. Bleakley, P. E. Crouch, and G. T. Yamaguchi 1993 — "Attributes of Engineering Graduates and Their Impact on Curriculum Design." *Journal of Engineering Education*, 82:4, 203-211.

Eveland, J. D. 1987 — *Scientific and Technical Information Exchange: Issues and Findings*. Washington, DC: National Science Foundation. (Not available from NTIS.)

Fry, B. M. 1953 — *Library Organization and Management of Technical Reports Literature*. Washington, DC: The Catholic University of America Press.

Garry, F. W. 1986 — "A Business Look at Engineering Education." *Engineering Education*, 76:4, 203-205.

Gibb, J. M. and E. Phillips 1979 — Better Fate for the Grey, or Non-Conventional, Literature." *Journal of Communication Studies* 1: 225-234.

Godfrey, L. E. and H.F. Redman 1973 — *Dictionary of Report Series Codes*. (2nd ed.) NY: Special Libraries Association.

Goldhor, R. S. and R. T. Lund 1983 — "University-to-Industry Advanced Technology Transfer: A Case Study." *Research Policy* 12: 121-152.

Katz, S. 1993	"The Entry-Level Engineer: Problems in Transition from Student to Professional." *Journal of Engineering Education*, 82:3, 171-174.
Mathes, J. C. and D. W. Stevenson 1976	*Designing Technical Reports*. Indianapolis, IN: Bobbs-Merill.
McClure, C. R. 1988	"The Federal Technical Report Literature: Research Needs and Issues." *Government Information Quarterly*. 5(1): 27-44.
McGowan, R. P. and S. Loveless 1981	"Strategies for Information Management: The Administrator's Perspective." *Public Administration Review* 41(3): 331-339.
Morrow, R. M. 1994	"Issues Facing Engineering Education." *Journal of Engineering Education*, 83:1, 15-18.
Mowery, D. C. 1983	"Economic Theory and Government Technology Policy." *Policy Sciences* 16: 27-43.
Mowery, D. C. and N. Rosenberg 1979	"The Influence of Market Demand Upon Innovation: A Critical Review of Some Recent Empirical Studies." *Research Policy* 8(2): 102-153.
National Academy of Sciences - National Academy of Engineering 1969	*Scientific and Technical Communication: A Pressing National Problem and Recommendations for Its Solution.* Report by the Committee on Scientific and Technical Communication. Washington, DC: National Academy Sciences; AKA the SATCOM Report.
Pinelli, T. E. 1991b	"The Information-Seeking Habits and Practices of Engineers." *Science and Technology Libraries* 11(3): 5-25.
Pinelli, T. E. 1991a	*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, T. E., J. M. Kennedy, and R. O. Barclay 1991	"The NASA/DoD Aerospace Knowledge diffusion Research Project." *Government Information Quarterly* 8(2): 219-233.

Pinelli, T. E., J. M. Kennedy, R. O. Barclay, and T. F. White 1991 — "Aerospace Knowledge Diffusion Research." *World Aerospace Technology '91: The International Review of Aerospace Design and Development* 1(1): 31-34.

President's Special Assistant for Science and Technology 1962 — *Scientific and Technological Communication in the Government.* Washington, DC: Government Printing Office; AKA the Crawford Report.

Redman, H. F. 1965/1966 — "Technical Reports: Problems and Predictions." *Arizona Librarian* 23: 11-17.

Roberts, E. B. and A. L. Frohman 1978 — "Strategies for Improving Research Utilization." *Technology Review* 80 (March/April): 32-39.

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

Ronco, P. G., et. al. 1964 — *Characteristics of Technical Reports That Affect Reader Behavior: A Review of the Literature.* Boston, MA: Tufts University, Institute for Psychological Research. (Available from NTIS, Springfield, VA PB-169 409.)

Shuchman, H. L. 1981 — *Information Transfer in Engineering.* Glastonbury, CT: The Futures Group.

Smith, R. S. 1981 — "Interaction Within the Technical Report Community." *Science and Technology Libraries* 1(4): 5-18.

Subramanyam, K. 1981 — *Scientific and Technical Information Resources.* NY: Marcel Dekker.

U.S. Department of Defense 1964 — *Glossary of Information Handling.* Defense Logistics Agency, Defense Documentation Center. Cameron Station, Alexandria, VA.

Williams, F. and D. V. Gibson 1990 — *Technology Transfer: A Communication Perspective.* Newbury Park, CA: Sage Publications.

APPENDIX A

NASA/DoD AEROSPACE KNOWLEDGE DIFFUSION RESEARCH PROJECT

Fact Sheet

The process of producing, transferring, and using scientific and technical information (STI), which is an essential part of aerospace research and development (R&D), can be defined 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 indicate, however, 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 about 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. Phase 1 investigates the information-seeking habits and practices of U.S. aerospace engineers and scientists, in particular their use of government-funded aerospace STI. Phase 2 examines the industry-government interface and emphasizes the role of the information intermediary in the knowledge diffusion process. Phase 3 concerns the academic-government interface and emphasizes the information intermediary-faculty-student interface. Phase 4 explores the information-seeking behaviors of non-U.S. aerospace engineers and scientists from Western European nations, India, Israel, Japan, and the former Soviet Union.

The results of this research project will help us to understand the flow of STI at the individual, organizational, national, and international levels. The findings 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. These results will contribute to increasing productivity and to improving and maintaining the professional competence of aerospace engineers and scientists. The results of our research are being shared freely with those who participate in the study.

Dr. Thomas E. Pinelli
Mail Stop 180A
NASA Langley Research Center
Hampton, VA 23681-0001
(804) 864-2491
Fax (804) 864-8311
T.E.Pinelli@larc.nasa.gov

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

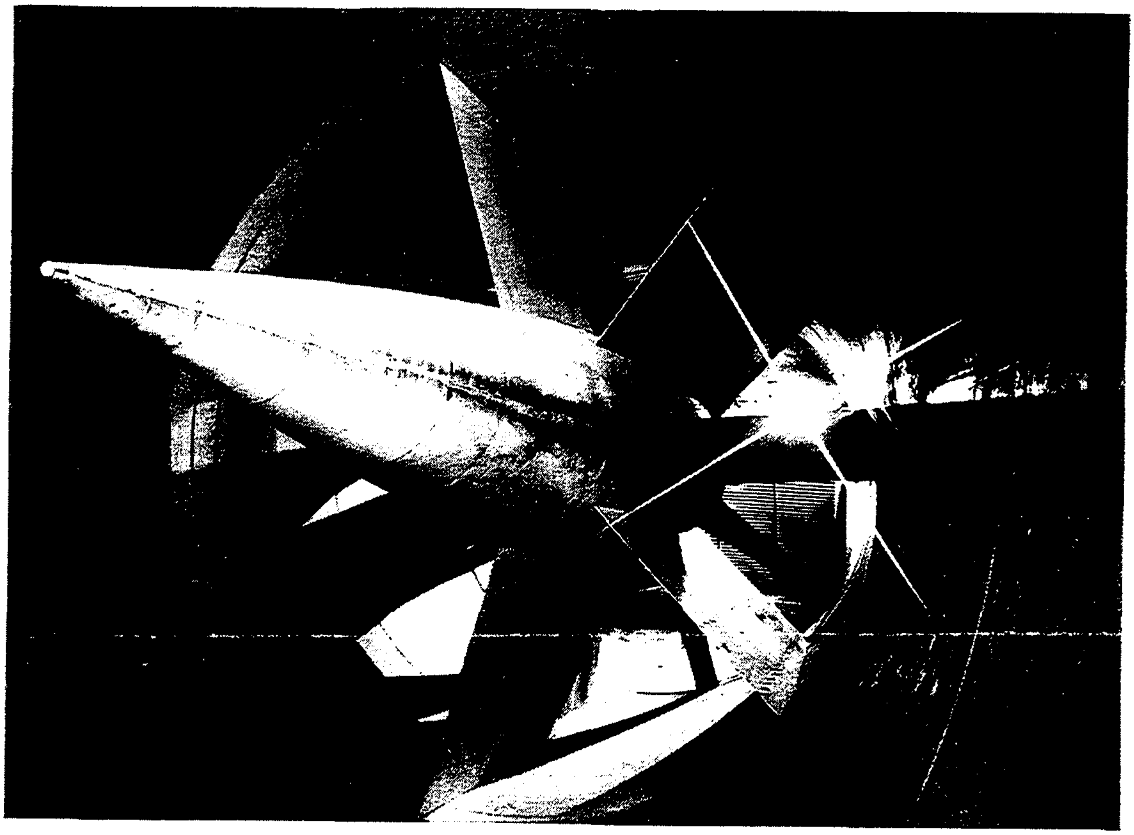
Rebecca O. Barclay
Dept. of Language, Lit. & Communication
Rensselaer Polytechnic Institute
Troy, NY 12180
(804) 399-5666
Fax (804) 397-4635
barclay@infi.net

PHASE 1 OF THE
NASA/DOD AEROSPACE KNOWLEDGE
DIFFUSION RESEARCH PROJECT

Technical Communications in Aerospace:

How Early Career Stage Aerospace Engineers and Scientists Obtain Information

AIAA Study



SPONSORED BY THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE DEPARTMENT OF DEFENSE WITH THE COOPERATION OF NEW YORK UNIVERSITY AND THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (AIAA)

The first group of questions ask about your use of technical information.

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

   Not at all Important 1 2 3 4 5 Very Important

2. In the past 6 months, how many hours did you spend each week communicating (*producing*) technical information?

   (Output) __________ hours per week writing
   __________ hours per week communicating orally

3. Compared to 5 years ago, how has the amount of time you have spent *communicating* technical information changed? (Circle ONE number)

   1 Increased
   2 Stayed the same
   3 Decreased

4. In the past 6 months, 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

5. As you have advanced professionally, how has the amount of time you have spent working with technical information *received from others* changed? (Circle ONE number)

   1 Increased
   2 Stayed the same
   3 Decreased

6. What percentage of your written technical communications involved:

Writing alone	__________%	→ (If 100%, go to Question 9.)
Writing with one other person	__________%	
Writing with a group of 2 to 5 people	__________%	
Writing with a group of more than 5 people	__________%	
	100 %	

7. In general, do you find writing as part of a group more or less productive (i.e., producing more written products or better written products) than writing alone? (Circle ONE number)

   1 A group is *less* productive than writing alone
   2 A group is *about* as productive as writing alone
   3 A group is *more* productive than writing alone
   4 Difficult to judge; no experience preparing technical information

8. In the past 6 months, did you work with the same group of people when producing written technical information? (Circle ONE number)

   1 Yes → About how many people were in the group? → number of people __________
   2 No → With about how many groups did you work? → number of groups __________
   ↓
   About how many people were in each group? → number of people __________

9. 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		
	Alone	In a Group	Average Number of People
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. DoD Technical Reports	______	______	______
m. NASA Technical Reports	______	______	______
n. Technical Talks/Presentations	______	______	______

10. Approximately how many times in the past 6 months did you *use* the following?

	Times Used in Past 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. DoD Technical Reports	______
m. NASA Technical Reports	______
n. Technical Talks/Presentations	______

11. In your work, how important is it for you to: (Circle number)

	Very Unimportant						Very Important	Don't Know
Effectively communicate technical information in writing	1	2	3	4	5	6	7	8
Effectively communicate technical information orally	1	2	3	4	5	6	7	8
Have a knowledge and understanding of engineering/science information resources and materials	1	2	3	4	5	6	7	8
Be able to search electronic (bibliographic) data bases	1	2	3	4	5	6	7	8
Know how to use a library that contains engineering/science information resources and materials	1	2	3	4	5	6	7	8
Effectively use computer, communication, and information technology	1	2	3	4	5	6	7	8

12. As part of your academic preparation, did you receive training or course work in: (Circle number)

	Yes	No	No Instruction Available
Technical writing/communication	1	2	8
Speech/oral communication	1	2	8
Using a library that contains engineering/science information resources and materials	1	2	8
Using engineering/science information resources and materials	1	2	8
Searching electronic (bibliographic) data bases	1	2	8
Using computer, communication, and information technology	1	2	8

13. If you received training or instruction in any of the following as part of your academic preparation, has it helped you perform your present professional duties? (Circle number)

	Not Helpful						Very Helpful	Don't Know	Did Not Receive Training
Technical writing/communication	1	2	3	4	5	6	7	8	10
Speech/oral communication	1	2	3	4	5	6	7	8	10
Using a library that contains engineering/science information resources and materials	1	2	3	4	5	6	7	8	10
Using engineering/science information resources and materials	1	2	3	4	5	6	7	8	10
Searching electronic (bibliographic) data bases	1	2	3	4	5	6	7	8	10
Using computer, communication, and information technology	1	2	3	4	5	6	7	8	10

The following questions pertain to the academic preparation of aerospace engineering and science students.

14. Do you think that undergraduate aerospace engineering and science students should have training or course work in technical communications (for example, technical writing/oral presentations)? (Circle the appropriate number)

1 Yes
2 No → Go to Question 21.
3 Don't know → Go to Question 21.

If you answered "yes" to Question 14, please answer Questions 15, 16, 17, 18, 19, and 20.

15. Do you think a technical communications course for undergraduate aerospace engineering and science students should be: (Circle the appropriate number)

1 Taken for academic credit
2 Not taken for academic credit
3 Don't know

16. Do you think the technical communications course should be: (Circle the appropriate number)

1 Taken as part of a required course
2 Taken as part of an elective course
3 Don't know

17. Do you think the technical communications course should be: (Circle the appropriate number)

1 Taken as part of an engineering course (for example, Engineering 201)
2 Taken as a separate course (for example, Technical Writing 101)
3 Taken as part of another course (that is, neither Engineering or English)
4 Don't know

18. Which of the following *principles* should be included in an undergraduate technical communications course for aerospace engineering and science students? (Circle the appropriate numbers)

	Yes	No
Defining the purpose of the communication	1	2
Assessing the needs of the reader	1	2
Organizing information	1	2
Developing paragraphs (introductions, transitions, and conclusions)	1	2
Writing sentences	1	2
Notetaking and quoting	1	2
Editing and revising	1	2
Choosing words (avoiding wordiness, jargon, slang, and sexist terms)	1	2
Other (specify) ________________		

19. Which of the following *mechanics* should be included in an undergraduate technical communications course for aerospace engineering and science students? (Circle the appropriate numbers)

	Yes	No
Abbreviations	1	2
Acronyms	1	2
Capitalization	1	2
Numbers	1	2
Punctuation	1	2
References	1	2
Spelling	1	2
Symbols	1	2
Other (specify) ________________		

20. Which of the following *on-the-job* skills should be included in an undergraduate technical communications course for aerospace engineering and science students? (Circle the appropriate numbers)

	Yes	No
Abstracts	1	2
Letters	1	2
Memoranda	1	2
Technical instructions	1	2
Journal articles	1	2
Conference/Meeting papers	1	2
Literature reviews	1	2
Technical manuals	1	2
Newsletter/newspaper articles	1	2
Oral (technical) presentations	1	2
Technical specifications	1	2
Technical reports	1	2
Use of information sources	1	2
Other (specify) ________________		

These next questions ask about the preparation of written technical communication as part of your professional duties.

21. What percentage of your written technical communication involves collaborative writing (i.e., writing as a member of a group)?

    ________ % (If 100% of your writing is done alone, go to Question 23.)

    If you do write as a member of a group, what percentage of your written technical communication is required to be collaborative?

    ________ %

22. In general, do you find writing as part of a group more or less productive (quantity/quality) than writing alone? (Circle number)

    1 Less productive than writing alone
    2 About as productive as writing alone
    3 More productive than writing alone

23. To what extent does lack of knowledge/skill about each of the following communication principles impede your ability to produce (i.e., quality/quantity) written technical communication? (Circle all that apply)

	Does Not Impede						Greatly Impedes	Don't Know
Defining the purpose of the communication	1	2	3	4	5	6	7	8
Assessing the needs of the reader	1	2	3	4	5	6	7	8
Preparing/presenting information in an organized manner	1	2	3	4	5	6	7	8
Developing paragraphs (introductions, translations, and conclusions)	1	2	3	4	5	6	7	8
Writing grammatically correct sentences	1	2	3	4	5	6	7	8
Notetaking and quoting	1	2	3	4	5	6	7	8
Editing and revising	1	2	3	4	5	6	7	8
Other (specify) ________								

24. Do you use computer technology to prepare written technical information? (Circle ONE number)

    1 Never → Go to Question 25
    2 Sometimes
    3 Frequently → Go to Question 26
    4 Always

25. If NEVER, which one of the following best explains your reasons for non-use? (Circle numbers)

    1 No/Limited computer access
    2 Lack of knowledge/skill using a computer
    3 Prefer not to use a computer
    4 Other (specify) ________

These questions ask about your use of electronic and information technologies.

26. Describe your use of the following electronic/information technologies in communicating technical information? (Circle the appropriate number for each)

Information Technologies	Already Use	Don't use but may in the future	Don't use and doubt if I will
Audio tapes and cassettes	1	2	3
Motion picture film	1	2	3
Video tape	1	2	3
Desktop/electronic publishing	1	2	3
Computer cassette/cartridge tapes	1	2	3
Electronic mail	1	2	3
Electronic bulletin boards	1	2	3
FAX or TELEX	1	2	3
Electronic data bases	1	2	3
Video conferencing	1	2	3
Computer conferencing	1	2	3
Micrographics and microforms	1	2	3

27. Do you ever use electronic (computer) networks? (Circle number)

1 Yes, I personally use them
2 Yes, I use them but through an intermediary
3 No
4 No, because I do not have access to electronic networks → Go to Question 30.
5 No, but I may use them in the future

If you answered "no" to Question 27, please go to Question 30. If you answered "yes" to Question 27, please continue to Question 28.

28. Do you use electronic networks for the following purposes? (Circle the appropriate number for each)

	Yes	No
To connect to geographically distant sites	1	2
For electronic mail	1	2
For electronic bulletin boards or conferences	1	2
For electronic file transfer	1	2
To log into computers for such things as computational analysis or to use design tools	1	2
To control equipment such as laboratory instruments or machine tools	1	2
To access/search a library catalog	1	2
To order documents from a library	1	2
To prepare scientific and technical papers with colleagues at geographically distant sites	1	2
For information search and data retrieval with the following protocols:		
FTP	1	2
gopher	1	2
WAIS	1	2
World Wide Web (WWW)	1	2

29. At your workplace, do you use electronic (computer) networks to communicate with: (Circle the appropriate number for each)

	Yes	No
Members of your work group	1	2
Other people in your organization at the SAME geographical site who are NOT in your work group	1	2
Other people in your organization at geographically DIFFERENT site who are NOT in your work group	1	2
People outside your work group	1	2

These questions ask about your use of libraries and library services in the performance of your present professional duties.

30. During the past six months, about how many times have you used a library to meet your engineering/science information needs?

_________ number of times

If you answered "0" times to Question 30, please go to Question 32. If you answered "1 or more" times to Question 30, please continue to Question 31.

31. During the past six months, how effective was the information obtained from the library for meeting your engineering/science information needs? (Circle number) → Go to Question 33

Very Ineffective						Very Effective	Don't Know
1	2	3	4	5	6	7	8

32. Which of the following statements describe your reasons for not using a library during the past six months? (Circle ALL that apply)

	Yes	No
I had no information needs	1	2
My information needs were met more easily met some other way	1	2
Tried the library once or twice before but I couldn't find the information I needed	1	2
The library is physically too far away	1	2
The library staff is not cooperative or helpful	1	2
The library staff does not understand my information needs	1	2
The library did not have the information I needed	1	2
I have my own personal library and do not need another library	1	2
The library is too slow in getting the information I need	1	2
We have to pay to use the library	1	2
We are discouraged from using the library	1	2

33. Do you use the following technical reports in performing your present professional duties? (Circle the appropriate numbers)

	Yes	No	Don't Have Access
AGARD reports	1	2	6
British ARC and RAE reports	1	2	6
Dutch NLR reports	1	2	6
ESA reports	1	2	6
Indian NAL reports	1	2	6
French ONERA reports	1	2	6
German DFVLR, DLR, and MBB reports ...	1	2	6
Japanese NAL reports	1	2	6
Russian TsAGI reports	1	2	6
U.S. NASA reports	1	2	6

34. Think of the most important job-related project, task, or problem you have worked on in the past six months. Which category best describes this work? (Circle only ONE number)

1 Research (either basic or applied)
2 Design/Development
3 Manufacturing/Production
4 Quality Assurance/Control
5 Computer Applications
6 Management (e.g., planning, budgeting, and managing research)
7 Other (specify): ____________________

35. How would you describe the overall complexity of the technical project, task, or problem you categorized in Question 34? (Circle ONE number)

Very Simple 1 2 3 4 5 Very Complex

36. How would you rate the amount of technical uncertainty that you faced when you stated the technical project, task, or problem categories in Question 34? (Circle ONE number)

Little Uncertainty 1 2 3 4 5 Great Uncertainty

37. While you were involved in the technical project, task, or problem, did you work alone or with others?

1 Alone
2 With others → In how many groups did you work? ________
About how many people were in each group? ________

38. Which of the following best describes the kinds of duties you performed while working on the project categorized in Question 34? (Circle ONE number)

1 Engineering
2 Science
3 Management
4 Other (specify): ____________________

39. 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) and put an X beside the steps you did not use.]

_________ Used my personal store of technical information, including sources I keep in my office
_________ Spoke with coworkers or people inside my organization
_________ Spoke with colleagues outside my organization
_________ Spoke with a librarian or technical information specialist
_________ Searched (or had someone search for me) an electronic (bibliographic) data base in the library
_________ Used literature resources (e.g., conference papers, journals, technical reports) found in my organization's library

_________ Used none of the above steps

40. Do you use the results of federally-funded aerospace R&D in your work? (Circle ONE number)

1 Yes
2 No

41. Did you use the results of federally-funded aerospace R&D in completing the project, task, or problem you categorized in Question 34? (Circle ONE number)

1 Yes
2 No ——→ Go to Question 46

42. How important were these results in completing the project, task, or problem you categorized in Question 34? (Circle ONE number)

Very Unimportant 1 2 3 4 5 Very Important

43. Were these results published in either a NASA or DoD technical report?

1 Yes
2 No

44. From which of the following sources did you learn about/obtain the results of the federally-funded aerospace R&D <u>you used in completing the project, task, or problem</u>? (Circle the appropriate number for ONLY those sources used in this incident.)

	Yes	No
Coworkers inside my organization	1	2
Colleagues outside my organization	1	2
NASA and DoD contacts	1	2
Publications such as NASA *STAR*	1	2
NASA and DoD sponsored and co-sponsored conferences and workshops	1	2
NASA and DoD technical reports	1	2
Professional and society journals	1	2
Librarians inside my organization	1	2
Trade journals	1	2
Searches of computerized data bases	1	2
Professional and society meetings	1	2
Visits to NASA and DoD facilities	1	2

45. Which, if any of the following problems were associated with using these results? (Check ALL that apply)

_________ The time and effort it took to locate the results
_________ 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

These data will be used to determine whether people with different backgrounds have different information-seeking behaviors and information practices.

46. Your gender: (Circle number)

1 Female
2 Male

47. Your age: (Enter number)

____

48. The highest college degree you hold: (Circle number)

1 No college degree
2 Bachelor's
3 Master's
4 Doctorate
5 Post-Doctorate
6 Other (specify): _________

49. Which of the following best describes your primary professional duties? (Circle ONE number)

1 Teaching/Academic (may include research)
2 Research
3 Design/Development
4 Manufacturing/Production
5 Quality Assurance/Control
6 Service/Maintenance
7 Marketing/Sales
8 Private Consultant
9 Management/Supervision
10 Other (specify): _________

50. Type of organization where you work: (Circle ONE number)

1 Academic
2 Government (civilian)
3 Government (military)
4 Industry
5 Private Consultant
6 Other (specify): _________

51. Was your academic preparation as an: (Circle ONE number)

1 Engineer
2 Scientist
3 Other (specify): _________

52. In your present position, do you consider yourself primarily an: (Circle ONE number)

1 Engineer
2 Scientist
3 Other (specify): _________

OVER ⟶

53. Is English your first (native) language: (Circle number)

1 Yes 2 No

54. Your years of continuous professional AIAA membership: (Enter number) ________

55. Your years of permanent (full-time) employment in aerospace: (Enter number) ________

56. Your years of permanent (full-time) employment with present employer: (Enter number) ________

57. Is any of your current work funded by the federal government? (Circle ONE number)

1 Yes 2 No 3 Don't know

58. To have a successful career, how important will it be for you to: (Circle number)

	Very Unimportant						Very Important	Don't Know
1 Have the opportunity to explore new ideas about technology or systems	1	2	3	4	5	6	7	8
2 Advance to a high-level staff technical position	1	2	3	4	5	6	7	8
3 Have the opportunity to work on complex technical problems	1	2	3	4	5	6	7	8
4 Work on projects that utilize the latest theoretical results in your specialty	1	2	3	4	5	6	7	8
5 Work on projects that require learning new technical knowledge	1	2	3	4	5	6	7	8
6 Establish a reputation outside your organization as an authority in your field	1	2	3	4	5	6	7	8
7 Receive patents for your ideas	1	2	3	4	5	6	7	8
8 Publish articles in technical journals	1	2	3	4	5	6	7	8
9 Communicate your ideas to others in your profession through papers delivered at professional society meetings	1	2	3	4	5	6	7	8
10 Be evaluated on the basis of your technical contributions	1	2	3	4	5	6	7	8
11 Become a manager or director in your line of work	1	2	3	4	5	6	7	8
12 Plan and coordinate the work of others	1	2	3	4	5	6	7	8
13 Advance to a policy-making position in management	1	2	3	4	5	6	7	8
14 Plan projects and make decisions affecting the organization	1	2	3	4	5	6	7	8
15 Be the technical leader of a group of less experienced professionals	1	2	3	4	5	6	7	8

THANK YOU!

Mail to:

NASA/DoD Aerospace knowledge Diffusion Research Project
NASA Langley Research Center
Mail Stop 180A
Hampton, VA 23681-0001

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1995	Technical Memorandum

4. TITLE AND SUBTITLE
How Early Career-Stage U.S. Aerospace Engineers and Scientists Produce and Use Information

5. FUNDING NUMBERS
WU 505-90

6. AUTHOR(S)
Thomas E. Pinelli, Rebecca O. Barclay, and John M. Kennedy

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-110181

11. SUPPLEMENTARY NOTES
*Report number 34 under the NASA/DoD Aerospace Knowledge Diffusion Research Project. Thomas E. Pinelli: Langley Research Center, Hampton, VA; Rebecca O. Barclay: Rensselaer Polytechnic Institute, Troy, NY; John M. Kennedy: Indiana University, Bloomington, IN.

12a. DISTRIBUTION/AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Unclassified–Unlimited Subject Category 82	

13. ABSTRACT *(Maximum 200 words)*
The U.S. government technical report is a primary means by which the results of federally funded research and development (R&D) are transferred to the U.S. aerospace industry. However, little is known about this information product in terms of its actual use, importance, and value in the transfer of federally funded R&D. To help establish a body of knowledge, the U.S. government technical report is being investigated as part of the *NASA/DoD Aerospace Knowledge Diffusion Research Project*. In this report, we summarize the literature on technical reports and provide a model that depicts the transfer of federally funded aerospace R&D via the U.S. government technical report. We present results from our investigation of aerospace knowledge diffusion vis-á-vis the U.S. government technical report, and present the results of research that investigated aerospace knowledge diffusion vis-á-vis the production and use of information by U.S. aerospace engineers and scientists who had changed their American Institute of Aeronautics and Astronautics (AIAA) membership from student to professional in the past five years.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Knowledge diffusion; Aerospace engineers and scientists; Information use; and U.S. government technical reports	49
	16. PRICE CODE: A03

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