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Technical Communications in Aerospace:
Results of Phase 1 Pilot Study

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TECHNICAL COMMUNICATIONS IN AERONAUTICS:
RESULTS OF AN EXPLORATORY STUDY

INTRODUCTION

This exploratory study investigated the technical communications practices of aeronautical engineers and scientists. The study, which utilized survey research in the form of a self-administered mail questionnaire, had a twofold purpose -- to gather baseline data regarding several aspects of technical communications in aeronautics and to develop and validate questions that could be used in a future study concerned with the role of the U.S. government technical report in aeronautics.

The study had five specific objectives. The first, to solicit the opinions of aeronautical engineers and scientists regarding the importance of technical communications to their profession; the second, to determine their use and production of technical communications; the third, to seek their views in light of their technical communications responses on the appropriate content of an undergraduate course in technical communications; the fourth, to determine their use of libraries, technical information centers, and on-line databases; and finally, to determine the use and importance of computer and information technology to them.

Data were collected by means of a self-administered mail questionnaire shown in Appendix A. The questionnaire was developed within the project team; circulated to selected technical communicators for review and comment; and pretested at the NASA Ames Research Center, the NASA Langley Research Center, and the McDonnell Douglas Corporation in St. Louis. Members of the American Institute of Aeronautics and Astronautics (AIAA) comprised the study population. The sample frame consisted of approximately 25 000 AIAA members in the U.S. with either academic, government, or industry affiliations. Simple random sampling was used to select 2,000 individuals from the sample frame to participate in the exploratory study. Six hundred and six (606) usable questionnaires were received by the established cut off date. The study, which spanned the period from July 1988 to November 1988, was conducted in conjunction with Old Dominion University under NAS1-18584, Task 28, to help ensure the objectivity and confidentiality of the data and to obtain research skills not readily available to the project.

BACKGROUND

The aerospace industry continues to be the leading positive contributor to the U.S. balance of trade among all merchandise industries. According to the U.S. Department of Commerce (1987), the U.S. aerospace industry can look forward to the next five years with optimism. At the same time, international industrial alliances will result in a more rapid diffusion of technology, increasing the pressure on the U.S. aerospace industry to push forward with new technological developments.

According to Mowery (1985), the U.S. commercial aircraft industry is unique among manufacturing industries in that a government research organization, the National Advisory Committee on Aeronautics (NACA), which became the National Aeronautics and Space Administration (NASA) in 1958, has for many years conducted and funded research on airframe and propulsion technologies. In its wind tunnels and laboratories, the NACA conducted both basic and applied research, guided by committees made up of representatives of industry, the military services, and university aeronautical engineers and scientists. According to Shapley and Roy (1985), a pattern of collaboration grew up that provided the technical basis for the success of the U.S. aerospace industry.

Shapley and Roy (1985) view the NACA as a model for implementing federal research and development (R&D) because the NACA approach "offered science, applied science, technology, and a system for coupling knowledge with the people who use it in the field." In other words, the NACA model can be viewed as a model for the diffusion of innovation in the U.S. aerospace industry.

Rogers (1983) defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of the social system." He further states that diffusion is "a special type of communication in that the messages are concerned with new ideas."

In terms of empirically derived data, very little is known about the diffusion of innovation in the aerospace industry both in terms of the channels used to communicate the ideas and the information-gathering habits and practices of the members of the social system (i.e., aeronautical engineers and scientists). Most of the channel studies, such as the work by Gilmore (1967) and Archer (1962), have been concerned with the transfer of aerospace technology to non-aerospace industries.

Most of the studies involving aeronautical engineers and scientists, such as the work by McCullough (1982) and Pinelli (1982), have been limited to the use of NASA scientific and technical information products and services and have not been concerned with their information-gathering habits and practices. Although researchers such as Davis (1975) and Spretnak (1982) have investigated the importance of technical communications to engineers, it is not possible to determine from the published results if the study participants included aeronautical engineers and scientists.

Regarding the information-gathering habits and practices of engineers and scientists, Kaufman (1983), who quotes Allen (1977), states that in spite of the substantial amount of information regarding the information-seeking habits of engineers and scientists, "There are still very few studies directed exclusively and explicitly at the communication behavior of engineers." Allen (1977) also notes that the common practice of social scientists to lump engineers with scientists "is especially self-defeating in information studies because confusion over the characteristics of the sample has led to what would appear to be conflicting results and to a great difficulty in developing normative measures for improvement of the information systems in either science or technology."

It is likely that an understanding of the process by which innovation in the aerospace industry is communicated through certain channels over time among the members of the social system would contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of aeronautical engineers and scientists.

Furthermore, since the federal government provides a substantial portion of funds for U.S. aerospace R&D, it is likely that an understanding of the innovation process would be helpful to those federal agencies involved in developing aerospace information policy and systems. As Menzel (1966) states

> The way in which [aeronautical] engineers and scientists make use of information at their disposal, the demands that they put on them, the satisfaction achieved by their efforts, and the resultant impact on their future work are among the items of knowledge which are necessary for the wise planning of [engineering and] science information systems and policy.

Finally, it is likely that research regarding the information-gathering habits and practices of aeronautical engineers and scientists and their technical communications practices would hold significant implications not only for technical communicators but also for technical managers, engineering educators, information managers, library and technical information specialists, and curriculum developers.

ACRONYMS

ABET	Accreditation Board for Engineering and Technology
AIAA	American Institute of Aeronautics and Astronautics
ANOVA	Analysis of Variance
AV	Audio Visual
CD-ROM	Compact Disc Read-Only Memory
DOD	Department of Defense
ERIC	Educational Resources Information Center
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration

PC	Personal Computer
R&D	Research and Development
SPSS-X	Statistical Package for the Social Sciences-X
S&T	Scientific and Technical
STI	Scientific and Technical Information

RELATED RESEARCH AND LITERATURE

The search for related research and literature included (1) print and computerized databases, including Engineering Index and the Educational Resources Information Center (ERIC); and (2) books, periodicals, reports, and conference proceedings. The search focused on user surveys specifically concerned with the roles of the engineering curriculum, the library and technical information center, and the use of computer and information technology in the creation and use of technical writing and communications among engineers. Data from these studies are included in this section under the corresponding study objective.

The Importance of Technical Communications

There is no consensus definition of technical communications. Most textbooks on the subject use the term to include the practices of technical writing and oral communications. For purposes of this study, technical communications is broadly defined and encompasses the skills needed and the processes and institutions used by engineers to acquire, produce, transfer, and use scientific and technical (S&T) information.

Davis (1975) published the results of a survey to determine, among other things, the importance of technical communications to "successful" engineers. Davis sent a self-administered mail questionnaire to 348 individuals listed in the 1973 edition of Engineers of Distinction: A Who's Who in Engineering. The response rate was 73.8 percent or 245 valid questionnaires.

In response to the question of how important writing is and if the ability to write effectively is needed, approximately 96 percent (134 respondents) indicated that the writing they did was either very important (51 percent) or was critically important (45 percent) in their position. None of the respondents indicated that their writing was unimportant.

In response to the question of whether the ability to write can effectively delay or prevent advancement for an individual who is otherwise qualified, eighty-nine percent of the respondents stated that, other considerations aside, the ability to write is usually an important or a critical consideration when a subordinate is considered for advancement.

Spretnak (1982) conducted a survey in 1980, "Technical Communication and the Professional Engineer," which was mailed tc 1,000 engineering alumni of the University of California, Berkeley. The population surveyed was randomly selected from a computerized roll of alumni from the classes of 1947-48 through 1977-78 with U.S. addresses. The survey, pretested on 28 randomly selected engineering alumni, was mailed to 1,000 alumni of whom 595 (59.5 percent) completed it.

In response to the question, "Do you have any general comments about the importance or relative unimportance of writing and speaking skills in engineering careers?", none of the respondents indicated that writing and speaking skills were unimportant. Excerpts from the responses to Spretnak's (1982) open-ended question appear below.

- o Technical communications is the key to success for every engineer.
- o Progression to upper levels is controlled, in great part, by an engineer's communication skills.
- o No doubt writing is the most important skill an engineer can possess.
- o Writing and speaking should receive the same attention as technical training.

Seventy-three percent reported that writing skills had aided their advancement. Ninety-five percent said they would consider writing ability in deciding whether to hire or promote an engineer, while 42 percent of the total respondents said that they would weigh writing and presentation skills "greatly."

Respondents were asked to provide "any advice for engineering students regarding the importance or relative importance of studying technical writing." Excerpts from Spretnak's (1982) responses to the open-ended question appear below.

> o Get all of the writing and speaking training you can get as early as you can. Your technical training will be obsolete in ten years; your communication skills will last.
>
> o Take as many communication courses as possible. All upper-level/mid-level managers are either excellent writers or speakers or both.
>
> o Communication courses are the most important studies in an engineering curriculum. Anyone can work problems and draw; only a few can really communicate. Communication is the name of the game.
>
> o Success in engineering is far more dependent on communication skills than, say, on mathematics.

The importance of writing to engineering as well as science students is echoed by David (1982), who states

> The single, greatest complaint our students make when polled about their undergraduate preparation consists of questions of the form: "Why didn't you teach us how to write?" They have found, much to their amazement, that one of their main jobs in the "real" world is writing, and that they are woefully unprepared to fulfill that part of their duties.

Davis (1975) reported that respondents to his study spent approximately 25 percent of their time writing technical communications and approximately 30 percent of their time working with technical communications prepared by others. Approximately 63 percent of the respondents reported that as their responsibilities increased, so too did the time they spent writing, and 94 percent of the respondents indicated that they spent more time working with written material as their responsibilities increased. According to Davis (1975), "As their responsibilities increased, respondents spent less of their time developing actual details of specific jobs and more time considering the work of others, making decisions from it, and inaugurating and carrying out appropriate action."

Spretnak (1982) reported that 79 percent of the respondents indicated that the amount of writing they did increased as they advanced in their careers. Thirty-two percent of the respondents said that the amount of writing they did "greatly" increased as they advanced in their careers. Approximately 62 percent of the respondents to the Spretnak study indicated that their writing was usually done under the pressure of deadlines. Almost all respondents reported not having as much time as they would prefer to devote to their writing. Less than 5 percent of the respondents either had access to or chose to work with a technical writer/editor.

Use and Production of Technical Communications

The review of related research and literature produced varying amounts of information on how engineers use and create specific kinds of technical information and technical information products and on the sources of information they use to solve technical problems. Respondents of the Davis (1975) study indicated they most frequently produced reports, memoranda, policies and procedures, and letters. Respondents to the Spretnak (1982) study reported the production of similar technical communication products. The review of related research and literature revealed little information regarding the kinds of technical information and technical information products used by engineers.

Allen (1977) reported that the technical report is the "principal written vehicle for transferring information in technology." In her study, Information Transfer in Engineering, Shuchman (1981) reported that 75 percent of the engineers surveyed used technical reports, that technical reports were important to engineers doing applied work, and that aerospace engineers used technical reports more than any other group of engineers in the study.

There is considerable evidence to support the use of the technical report in aeronautics. 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 technical report in 1915." According to Stohrer (1981), "a variety of information products and services are utilized by the Department of Defense (DOD) and NASA STI systems. Within both of these systems, the U.S. government technical report is used as a primary means of transferring the results of U.S. government (performed and sponsored) R&D to the aeronautical community."

However, McClure (1988) states that few information product studies have focused on the U.S. government technical report. On the subject of these studies, McClure (1988) states that "it is often unclear whether U.S. government technical reports, non-government technical reports, or both were included. Because of competing or unclear definitions, the results of many of these studies are noncomparable."

Shuchman (1981) sought to determine the specific kinds of information used and produced by engineers. The engineers in her study were employed in 89 different companies, were classified into 14 industries, and performed both R&D and non-R&D activities. The engineers in her study represented the following major engineering disciplines: aeronautical, civil, chemical/environmental, electrical, industrial, and mechanical.

The kinds of information used and produced by the participants in Shuchman's (1981) study are presented for all engineers and aeronautical engineers as a subset of the sample population, in descending order of their use and production.

INFORMATION USED

All Engineers	Aeronautical Engineers
Basic S&T knowledge	Basic S&T knowledge
In-house technical data	In-house technical data
Physical data	Computer programs
Product characteristics	Physical data
Design methods	Design methods

INFORMATION PRODUCED

All Engineers	Aeronautical Engineers
In-house technical data	In-house technical data
New methods	Physical data
Design methods	Basic S&T data
Physical data	Design methods
Basic S&T data	New methods

With minor exceptions, the kinds of information used and produced by all engineers compared closely with the kinds of information used and produced by aeronautical engineers. The major difference between the two groups was in the use of computer programs by aeronautical engineers. Although both groups produced the same kinds of information, they differed in the order of production.

However, a comparison of the kinds of information used and produced by aeronautical engineers reveals some interesting differences. While basic S&T knowledge is the kind of information used most, it ranked third as the kind of information produced by aeronautical engineers. Likewise, while computer programs are the third most frequently used kind of information, they are absent from the list of information produced by aeronautical engineers. Shuchman (1981) made no attempt to correlate the kinds of technical information used and produced with the kinds of technical information products used and produced. While such a comparison would yield useful information, the data reported on "kinds of technical information used and produced" are useful, nevertheless, because they represent a departure from tradition by viewing both use and production as related processes.

Shuchman (1981) also sought to determine the sources of information used by engineers to solve technical problems. Her findings are presented for engineers as a group and for aeronautical engineers as a subset of the sample population in descending order of their use.

INFORMATION SOURCES USED
WHEN SOLVING A TECHNICAL PROBLEM

All Engineers	Aeronautical Engineers
Internal sources	Internal sources
Texts	Government sources
Government sources	Texts
Sales materials	Professional sources
External sources	Market sources
Professional sources	External sources
Market sources	Sales material

The kinds of information sources used when solving a technical problem were identical except for their order of importance. Engineers as a group and aeronautical engineers as a subset of the group favored the use of internal sources which include conversations with colleagues, discussions with supervisors, and in-house technical reports. Aeronautical engineers next turned to government sources, which include information produced by government agencies, such as specifications and standards, regulations, and technical reports. Texts, which include handbooks and tables, were used next, followed by professional sources, which include dissertations, conference proceedings, and abstracting publications.

Market sources, which include information prepared by trade associations, registered patents, and information obtained from customers, were followed by external sources, which include information obtained from employees of other firms, external consultants, and from university employees. External sources, the least important information source, included catalogs, trade shows, advertisements, and sales representatives.

Content for an Undergraduate Course in Technical Communications

The question of what should be included in an undergraduate technical communications course has been the topic of considerable discussion by technical communicators. Kellner (1982) states that "there is no consensus or even close agreement about what constitutes a technical writing course." Feinberg and Goldman (1985) and Green and Nolan (1984) reported the results of a survey of technical communicators which, according to the authors of the two studies, could be used as the basis for designing the content of a technical communications course.

The overwhelming preponderance of the respondents to the Davis (1975) study indicated that all students in scientific and engineering curricula should either be required or encouraged to take a course in technical writing. Eighty-one percent of the respondents indicated that a course in technical writing should be required of all students and sixteen percent indicated that it should be an elective, with all students encouraged to take it. Only four percent of the respondents differed from this position.

Respondents to the Davis (1975) study were then asked to select from a list of topics those that were essential, OK, or not important for inclusion in a technical writing course. "Clarity of expression" and "analyzing a situation and producing a communication to fit the reader's needs" were rated as "essential" by the respondents. Sixty-two of the respondents listed one or more additional suggestions for possible course content, the general topic of brevity (under a variety of names such as "directness," "conciseness," "economy," and "others") being most frequently mentioned.

Respondents were then asked, "What should be the main emphasis in such a course -- the most important thing that a student should learn or be able to do as a result of taking it?" Of the 245 respondents, 207 supplied specific answers to this question. The "top three categories" appear below.

- clarity (directness, simplicity, unambiguousness, not to be misunderstood, comprehensibility, no ambiguity, etc.)

- brevity (conciseness, compactness, no extraneous words, succinctness, etc.)

- logical order (organization of ideas, continuity of thought, outline, not jump around, etc.)

Spretnak (1982) asked respondents to her survey, "What common problems do you notice in the writing of professional engineers?" Her thinking was that the common problems would form the basis for a course in technical writing. The most frequent responses included grammatical errors, lack of coherence, illogical ordering of ideas, choppy sentences, wordiness, overly long sentences, and a rambling style.

The Use of Libraries, Technical Information Centers, and On-Line Databases

The process by which engineers solve technical problems affects their use of libraries and technical information centers. The results of Shuchman's (1981) study, which are supported by the findings of several engineering information use studies, confirm this position. The steps the engineers in Shuchman's study followed in solving technical problems appear below.

HOW ENGINEERS SOLVE TECHNICAL PROBLEMS

Steps in Solving Technical Problems	Percent of Cases
1. Consulted personal store of technical information	93
2. Informal discussion with colleagues	87
3. Discussed problem with supervisor	61
4. Consulted internal technical reports	50
5. Consulted key person in firm who usually knows new information	38
6. Consulted library sources (e.g., technical journals, conference proceedings)	35
7. Consulted outside consultant	33
8. Used electronic databases	20
9. Consulted librarian/technical information specialist	14
10. No pattern in problem-solving	5

Herner (1954) found that engineers at Johns Hopkins University considered their personal knowledge and informal discussions with colleagues and with experts within their organization to be most useful when faced with solving a technical problem. Rosenbloom and Wolek (1970) found that engineers favored the use of interpersonal communications (e.g., discussions with colleagues within their organization) when faced with the need to solve a technical problem. These findings are supported by Kremer (1980) and Kaufman (1983). Only after they have exhausted their personal store of information and have consulted their colleagues will engineers turn to another information source, such as a library.

In Shuchman's study, libraries ranked sixth as the information source engineers used in solving a technical problem. The fact that librarians and technical information specialists ranked ninth as the information source engineers used in solving a technical problem tends to support the hypothesis that engineers tend to assume personal responsibility for fulfilling their information needs. This statement is supported by the engineers in Shuchman's study who attempted to find the information themselves in the library before soliciting the help of a librarian or technical information specialist.

Allen (1977) corroborated these findings, noting that although the library is an important source of information, rarely do engineers make full use of its potential. He too reported that engineers tend to search for library information themselves, only in "rare" instances seeking the services of a librarian or technical information specialist.

Other studies suggest several reasons why engineers do not seek technical information in libraries. Apart from their "personal" and "informally" directed approach to fulfilling their technical information needs, Frohman (1968), quoted by Allen (1977), states that the extent of library use is related inversely to the distance separating the user from the library. Allen (1977) summarized his discussion of library use by observing that "the value seen in using the library simply does not seem great enough to overcome the effort involved in either traveling to it or using it once the person is there."

Information on the use of electronic bibliographic databases by engineers is limited. Those engineers who participated in Shuchman's (1981) study made little use of on-line databases. In the steps used in solving a technical problem, databases ranked eighth, just before librarians and technical information specialists. Kaufman (1983) found that approximately five percent of the engineers in his study used on-line databases when searching for the solution to a technical problem. Engineers in Kaufman's (1983) study indicated that "accessibility" was the single most important criterion for determining the use of an on-line database. Furthermore, when the engineers in Kaufman's (1983) study did use on-line databases, they did so most frequently to define or redefine the technical problem and continued to use the databases for the duration of the attempt to solve the technical problem.

Finally, in analyzing the use of on-line databases by engineers, it is important to keep in mind that significant changes have occurred in on-line databases in the years since the Shuchman (1981) and Kaufman (1983) studies were conducted. Perhaps the single greatest change has been the proliferation of databases. Williams (1987) states that "more than two thousand databases are now publicly available in machine-readable form, searchable through optical disc technologies or through a telecommunications link to an on-line search service." Anderson (1987) lists 18 specialized engineering databases and states that their creation is due, in part, to the evolution of specialized engineering disciplines.

The impetus for many of these changes is attributable to a decrease in the cost of computer technology, the introduction of new information technologies such as CD-ROM and videodisc, and the availability of new information products. These changes, according to Harter and Jackson (1988), create exciting new opportunities for improving access to information via end-user searching but also raise a host of questions and issues relative to bibliographic databases. However, as Bikson et al. (1984) state, to take advantage of on-line databases, the user also has to be assured of the following.

- Availability of a computer terminal
- Adequate connect time
- Subscriptions to an array of bibliographic services
- Skill in using the services (either directly or via an intermediary)
- Ability to acquire an item of information once it has been identified.
- Funds to cover the expenses that these efforts entail (in labor, equipment, and services)

Finally, there is considerable interest, at least in the related literature, in end-user searching of bibliographic databases. Mischo and Lee (1987) cite the following reasons for this increased interest.

- The continued exponential growth of information and the demonstrated value of on-line information retrieval
- The wide availability on-line full-text databases

- o The proliferation of microcomputer workstations with communications capabilities in both the workplace and home settings
- o The emphasis on computer literacy in education, office automation, professional occupations, and recreation
- o The inauguration of nonpeak-time, less expensive, more user friendly search systems
- o The growing awareness among the end-user population of the existence of on-line databases
- o The growing familiarity by library users of on-line catalogs and, by extension, on-line databases
- o The increase of workloads for intermediaries
- o The development of research and commercial front-end and gateway software packages to facilitate on-line searching by untrained users

Use and Importance of Computer and Information Technology

One of Shuchman's (1981) goals in investigating the use of computer and information technology by engineers was to "identify the attitudes [of engineers] toward and use patterns of computer and information technology in an effort to forecast the potential value of new information technologies." Overall, the survey results indicated that computer and information technology has "high" potential usefulness, but relatively low use among engineers. In analyzing this statement, it is important to keep in mind that the "state-of-the-art" in computer and information technology has changed dramatically in the seven years since the Shuchman (1981) study was released.

U.S. industry has invested heavily in computer and information technology for such purposes as enhancing the quality of managerial decision making and professional work products, improving efficiency and productivity, and increasing profitability. According to the U.S. Congress, Office of Technology Assessment (1988), "over 40 percent of all new investments in plant and equipment are now in a category called 'information technology' -- computers, communication equipment, and related information equipment. This is double its share in 1978." Since 1981, the cost of computer hardware and computer storage has decreased and computing power has significantly increased. Many new computer and information technology products have entered the market. However, according to Shuchman (1981), "such occurrences are of limited value unless management decisions are made that increase the accessibility and utility of computer and information technology."

In Shuchman's study, respondents were asked to indicate the use, non-use, and potential usefulness of 21 computer and information technologies. For purposes of data analysis, these 21 technologies have been arranged into the following four groups. The titles of the groups were contrived to provide a label for identification purposes only.

Computer Devices -- Group 1

Computations
Keyboard
Line printer
Accessing data banks
Video displays
Computer-aided instruction
Line printer-graphics

Information Transmission -- Group 2

Fast facsimile
Teleconferencing
Audio conference calls

Recorded/Prerecorded -- Group 3

Audio cassettes
Audio with high speed playback
Films
Video disks

Advanced Technology -- Group 4

Video telephone
Video closed circuit TV
Audio recognition
Text recognition
Graphics recognition
Speech synthesis

Data from Shuchman's study, which were used to make comparisons among the four computer and information technology groups and the six engineering disciplines, appear in Table A. Data are expressed in percentages of non-use, use, and potential usefulness.

TABLE A

Non-Use, Use, and Potential Usefulness of Computer and Information Technology by Engineering Disciplines*
(All Values are Percentages)

(1) Group 1 Computer Devices

Engineering Discipline	Non Use	Use	Potential Usefulness	Total
Aeronautical n = 84	16	62	22	100
Civil n = 260	27	43	30	100
Chemical/ Environmental n = 97	24	42	34	100
Electrical n = 241	15	52	33	100
Industrial n = 155	20	51	29	100
Mechanical n = 237	25	44	31	100

(2) Group 2 Information Transmission

Engineering Discipline	Non Use	Use	Potential Usefulness	Total
Aeronautical n = 84	17	57	26	100
Civil n = 260	35	39	26	100
Chemical/ Environmental n = 97	26	39	35	100
Electrical n = 241	30	38	32	100
Industrial n = 155	30	41	29	100
Mechanical n = 237	28	42	30	100

(3) Group 3 Recorded/Prerecorded

Engineering Discipline	Non Use	Use	Potential Usefulness	Total
Aeronautical n = 84	34	35	31	100
Civil n = 260	41	25	34	100
Chemical/ Environmental n = 97	38	24	38	100
Electrical n = 241	46	22	32	100
Industrial n = 155	42	28	30	100
Mechanical n = 237	40	25	35	100

(4) Group 4 Advanced Technology

Engineering Discipline	Non Use	Use	Potential Usefulness	Total
Aeronautical n = 84	52	8	40	100
Civil n = 260	65	4	31	100
Chemical/ Environmental n = 97	54	7	39	100
Electrical n = 241	57	6	37	100
Industrial n = 155	60	6	34	100
Mechanical n = 237	55	8	37	100

*Source Shuchman (1981)

Computer and information technologies in Group 1 were used by half of the engineers in the study. As shown in Table A.1, almost two-thirds (62 percent) of the aeronautical engineers used Group 1 technologies. Next to electrical engineers (15 percent), aeronautical engineers had the lowest "non-use" (16 percent) of Group 1 technologies of the 6 engineering disciplines, while 22 percent of those aeronautical engineers surveyed indicated that Group 1 technologies had "potential usefulness."

As shown in Table A.2, a larger-than-average number of aeronautical engineers (57 percent) used Group 2 technologies. Of the six engineering disciplines, aeronautical engineers had the lowest "non-use" (17 percent) of Group 2 technologies, while 26 percent of those aeronautical engineers surveyed indicated that Group 2 technologies had "potential usefulness."

Group 3 technologies represent both traditional and evolving technologies. Slightly more than half of those engineers who responded used slides and viewgraphs, while only 4 percent of the respondents used high speed video. As shown in Table A.3, slightly more than one-third (35 percent) of the aeronautical engineers used Group 3 technologies. Of the 6 engineering disciplines, aeronautical engineers had the lowest "non-use" (34 percent) of the Group 3 technologies and 31 percent of those aeronautical engineers surveyed indicated that Group 3 technologies had "potential usefulness."

Group 4 technologies, which contain some of the "newer" developments in computer and information technology, were used by a small percentage of the respondents. As shown in Table A.4, aeronautical and mechanical engineers represented the highest percentages of Group 4 technology users. Of the six engineering disciplines, aeronautical engineers had the lowest "non-use" (52 percent) of the Group 4 technologies and 40 percent of those aeronautical engineers surveyed indicated that Group 4 technologies had "potential usefulness."

Discussion

The results of the Davis (1975) and Spretnak (1982) surveys indicate that the ability to communicate technical information effectively is an important dimension of the professional engineer's work. Conversely, the inability to communicate in written and oral form can hinder an engineer's on-the-job effectiveness and his or her advancement. The results of these two studies indicate that engineers spend a considerable portion of their on-the-job time communicating and that as their careers advance, so too does the amount of time they spend working with technical communications from others.

Judging from the comments offered by the engineers who participated in these two studies, it appears that technical communications should be incorporated into the undergraduate engineering curriculum. How many of the fifty-three accredited undergraduate aeronautical engineering programs require or encourage technical communications as an elective is unknown. If technical communications is required or encouraged as part of these programs, are such items as technical writing, oral presentations, library instruction, research skills, and computer skills incorporated? If technical communications is required or encouraged as part of these programs, it might be helpful to understand the rationale upon which its inclusion is based. Is it included for reasons of accreditation or because the need for such instruction has been confirmed by employers?

The question of what should be included in an undergraduate technical writing course or curriculum has been the topic of some discussion among technical communicators and practicing engineers. While there is some indication as to the topics that should be included in an undergraduate technical communications course, there is little guidance in terms of the on-the-job communications that should be included. Other than the technical report, the research and related literature provide little insight into the kinds of technical information used and produced and the kinds of technical information products used and produced by aeronautical engineers. Although aeronautical engineers appear to use computer and information technology to a greater extent than other engineers, little is known regarding the actual extent of use.

Although libraries, technical information centers, and on-line databases are important sources of information, they tend not to be fully utilized by engineers. Does the same hold true for aeronautical engineers and scientists? When engineers do use the library or technical information center, they tend not to seek the services of a librarian or technical information specialist. Does the same hold true for aeronautical engineersa and scientists? According to Allen (1977), library use by engineers is an inverse function of the distance separating the engineer from the library. Does the same hold true for aeronautical engineers and scientists?

PRESENTATION AND DISCUSSION OF THE DATA

The questionnaire used in this study (1989) contained 35 questions: 25 questions concerned technical communications in aeronautics, 8 questions concerned demographic information about the survey respondents, and 2 open-ended questions allowed survey respondents to comment on the topics covered in the questionnaire and to offer suggestions for improving technical communications in aeronautics. The responses to each question are presented for each survey topic.

Demographic data are presented first, followed by data regarding technical communications in aeronautics, which are grouped according to the five study objectives. Each question is then followed by the aggregated tallies of responses to it. Of the 2,000 questionnaires mailed, 606 completed surveys (30.3 percent response rate) were received. The data were analyzed using the Statistical Package for the Social Sciences-X (SPSS-X) designed for use with a personal computer (PC). Appendix B contains the aggregated tallies for the 606 questionnaires.

Cross tabulations were prepared to explore the relationships between responses to the 25 questions and the respondents' organizational affiliation. Affiliations included academic, government (NASA and non-NASA), and industry. The "academic" category includes responses from academic and not-for-profit organizations.

The Chi-square and one-way ANOVA (Analysis of Variance) at the .05 level of statistical significance were used as the non-parametric and parametric tests for relationships between the responses to the 25 questions and the organizational affiliations of the respondents. Appendix C contains the cross tabulations for the 25 questions. Those cross tabulations found to be statistically significant at .05 are presented in Part A of Appendix C. Responses to the open-ended questions are included as Appendix D.

Demographic Information About the Survey Respondents

Survey respondents were asked to provide information regarding their professional duties, type of organization, years of professional work experience, their AIAA interest group, their level of education, their educational preparation, whether American English was their first (native) language, and their gender.

Background data (Table B) collected as part of the survey revealed that approximately 38 percent of the respondents stated that their professional duties were design/development and approximately 24 percent indicated their professional duties involved administration/management (15.4 percent for profit and 8.4 percent not-for-profit). Approximately 20 percent indicated that their professional duties involved research.

TABLE B

Summary: Professional Duties	Number	Percentage
Research	118	19.5
Administration/Management(for profit)	93	15.4
Administration/Management(not-for-profit sector)	51	8.4
Design/Development	226	37.4
Teaching/Academic	35	5.8
Manufacturing/Production	10	1.7
Private Consultant	14	2.3
Service/Maintenance	1	0.2
Marketing/Sales	23	3.8
Other	33	5.5
	604	100.0

Approximately 62 percent of the respondents were affiliated with industrial organizations (Table C), followed by 16 percent who worked with government (non-NASA) organizations. About 12 percent of the respondents worked with NASA and about 7 percent were affiliated with academic organizations.

TABLE C

Summary: Type of Organization	Number	Percentage
Academic	41	6.8
Industrial	376	62.1
Not-for-Profit	17	2.8
Government (Non-NASA)	97	16.0
NASA	74	12.3
	605	100.0

Approximately 35 percent of the respondents had 10 or fewer years of professional work experience (Table D), and approximately 54 percent had 20 or fewer years of professional work experience. Approximately 77 percent had 30 or fewer years of professional work experience, an approximately 23 percent had 31 or more years of professional work experience.

TABLE D

Summary: Years of Professional Work Experience	Number	Percentage
0 to 5 years	107	17.7
6 to 10 years	105	17.4
11 to 15 years	59	9.8
16 to 20 years	57	9.4
21 to 30 years	141	23.4
31 or more years	137	22.4
	606	100.0

Approximately 31 percent of the respondents selected aerospace sciences as their AIAA interest group (Table E), followed by approximately 20 percent in propulsion and energy. The third and fourth most frequently selected AIAA interest groups were aircraft systems (13. percent) and structures, design, and test (13.7 percent). Eight percent selected aerospace and information systems 8 percent and about six percent of the respondents selected administration/management as their AIAA interest group.

TABLE E

Summary: AIAA Interest Group	Number	Percentage
Aerospace Science	183	30.6
Aircraft Systems	82	13.7
Structures, Design, and Test	82	13.7
Propulsion and Energy	120	20.1
Aerospace and Information Systems	48	8.0
Administration/Management	37	6.2
Other	46	7.7
	598	100.0

About one percent or four respondents reported having less than a bachelors degree (Table F), while approximately 33 percent of the respondents held a bachelors degree. Just over 66 percent of the respondents held graduate degrees, with about 44 percent having masters degrees and about 23 percent holding doctorates.

TABLE F

Summary: Level of Education	Number	Percentage
No degree	4	0.7
Bachelors	198	32.8
Masters	264	43.7
Doctorate	137	22.7
Other	1	0.1
	604	100.0

Approximately 90 percent of the respondents (Table G) indicated that they were engineers, and approximately 10 percent indicated that they were scientists.

TABLE G

Summary: Engineer or Scientist	Number	Percentage
Engineer	541	89.9
Scientist	61	10.1
	602	100.0

Approximately 94 percent of the respondents (Table H) indicated that American English was their first (native) language. Approximately six percent indicated that American English was not their first (native) language.

TABLE H

Summary: American English is First (Native) Language	Number	Percentage
Yes	567	93.6
No	39	6.4
	606	100.0

Approximately 95 percent of the respondents were male (Table I) and approximately five percent were female.

TABLE I

Summary: Gender	Number	Percentage
Male	577	95.2
Female	29	4.8
	606	100.0

Survey Objective 1: The Importance of Technical Communications

To determine the importance of technical communications in aeronautics, survey respondents were asked to indicate the importance of communicating technical information effectively, the number of hours spent each week communicating technical information to others, the number of hours spent each week working with technical communications received from others, and how their professional advancement has affected the amount of time they spend communicating technical information to others and working with technical communications from others.

Approximately 99 percent of the aeronautical engineers and scientists surveyed (Table J) indicate that the ability to communicate technical information effectively is important. Only .5 percent indicate that this ability is not important. These data correlate well with the results of the Davis (1975) and Spretnak (1982) studies.

TABLE J

Summary: Importance of Technical Communications	Number	Percentage
Very important	542	89.7
Somewhat important	59	9.8
Not at all important	3	0.5
	604	100.0

Respondents were asked to comment on the question, "What can be done to improve technical communications in aeronautics?" Excerpts from the responses to this open-ended question follow.

- o Technical communications needs to be stressed as part of the undergraduate engineering curriculum.

- o Teach engineering students how to write for non-technical audiences, teach them how to present technical data to both technical and non-technical audiences, and the correct use of grammar.

- o Teach engineering students how to communicate; effective communication is essential to the success of today's engineer.

- o I cannot emphasize enough the need for engineers to be trained in English grammar, spelling, writing, and presentation skills.

Survey respondents spend an average of 13.95 hours per week communicating technical information to others (Table K). Based on a 40-hour work week, they spend approximately 35 percent of their work week communicating technical information to others. Respondents to the Davis (1975) study spent approximately 25 percent of their time producing (writing) technical communications.

TABLE K

Summary: Hours Spent Per Week Communicating Technical Information to Others	Number	Percentage
5 hours or less	102	17.1
6 to 10 hours	189	31.7
11 to 20 hours	237	39.8
21 hours or more	68	11.4
	596	100.0

Mean = 13.95 hours

Aeronautical engineers and scientists spend approximately 13 hours a week working with technical communications received from others (Table L). In a 40-hour work week, they spend approximately 31 percent of their week with such work. Respondents to the Davis (1975) study spent about 30 percent of their time working with technical communications received from others. Considering both the time spent working on the preparation of technical information and the time spent working with technical information received from others, technical communications takes up approximately 66 percent of the aeronautical engineer's and scientist's 40-hour work week.

TABLE L

Summary: Hours Spent Per Week Working With Technical Communications Received From Others	Number	Percentage
5 hours or less	126	21.1
6 to 10 hours	222	37.2
11 to 20 hours	197	33.0
21 hours or more	52	8.7
	597	100.0

Mean = 12.57 hours

Approximately 72 percent of the survey respondents indicate that as they advanced professionally, the amount of time they spent communicating technical information to others increased (Table M). Approximately 15 percent indicate that the amount of time spent communicating technical information to others stayed the same, and approximately 13 percent indicate that the amount of time they spent communicating technical information to others decreased as they advanced professionally. Approximately 63 percent of the respondents in the Davis (1975) study and 79 percent of the respondents in the Spretnak (1982) study reported that the amount of time they spent preparing (writing) technical communications increased as they advanced in their careers.

TABLE M

Summary: Professional Advancement -- Amount of Time Spent Communicating Technical Information to Others	Number	Percentage
Increased	433	71.7
Stayed the same	93	15.4
Decreased	78	12.9
	604	100.0

Approximately 61 percent of the respondents indicate that as they advanced professionally, the amount of time they spent working with technical communications received from others increased (Table N). Approximately 26 percent indicated that the amount of time spent working with technical communications received from others stayed the same as they advanced professionally, and approximately 13 percent indicate that the amount of time spent working with technical communications received from others decreased as they advanced professionally. Approximately 91 percent of the respondents to the Davis (1975) study indicated that they spend more time working with written materials as their responsibilities increased.

TABLE N

Summary: Professional Advancement -- Amount of Time Spent Working With Technical Communications Received From Others	Number	Percentage
Increased	367	61.2
Stayed the same	155	25.9
Decreased	77	12.9
	599	100.0

Survey Objective 2: The Use and Production of Technical Communications

To determine the use and production of technical communications, survey respondents were asked to indicate the volume and type of technical information they produced and the sources of help they sought in producing their information and in solving technical problems.

Memos, letters, and A/V (audio visual) materials are most frequently produced by aeronautical engineers and scientists (Table O). On the average, respondents produced approximately 29 memos, 22 letters, and 7 A/V materials in the past six months.

TABLE O

Summary: Technical Information Product Production	None	1-5	6-10	11 and Above	Total %	Average
Letters	15.0	22.7	22.8	39.5	100	22.2
Memos	8.6	14.9	19.1	57.4	100	28.8
Technical reports-Government	60.9	31.7	5.6	1.8	100	1.6
Technical reports-Other	57.1	34.2	6.5	2.2	100	1.9
Proposals	47.4	46.4	4.2	2.0	100	1.8
Technical manuals	84.9	13.9	1.2	0.0	100	0.3
Computer program documentation	70.0	24.6	3.6	1.8	100	1.3
Journal articles	80.0	19.4	0.4	0.2	100	0.4
Conference/Meeting papers	62.8	33.9	1.8	1.5	100	1.1
Trade/Promotional literature	93.0	5.6	0.9	0.5	100	0.3
Press releases	90.0	9.3	0.2	0.5	100	0.3
Drawings/Specifications	71.8	17.8	3.3	7.1	100	3.2
Speeches	54.0	35.0	7.5	3.5	100	2.2
Audio/Visual materials	30.1	36.2	17.4	16.3	100	6.6

Other technical information products were produced far less frequently. Trade and promotional literature, press releases, and technical manuals were the technical information products produced least frequently. Based on average production, the five most frequently and least frequently produced products are summarized on the following page.

<u>Most Frequently Produced</u> 6-month production	<u>Least Frequently Produced</u> 6-month production
Memos	Trade/promotional literature
Letters	Press releases
A/V materials	Technical manuals
Drawings/specifications	Journal articles
Speeches	Conference/meeting papers

A one-way ANOVA (Analysis of Variance) (Table P) was used to compare respondents' organizational affiliations with their production of technical information. Academic respondents

TABLE P

Comparison of the Average Number of Technical Information Products Used by Organizational Affiliation					
Product	Academic	Industrial	Government	NASA	Average Number
Letters	44.0	20.2	21.2	16.5	22.0
Government technical reports	.9	.9	1.4	2.1	1.6
Other technical reports	1.8	2.5	.5	.4	1.9
Proposals	2.3	2.2	.5	.5	1.8
Journal articles	1.3	.2	.3	.5	0.4

ANOVA is significant at $P < .05$

produced significantly more letters, proposals, and journal articles than did respondents in the other groups. Industrial respondents produced significantly more nongovernmental technical reports than did respondents in the other groups. Similarly, NASA respondents produced significantly more government technical reports than did respondents in the other groups.

On the average, memos, letters, and drawings/specifications were the technical information products most frequently used by aeronautical engineers and scientists during a one-month period (Table Q).

TABLE Q

Summary: Technical Information Product Use	None	1-5	6-10	11 and Above	Total %	Average
Letters	18.7	30.4	20.5	30.4	100	16.7
Memos	10.3	27.7	17.5	44.5	100	24.3
Technical reports-Government	35.3	44.8	12.9	7.0	100	4.2
Technical reports-Other	34.5	46.3	11.0	8.2	100	4.5
Proposals	57.2	38.2	3.8	0.8	100	1.4
Technical manuals	60.9	31.1	4.8	3.2	100	2.2
Computer program documentation	55.7	34.5	5.3	4.5	100	3.0
Journal articles	34.9	36.8	14.9	13.4	100	6.7
Conference/Meeting papers	43.8	39.8	10.0	6.4	100	4.3
Trade/Promotional literature	54.1	27.6	9.1	9.2	100	5.7
Drawings/Specifications	56.3	23.7	8.5	11.5	100	7.9
Audio/Visual materials	47.0	33.4	11.9	7.7	100	5.5

The five most frequently and least frequently used (on the average) technical information products are summarized below.

Most Frequently Used 1-month use	Least Frequently Used 1-month use
Memos	Proposals
Letters	Technical manuals
Drawing/specifications	Computer program documentation
Journal articles	Government technical reports
Trade and promotional literature	Conference/meeting papers

Letters, memos, and drawings/specifications are frequently produced and used. Technical manuals are the least produced and used technical information products. Somewhat surprising is the lack of use and production of technical reports. The related research and literature indicate that technical reports are important technical information products in aeronautics. However, the study question was concerned with production and use, not importance. Technical reports did not appear on the list of either the most frequently produced or most frequently used information products.

A one way ANOVA (Table R) was used to compare respondents' organizational affiliations with their use of specific technical information products. NASA respondents used significantly more

TABLE R

Comparison of the Average Number of Technical Information Products Produced by Organizational Affiliation					
Product	Academic	Industrial	Government	NASA	Average Number
Government technical reports	2.8	3.6	5.1	7.3	4.2
A/V material	2.7	4.0	4.1	17.8	5.5

ANOVA is significant at $P < .05$

government technical reports and A/V materials than did respondents in other groups.

Aeronautical engineers and scientists seek the help of both people and other information sources to prepare technical information products (Table S). Other colleagues, secretaries, a

TABLE S

Summary: Technical Information Production -- Sources of Help	Always		Usually		Sometimes		Never		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Other colleagues	68	11.3	240	39.8	278	46.2	16	2.7	602	100
Secretaries	141	23.4	168	27.9	216	35.8	78	12.9	603	100
Technical writers or editors	9	1.6	28	4.8	231	40.0	310	53.6	578	100
A thesaurus/dictionary	127	21.3	174	29.3	249	41.8	45	7.6	595	100
A style manual	9	1.6	27	4.7	205	35.5	336	58.2	577	100
A grammar hotline	1	0.2	4	0.7	31	5.4	533	93.7	569	100

thesaurus, and a dictionary are "always" or "usually" used. From the available data, it is difficult to determine if technical writers and editors are so little used because they are unavailable or for some other reason.

Aeronautical engineers and scientists prepare artwork for their visual aids in various ways (Table T). Most of them prepare their own artwork using a computer (34.4 percent), followed by those who use a combination of self and a graphics department (30.3 percent), followed by those who use the graphics department alone (16.7 percent). Approximately 10 percent of the respondents apparently prepare their own artwork, apparently manually.

TABLE T

Summary: Artwork -- How Produced	Number	Percentage
I do my own artwork without a computer	62	10.3
I do my own artwork with a computer	206	34.4
The graphics department does my artwork	100	16.7
Sometimes I do it and sometimes the graphics department does it	182	30.3
A secretary does it	38	6.3
The artwork is prepared elsewhere	12	2.0
	600	100.0

Aeronautical engineers and scientists were asked to identify the types of technical information they produce (Table U). The

TABLE U

Summary: Types of Technical Information Produced in Performance of Present Duties	Yes		No		Total	
	No.	%	No.	%	No.	%
Scientific and technical information	555	92.2	47	7.8	602	100
Experimental techniques	269	44.7	333	55.3	602	100
Codes of standards and practices	126	20.9	476	79.1	602	100
Design procedures and methods	282	47.0	318	53.0	600	100
Computer programs	344	57.1	258	42.9	602	100
Government rules and regulations	92	15.4	507	84.6	599	100
In-house technical data	511	84.9	91	15.1	602	100
Product and performance characteristics	350	58.2	251	41.8	601	100
Economic information	164	27.2	438	72.8	602	100
Technical specifications	359	59.6	243	40.4	602	100
Patents	109	18.1	493	81.9	602	100

five most frequently produced and least frequently produced types of technical information are shown below.

Most Frequently Produced	Least Frequently Produced
S&T information	Government rules and regulations
In-house technical data	Patents
Technical specifications	Codes of standards and practices
Product and performance characteristics	Economic information
Computer programs	Experimental techniques

Chi-square cross tabulations were used to compare respondents' organizational affiliation with their production of specific types of technical information (Table V). Academic

TABLE V

Comparison of the Types of Technical Information Produced by Organizational Affiliation

Type of Technical Information	Academic		Industrial		Government		NASA		Total	Expected
	No.	%	No.	%	No.	%	No.	%	No.	%
Codes of standards and practices	6	10.3	82	22.0	27	27.8	11	14.9	126	20.9
Experimental techniques	33	56.9	155	41.6	40	41.2	41	55.4	269	44.7
Government rules and regulations	5	8.6	15	4.0	52	54.2	20	27.0	92	15.4
In-house technical data	36	62.1	329	88.2	84	86.6	62	83.8	511	84.9
Product and performance	19	32.8	251	67.3	51	53.1	29	39.2	350	58.2
Economic information	10	17.2	117	31.4	24	24.7	13	17.6	164	27.2
Technical specifications	23	39.7	248	66.5	49	50.5	39	52.7	359	59.6

Chi-square is significant at $P < .05$

and NASA respondents are more likely to produce experimental techniques than expected. Government respondents are more likely and academic and NASA respondents are less likely than expected, to produce codes of standards and practices. Government and NASA respondents were more likely and academic and industrial less likely than expected to produce government rules and regulations. Academic respondents are less likely than expected to produce in-house technical data. Industrial respondents are more likely and academic and NASA respondents less likely than expected to produce product and performance characteristics. Academic and NASA respondents are less likely than expected to produce economic information. Academic respondents are less likely than expected to produce technical specifications.

Aeronautical engineers and scientists were asked to identify the types of technical information they used (Table W). The five

TABLE W

Summary: Types of Technical Information Used to Perform Present Duties	Yes		No		Total	
	No.	%	No.	%	No.	%
Scientific and technical information	584	97.0	18	3.0	602	100
Experimental techniques	363	60.4	238	39.6	601	100
Codes of standards and practices	287	47.8	314	52.2	601	100
Design procedures and methods	336	55.9	265	44.1	601	100
Computer programs	486	80.7	116	19.3	602	100
Government rules and regulations	432	71.9	169	28.1	601	100
In-house technical data	545	90.5	57	9.5	602	100
Product and performance characteristics	435	72.3	167	27.7	602	100
Economic information	215	35.8	386	64.2	601	100
Technical specifications	463	76.9	139	23.1	602	100
Patents	85	14.1	517	85.9	602	100

most frequently used and least frequently used kinds of technical information are summarized below.

Most Frequently Used	Least Frequently Used
S&T information	Patents
In-house technical data	Economic information
Computer programs	Codes of standards and practices
Technical specifications	Design procedures and methods
Product and performance characteristics	Experimental techniques

Chi-square cross tabulations were used to compare respondents' organizational affiliation with their use of specific types of technical information (Table X). Academic

TABLE X

Comparison of the Types of Technical Information Used by Organizational Affiliation

Type of Technical Information	Academic		Industrial		Government		NASA		Total	Expected
	No.	%	No.	%	No.	%	No.	%	No.	%
Codes of standards and practices	15	25.9	200	53.8	42	43.3	30	40.5	287	47.8
Design procedures	20	34.5	232	62.4	50	51.5	34	49.5	336	55.9
Government rules and regulations	20	34.5	275	73.7	81	84.4	56	75.7	432	71.9
In-house technical data	36	62.1	354	94.9	89	91.8	66	89.2	545	90.2
Product and performance	28	48.3	294	78.8	71	73.2	42	56.8	435	72.3
Economic information	18	31.0	151	40.6	28	28.9	18	24.3	215	35.8
Technical specifications	32	55.2	311	83.4	73	75.3	47	63.5	463	76.9
Patents	4	6.9	66	17.7	9	9.3	6	8.1	85	6.9

Chi-square is significant at $P < .05$

respondents are less likely than expected to use codes of standards and practices, less likely than expected to use government rules and regulations, and less likely than expected to use in-house technical data. Academic and NASA respondents are less likely than expected to use product and performance characteristics and technical specifications. NASA respondents are less likely than expected to use economic information.

Data on the types of technical information produced and used by aeronautical engineers and scientists in this (1989) study were compared with the data reported for the aeronautical engineers in Shuchman's (1981) study. The five types of technical information most frequently produced and used are presented for comparison.

INFORMATION PRODUCED

Shuchman	Pinelli et al.
In-house technical data	S&T information
Physical data	In-house technical data
S&T information	Technical specifications
Design methods	Product and performance characteristics
Computer programs	Computer programs

INFORMATION USED

Shuchman	Pinelli et al.
S&T information	S&T information
In-house technical data	In-house technical data
Computer programs	Computer programs
Physical data	Technical specifications
Design methods	Product and performance characteristics

The sample sizes (Shuchman n=84 and Pinelli et al. n=606) and the research designs for the two studies affect the extent to which a valid comparison can be made between the two sets of data. Nevertheless, to the extent that such a comparison is valid, the types of technical information produced in both studies compare reasonably well. However, there is a much better fit between the types of technical information used.

As shown in Table Y, aeronautical engineers and scientists

TABLE Y

Summary: Solving a Technical Problem -- Source of Technical Information Used	Always		Usually		Sometimes		Never		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Personal knowledge	256	42.7	276	46.0	68	11.3	0	0.0	600	100
Informal discussions with colleagues	120	20.0	344	57.2	135	22.5	2	0.3	601	100
Discussions with supervisors	60	10.1	208	35.0	283	47.6	43	7.3	594	100
Discussions with experts in your organization	112	18.7	304	50.8	176	29.4	7	1.1	599	100
Discussions with experts outside of your organization	37	6.2	116	19.3	397	66.2	50	8.3	600	100
Technical reports-Government	35	5.8	166	27.7	363	60.5	36	6.0	600	100
Technical reports-Other	34	5.7	178	29.7	368	61.4	19	3.2	599	100
Professional journals/conference meeting papers	56	9.4	154	25.8	318	53.3	69	11.5	597	100
Textbooks	53	8.8	185	30.8	324	54.0	38	6.4	600	100
Handbooks and standards	40	6.8	164	27.7	331	55.9	57	9.6	592	100
Technical information sources, such as on-line data bases, indexing and abstracting guides, CD-ROM, and current awareness tools	7	1.2	41	7.0	262	44.8	275	47.0	585	100
Librarians/technical information specialists	16	2.7	68	11.4	294	66.0	119	19.9	597	100

use a variety of information sources when solving a technical problem. The "always" and "usually" responses, which appear as percentages in Table Y, were combined to form the list of sources used to solve technical problems. They use, in decreasing order of frequency, the following sources.

SOURCES USED BY AERONAUTICAL ENGINEERS AND SCIENTISTS TO SOLVE TECHNICAL PROBLEMS

Sources	Percent of Cases
1. Personal knowledge	88.7
2. Informal discussion with colleagues	77.2
3. Discussions with experts within the organization	69.5
4. Discussions with supervisor	45.1
5. Textbooks	39.6
6. Technical reports	35.4
7. Journals and conference/meeting papers	35.2
8. Handbooks and standards	34.5
9. Government technical reports	33.5
10. Discussions with experts outside of the organization	25.5
11. Librarians/technical information specialists	14.1
12. Technical information sources such as on-line databases	8.2

The kinds of information sources used by aeronautical engineers and scientists in this study (1989) to solve technical problems compare favorably with the related research and literature. Like engineers in general, aeronautical engineers and scientists display the same preference for using personal knowledge and informal sources.

In an attempt to validate the findings, the sources used by the aeronautical engineers in this (1989) study were compared with the steps used by the engineers in Shuchman's study of Information Transfer in Engineering. (See page 20.) With minor exceptions, the aeronautical engineers and scientists in this study sought information from sources similar to the sources used by engineers in Shuchman's study. Both groups begin with what Allen (1977) calls an "informal search for information followed by the use of 'formal' information sources. Only as a last resort do they turn to librarians and technical information specialists and bibliographic tools for assistance."

Survey Objective 3: Content for an Undergraduate Course in Technical Communications

To obtain the views of aeronautical engineers and scientists on the content for an undergraduate course in technical communications, survey respondents were asked if they had taken a course(s) in technical communications/writing, the degree to which the course(s) helped them communicate technical information, and their opinions regarding topics and on-the-job communications they recommended be included in an undergraduate technical communications course.

Approximately 24 percent of the respondents had taken at least one course in technical communications/writing as undergraduates (Table Z). Approximately 20 percent of the

TABLE Z

Summary: Technical Communications/Writing Coursework Taken	Number	Percentage
Yes, as an undergraduate	148	24.4
Yes, after graduation	119	19.6
Yes, both	149	24.6
No	190	31.4
	606	100.0

respondents had taken such a course after graduation and approximately 25 percent had done so both as undergraduates and after graduation. Approximately 31 percent of the respondents indicated that they had taken no such course.

Approximately 97 percent of those respondents who had taken a course(s) in technical communications/writing indicated that doing so has helped them to communicate technical information (Table AA). The respondents are fairly evenly divided as to

TABLE AA

Summary: Technical Communications/Writing Coursework -- How Helpful	Number	Percentage
A lot	175	42.5
A little	223	54.1
Did not help	14	3.4
	412	100.0

whether the course(s) helped them "a lot" (42.5 percent) or "a little" (54.1 percent). Approximately four percent of the respondents indicate that their course(s) had not helped them.

The percentage of "yes" responses to the list of principles to be included in an undergraduate technical communications course range from a high of 96.5 percent (organizing information) to a low of 50 percent (notetaking and quoting). (See Table BB.) Eight of the ten topics (principles) received "yes" responses of

TABLE BB

Summary: Topics for an Undergraduate Technical Communications Course for Aeronautical Engineers and Scientists -- Principles	Yes		No		Total	
	No.	%	No.	%	No.	%
Defining the communication's purpose	547	90.7	56	9.3	603	100
Assessing readers' needs	490	81.7	110	18.3	600	100
Organizing information	582	96.5	21	3.5	603	100
Developing paragraphs (introductions, transitions, and conclusions)	520	86.2	83	13.8	603	100
Writing sentences (active vs. passive voice, parallel ideas, shifts in person or tense)	483	80.0	121	20.0	604	100
Using standard English grammar	469	77.8	134	22.2	603	100
Notetaking and quoting	299	50.0	299	50.0	598	100
Editing and revising	469	77.8	134	22.2	603	100
Choosing words (avoiding wordiness, jargon, slang, sexist terms)	491	81.4	112	18.6	603	100
Using information technology (video conferencing, electronic data bases, etc.)	365	60.7	236	39.3	601	100

greater than 75 percent. These eight topics are listed below in descending order of importance.

Topic	Percentage Response
Organizing information	96.5
Defining the communication's purpose	90.7
Developing paragraphs	86.2
Assessing readers' needs	81.7
Choosing words	81.4
Writing sentences	80.0
Editing and revising	77.8
Using standard English grammar	77.8

The percentage of "yes" responses to the list of mechanics to be included in an undergraduate technical communications course range from a high of 76.7 percent (references) to a low of 48.7 percent (numbers). (See Table CC.) Six of the eight topics

TABLE CC

Summary: Topics for an Undergradate Technical Communications Course for Aeronautical Engineers and Scientists -- Mechanics	Yes		No		Total	
	No.	%	No.	%	No.	%
Abbreviations	304	51.4	288	48.6	592	100
Acronyms	295	49.7	298	50.3	593	100
Capitalization	361	61.0	231	39.0	592	100
Numbers	286	48.7	301	51.3	587	100
Punctuation	450	75.9	143	24.1	593	100
References	455	76.7	138	23.3	593	100
Spelling	386	65.1	207	34.9	593	100
Symbols	339	57.3	253	42.7	592	100

(mechanics) received "yes" responses of more than 50 percent. These six topics are listed below in descending order of importance.

Topic	Percentage Response
References	76.7
Punctuation	75.9
Spelling	65.1
Capitalization	61.0
Symbols	57.3
Abbreviations	51.4

The percentage of "yes" responses to the list of topics (on-the-job communications) to be included in an undergraduate technical communications course range from a high of 95.3 percent (oral presentations) to a low of 24.3 percent (newsletter articles). (See Table DD.) Seven of the 11 topics

TABLE DD

Summary: Topics for an Undergraduate Technical Communications Course for Aeronautical Engineers and Scientists -- On-the-Job Communications	Yes		No		Total	
	No.	%	No.	%	No.	%
Abstracts	406	69.0	182	31.0	588	100
Letters	412	69.4	182	30.6	594	100
Memos	463	77.8	132	22.2	595	100
Instructions	340	57.6	250	42.4	590	100
Journal articles	275	46.4	318	53.6	593	100
Literature reviews	220	37.3	370	62.7	590	100
Manuals	287	48.3	307	51.7	594	100
Newsletter articles	143	24.3	445	75.7	588	100
Oral presentations	567	95.3	28	4.7	595	100
Specifications	330	55.7	262	44.3	592	100
Use of information sources	468	79.1	124	20.9	592	100

(on-the-job communications) received "yes" responses of more than 50 percent. These seven topics are listed below in descending order of importance.

Topic	Percentage Response
Oral presentations	95.3
Use of information sources	79.1
Memos	77.8
Letters	69.4
Abstracts	69.0
Instructions	57.6
Specifications	55.7

Respondents were asked to consider specific types of technical reports for inclusion in an undergraduate technical communications course. The percentage of "yes" responses to the list range from a high of 79.1 percent (progress reports) to a low of 50.9 percent (trouble reports). (See Table EE.)

TABLE EE

Summary: Topics for an Undergradate Technical Communications Course for Aeronautical Engineers and Scientists -- Types of Technical Reports	Yes		No		Total	
	No.	%	No.	%	No.	%
Feasibility	344	62.3	208	37.7	552	100
Investigative	368	66.7	184	33.3	552	100
Laboratory	392	70.9	161	29.1	553	100
Progress	440	79.1	116	20.9	556	100
Test	436	78.6	119	21.4	555	100
Trip	302	54.3	254	45.7	556	100
Trouble	282	50.9	272	49.1	554	100

Progress (79.1 percent) and test (78.6 percent) reports received the highest percentage of "yes" responses. Trip (54.3 percent) and trouble (50.9 percent) reports received the lowest percentage of "yes" responses.

In an attempt to validate these findings, the top five recommended on-the-job communications were compared with the top five (on the average) technical communications products "produced" and "used" by aeronautical engineers and scientists.

Communications Produced	Communications Used	Communications Recommended
Memos	Memos	Oral presentations
Letters	Letters	Use of information sources
A/V materials	Drawings/ specifications	Memos
Drawings/ specifications	Journal articles	Letters
Speeches	Trade/promotional literature	Abstracts

The recommended topics compared quite favorably with the technical communications products "produced" and "used" by aeronautical engineers and scientists. Memos and letters are included in all three lists. Oral presentations, which rank first on the list of recommended topics would include the use of A/V materials and the oral delivery (i.e., speech) of the content, which rank third and fifth, respectively, on the list of products "produced." Drawings and specifications rank sixth and seventh, respectively, on the list of recommended topics and fourth and third, respectively, on the list of products "produced" and "used." Considered as a group, technical reports would make the recommended topics list. In terms of products "produced" they rank sixth and they ranked seventh in terms of products "used."

The inclusion and relative importance (i.e., second) of "use of information sources" on the list of recommended topics are of particular interest. This finding tends to support Allen's (1979) claim that "engineers tend to search for library information themselves." Knowing how to use information sources would decrease the likelihood of an engineer utilizing the services of the information professional.

Survey Topic 4: Use of Libraries, Technical Information Centers, and On-Line Databases

To determine the use of libraries, technical information centers, and on-line databases, survey respondents were asked three questions. They were asked to indicate how often they used a library or technical information center, their use of on-line databases, and how they search the databases.

Ninety-four percent of the respondents indicate that they use a library or technical information center (Table FF).

TABLE FF

Summary: Use of Library or Technical Information Center	Number	Percentage
Daily	12	2.0
Two to six times a week	60	10.0
Once a week	90	15.0
Two to three times a month	116	19.2
Once a month	102	16.9
Less than once a month	186	30.9
Do not use	36	6.0
	602	100.0

The frequency rates vary among respondents, with 27 percent using a library or technical information center one or more times a week. Approximately 36 percent of the respondents use a library or technical information center one or more times a month, while approximately 31 percent use a library or technical information center less than once a month. The use of libraries and technical information centers by aeronautical engineers and scientists in this (1989) study compares favorably with the use rate of libraries and technical information centers by engineers reported in the related research and literature.

Less than half or 44.1 percent of the survey respondents use on-line databases (Table GG). Of those survey respondents

TABLE GG

Summary : Use of Electronic Databases	Number	Percentage
Yes	265	44.1
No	336	55.9
	601	100.0

who use on-line databases, 23 percent do all or most of their own searches (Table HH). Approximately 65 percent use an intermediary to do most or all of their searches, while about 12 percent do half and the other half use an intermediary for searches.

TABLE HH

Summary: Use of Electronic Databases-- How Searched	Number	Percentage
Do all searches yourself	18	6.9
Do most searches yourself	42	16.1
Do half by yourself and half through an intermediary (e.g. librarian)	32	12.3
Do most searches through an intermediary (e.g. librarian)	92	35.2
Do all searches through an intermediary	77	29.5
	261	100.0

Based on Chi-square tabulations (see Appendix C), academic respondents are more likely to use (62.1 percent) on-line databases than expected (44.1 percent).

Survey Topic 5: Use and Importance of Computer and Information Technology

To determine the use and importance of computer and information technology, survey respondents were asked about their use of computer technology, whether computer technology has increased their ability to communicate technical information, and what types of computer and information technology they used.

Approximately 91 percent of the respondents use computer technology (Table II), while approximately 70 percent of the respondents "always" or "usually" use it, and approximately 22 percent "sometimes" use it.

TABLE II

Summary: Use of Computer Technology for Preparing Technical Communications	Number	Percentage
Always	232	38.3
Usually	191	31.5
Sometimes	131	21.6
Never	52	8.6
	606	100.0

Approximately 95 percent of those respondents who use computer technology indicate that it has increased their ability to communicate technical information (Table JJ).

TABLE JJ

Summary : Computer Technology--Increased Ability to Communicate Technical Information	Number	Percentage
A lot	342	61.7
A little	183	33.1
Not at all	29	5.2
	554	100.0

Aeronautical engineers and scientists use a variety of software for preparing written technical communications (Table KK). The percentage of "yes" responses ranges from a high

TABLE KK

Summary: Use of Software to Prepare Written Technical Communications	Yes		No		Total	
	No.	%	No.	%	No.	%
Word processing	520	94.4	31	5.6	551	100
Outliners and prompters	59	10.8	486	89.2	545	100
Grammar and style checkers	62	11.8	484	88.2	546	100
Spelling checkers	347	62.9	205	37.1	552	100
Thesaurus	174	31.8	373	68.2	547	100
Business graphics	197	36.0	350	64.0	547	100
Scientific graphics	353	64.4	195	35.6	548	100

of 94.4 percent (word processing) to a low of 10.8 percent (outliners and prompters). Word processing software is used most frequently (94.4 percent), followed by scientific graphics (64.4 percent), then by spelling checkers (62.9 percent). The least used software is outliners and prompters (10.8 percent).

Chi-square cross tabulations were used to compare the respondents' organizational affiliation with their use of specific kinds of software. Government (71 percent) and NASA (72.9 percent) respondents make greater use of spelling checkers than expected (62.8 percent). Government respondents (42.4 percent) are more likely than expected (31.9 percent) to use a thesaurus. NASA (80 percent) respondents are more likely to use scientific graphics than expected (64.5 percent).

Less than half of the respondents (45.5 percent) make use of an integrated graphics, text, and modeling engineering workstation for preparing written technical communications (Table LL).

TABLE LL

Summary: Use of An Integrated Graphics, Text, and Modeling Engineering Workstation for Preparing Written Technical Communications	Number	Percentage
Always	39	7.1
Usually	61	11.2
Sometimes	149	27.2
Never	298	54.5
	547	100.0

Of the respondents who do make use of such a workstation, approximately 18 percent "always" or "usually" use it, while approximately 27 percent "sometimes" use it in preparing written technical communications.

Approximately 59 percent of the respondents use electronic or desk-top publishing systems for preparing written technical communications (Table MM). Of the aeronautical engineers and

TABLE MM

Summary: Use of Electronic or Desk-Top Publishing Systems for Preparing Written Technical Communiations	Number	Percentage
Always	65	11.9
Usually	112	20.4
Sometimes	147	26.8
Never	224	40.9
	548	100.0

scientists who do use electronic or desk top publishing, approximately 32 percent "always" or "usually" use it, while approximately 27 percent "sometimes" use it for preparing written technical communications.

Aeronautical engineers and scientists use a variety of information technologies to communicate technical information (Table NN). The percentage of "I already use it" responses

TABLE NN

Summary: Use, Non-Use, and Potential Use of Information Technologies to Communicate Technical Information	I already use it		I don't use it, but may in the future		I don't use it, and doubt if I will		Total	
	No.	%	No.	%	No.	%	No.	%
Audiotapes and cassettes	118	20.3	172	29.6	292	50.1	582	100
Motion picture film	118	20.5	142	24.7	315	54.8	575	100
Videotape	275	46.5	234	39.6	82	13.9	591	100
Desk-top/electronic publishing	272	46.5	243	41.5	70	12.0	585	100
Floppy disks	441	74.5	112	18.9	39	6.6	592	100
Computer cassette/cartridge tapes	129	22.7	222	39.0	218	38.3	569	100
Electronic mail	274	46.6	255	43.4	59	10.0	588	100
Electronic bulletin boards	148	25.7	308	53.6	119	20.7	575	100
FAX or TELEX	501	84.3	64	10.8	29	4.9	594	100
Electronic databases	290	50.3	233	40.4	54	9.3	577	100
Video conferencing	95	16.3	363	62.4	124	21.3	582	100
Teleconferencing	344	58.7	182	31.1	60	10.2	586	100
Micrographics and microforms	100	18.0	245	44.0	212	38.0	557	100
Laser disc/video disc/CD-ROM	35	6.1	370	64.9	165	29.0	570	100
Electronic networks	185	32.2	303	52.8	86	15.0	574	100

ranges from a high of 84.3 percent (FAX or TELEX) to a low of 6.1 percent (laser disc/video disc/CD-ROM). The most frequently used information technologies, in descending order of use, for communicating technical information follow.

Information Technology	Percentage Use
FAX or TELEX	84.3
Floppy disks	74.5
Teleconferencing	58.7
Electronic databases	50.3
Electronic mail	46.6
Videotape	46.5
Desk-top/electronic publishing	46.5

Chi-square cross tabulations were used to compare respondents' organizational affiliation with their use of specific information technologies. NASA respondents were more likely to use desk-top publishing (62.3 percent) than expected (46.6 percent) and electronic mail (72.6 percent) than expected (46.5 percent). They are more likely to use electronic bulletin boards (57.7 percent) than expected (25.8 percent). NASA respondents are also more likely to use video conferencing (31.9 percent) than expected (16.2 percent). They are also more likely to use teleconferencing (71.8 percent) and electronic networks (56.3 percent) than expected (58.6 percent and 32.1 percent).

A further look at Table NN reveals several information technologies for which a considerable number of "I don't use it, and doubt if I will" responses were recorded. The percentages of these responses range from a high of 54.8 percent (motion picture film) to a low of 4.9 percent (FAX or TELEX).

The five information technologies receiving the highest percentage of the "don't use, and doubt if I will" responses appear below in descending order of non-use.

Information Technology	Percentage Non-Use
Motion picture film	54.8
Audiotapes and cassettes	50.1
Computer cassette/cartridge tapes	38.3
Micrographics and microforms	38.0
Laser disc/video disc/CD-ROM	29.0

Table NN also indicates several information technologies for which a considerable percentage of "I don't use it, but may in the future" responses were recorded. The percentages of these responses range from a high of 64.9 percent (laser disc/video disc/CD-ROM) to a low of 10.8 percent (FAX or TELEX). The five information technologies receiving the highest percentage of "I don't use it, but may in the future" appear below in descending order of potential use.

Information Technology	Percentage Non-Use
Laser disc/video disc/CD-ROM	64.9
Video conferencing	62.4
Electronic bulletin boards	53.6
Electronic networks	52.8
Micrographics and microforms	44.0

The aeronautical engineers and scientists in this study make considerable use of computer and information technology. Their use compares quite favorably with the use of information technology by aeronautical engineers in Shuchman's (1981) study.

SUMMARY AND IMPLICATIONS

This exploratory study investigated technical communications in aeronautics by surveying aeronautical engineers and scientists. The study had five specific objectives. The first, to solicit the opinions of aeronautical engineers and scientists regarding the importance of technical communications to their profession; the second, to determine their use and production of technical communications; the third, to seek their views in light of their technical communications experience on the appropriate content of an undergraduate course in technical communications; the fourth, to determine their use of libraries, technical information centers, and on-line databases; and fifth, to determine the use and importance of computer and information technology among the respondents.

Data were collected through a self-administered mail questionnaire that was pretested at three engineering organizations. Members of the American Institute of Aeronautics and Astronautics (AIAA) comprised the study population. The sample frame consisted approximately 25 000 AIAA members in the U.S. with either academic, government, or industrial affiliations. Simple random sampling was used to select 2,000 individuals from the sample frame to participate in the study.

Six hundred and six (606) usable questionnaires (30.3 percent response rate) were received by the established cut off date. The Chi-square and one-way ANOVA (Analysis of Variance) at the .05 level of statistical significance were used as the non-parametric and parametric tests for relationships between the responses to the 25 questions and the organizational affiliations of the respondents.

Demographic Information

Survey respondents were asked to provide information regarding their professional duties, organizational affiliation, years of professional work experience, their AIAA interest group, whether American English was their first (native) language, and their gender. Approximately 38 percent stated that their professional duties were design/development, 24 percent administration/management, and 20 percent research. Approximately 62 percent were affiliated with industry, 28 percent with government, and 7 percent with academia. Approximately 35 percent had 10 or fewer years of professional work experience, 54 percent had 20 or fewer years, and 77 percent had 30 or fewer years of professional work experience. Approximately 31 percent selected aerospace sciences as their AIAA interest group and 20 percent chose propulsion and energy. Approximately 33 percent held a bachelor's degree, while just over 66 percent held graduate degrees. Approximately 90 percent of the respondents were trained as engineers. American English was the first (native) language of approximately 94 percent and approximately 95 percent of the respondents were male.

Limitations of the Study

By definition, an exploratory study has certain limitations. It is often conducted when relatively little is known about a subject to test the feasibility of undertaking a more carefully planned study and to develop methods that could be used in such a study. While exploratory studies go beyond mere description and can clarify relationships between variables, they stop short of explaining or predicting why or how something happens.

This study was conducted to gather baseline data regarding several aspects of technical communications in aeronautics and to develop and validate questions that could be used in a future study concerned with the role of the U.S. government technical report in aeronautics. Given this limited purpose -- the low response rate (30.3 percent), which is fairly typical for mail surveys, and the limitations associated with "user" studies -- no claims are made regarding the extent to which the attributes of the respondents accurately reflect the attributes of the "non-respondents" or the attributes of the population being studied. A much more rigorous research design would be needed before such claims could be made. However, because the demographic characteristics of the survey respondents closely approximate those of the AIAA membership, certain general statements regarding technical communications in aeronautics can be formulated.

Despite the limitations of this study, these findings add considerable information to the knowledge of technical communications practices among aeronautical engineers and scientists; reinforce some of the conventional wisdom about technical communications and question other widely-held notions; hold significant implications for technical communicators, information managers, research and development managers, and curriculum developers. The survey findings are summarized and implications are presented for each study objective.

Survey Objective 1: The Importance of Technical Communications

Summary. Previous studies have determined that the ability to communicate technical information effectively is important to engineers. While true for engineers in general, it is no less true for the aeronautical engineers and scientists in this study. Generally satisfied with the technical-knowledge preparation of entry-level engineers, industry officials worry about their writing and presentation skills. "If there is a significant problem with entry hires, it lies in their lack of training and skill in communications," a General Dynamics official was quoted as saying (Kandebo, 1988). The same article goes on to note that "General Dynamics and other aerospace firms are concerned that a growing number of entry-level engineers cannot write technical reports, fail to make effective presentations of their ideas or concepts, and find it difficult to communicate with peers."

Based on a 40-hour work week, the aeronautical engineers and scientists in this study spend approximately 66 percent of their work week either producing or working with technical communications prepared by others. As they advance professionally, so too does the amount of time they spend producing and working with technical communications prepared by others.

Implications. If, as the results indicate, the ability to communicate technical information effectively is very important to aeronautical engineers and scientists, how is its importance perceived by engineering educators and technical managers? If technical communications consume approximately 66 percent of a 40-hour work week and play a significant role in professional advancement, to what extent does theory interact with practice? That is, to what extent do aeronautical engineers and scientists receive training/education in technical communications as part of their academic preparation? At this level, is technical communications training required, encouraged, or neither required nor encouraged? What rationale underlies those aeronautical engineering programs in which technical communications training is either required or encouraged? Is inclusion of technical communications in the aeronautical engineering curriculum based, in part, on needs expressed by alumni and employers and/or program accreditation?

To what extent do technical managers emphasize technical communications education/training in the workplace? Do they emphasize the importance of effective communications by sponsoring in-house training such as courses and workshops? Do they support aeronautical engineers and scientists attending seminars and off-site workshops designed to promote effective communication skills? To what extent have technical communicators in the aerospace industry developed technical communications outreach programs by providing writing/editing and consultation services for aeronautical engineers and scientists? To what extent have they sought to develop and/or sponsor technical communications workshops, seminars, and courses for aeronautical engineers and scientists?

Survey Objective 2: The Use and Production of Technical Communications

Summary. Memos, letters, and audio/visual (A/V) materials are the technical information products most frequently produced by the aeronautical engineers and scientists in this study. On the average, they produce 29 memos, 22 letters, and 7 A/V materials in a 6-month period. Memos, letters, and drawings/specifications are the technical information products most frequently used by survey respondents. On the average, they use 24 memos, 17 letters, and 8 drawings/specifications in a 1-month period.

The survey respondents seek the help of both people and reference materials when preparing technical communications. Other colleagues, secretaries, a dictionary, and a thesaurus are the sources used most frequently when they produce technical communications. However, the majority of them prepare artwork in one of two ways. For the most part they either prepare their own artwork using a computer or split the responsibility by sometimes doing it themselves and sometimes having a graphics department do it.

The aeronautical engineers and scientists in this study produce and use various types of technical information in performing their duties. For the most part they produce and use S&T information, in-house technical data, computer programs, product and performance characteristics, and technical specifications. They also use a variety of information sources when solving technical problems. Like engineers in general, the aeronautical engineers and scientists in this study prefer to use their personal knowledge and informal sources to solve technical problems.

Implications. The results of the survey show little difference between the types of technical communications produced and used by aeronautical engineers and scientists. Somewhat surprising is the lack of production and use of technical reports. However, the questions were limited to production and use and did not deal with importance. It might be helpful for academics to know the relative importance of these technical communication products, including technical reports, for purposes of curriculum and course development.

The aeronautical engineers and scientists in this study seek the help of colleagues and secretaries when preparing technical information products. If colleagues and secretaries are used as consultants, what type of technical communications training do/should these individuals have? Why are technical writers and editors used so infrequently for this purpose? Does the modest use of technical writers and editors reflect a lack of availability/accessibility of such services, a lack of knowledge about these services, or a preference not to use such services? It might be helpful to know the extent to which technical writing and editing services exist in the aerospace industry.

Approximately 34 percent of the aeronautical engineers and scientists in this study prepare their own artwork using a computer, followed by those who rely partially on themselves and on a graphics department (30.3 percent) for the preparation of their artwork.

Poorly designed visuals, that is, visuals that are not prepared according to generally accepted guidelines and standards, hinder and obscure the effective transfer of technical information. As Karten (1988) states, "PC graphics software makes it a breeze to create visuals. But although a picture may be worth a thousand words, too many of these computer-generated visuals require a thousand extra **spoken** words before they make any sense." Do guidelines and standards exist for PC-prepared visuals? Are technical communicators and aeronautical engineers and scientists aware of them? To what extent does the aerospace industry utilize these guidelines and how is their proper use enforced? Do/should aeronautical engineers and scientists receive training in or exposure to these guidelines and standards as part of their academic preparation?

The types of technical information produced and used by the aeronautical engineers and scientists in this study compare reasonably well with data from Shuchman's (1981) study. What is not known, however, is the relative importance of the types of technical information produced and used in relation to the professional duties performed by aeronautical engineers and scientists. Furthermore, how do the types of technical information produced and used compare with the types of technical information products produced and used?

According to Sayer (1965), "Engineering is a production system in which information is the raw material. Whatever the purpose of the engineering effort, the engineer is an information processor who is constantly faced with the problem of effectively acquiring and using data and information." The aeronautical engineers and scientists in this study used a variety of information sources when solving a technical problem. Their preference for the use of personal contacts over formal information sources confirms the findings of the related research and literature.

The aeronautical engineers and scientists in this study view themselves as ideal evaluators of information in their area of expertise. How did they become qualified to serve in this capacity? Is it because they receive training in the use of information sources as part of their academic preparation? What kind of exposure to information sources, if any, do aeronautical engineers and scientists receive as part of their academic preparation? In terms of efficiency and productivity, does this individual approach to problem-solving constitute a wise use of engineering manpower? How effective can a formal engineering information system be if it does not take into account the information-seeking habits and preferences of the user? Could the efficiency of both the system and the user be increased by the addition of advocacy intermediaries (i.e., librarians and technical information specialists)?

Survey Objective 3: Content for an Undergraduate Course in Technical Communications

Summary. About 70 percent of the survey respondents had taken a technical communications or technical writing course either at the undergraduate level, after graduation, or both. They were fairly evenly divided as to whether the course(s) had helped them "a lot" (42.5 percent) or "a little" (51.5 percent).

Respondents indicate that the following principles, mechanics, and on-the-job communications should be included in an undergraduate technical communications course for aeronautical engineers and scientists.

Principles	Percentage Response
Organizing information	96.5
Defining the communication's purpose	90.7
Developing paragraphs	86.2
Assessing readers' needs	81.7
Choosing words	81.4
Writing sentences	80.0
Editing and revising	77.8
Using standard English grammar	77.8

Mechanics	Percentage Response
References	76.7
Punctuation	75.9
Spelling	65.1
Capitalization	61.0
Symbols	57.3
Abbreviations	51.4

On-the-Job Communications	Percentage Response
Oral presentations	95.3
Use of information sources	79.1
Memos	77.8
Letters	69.4
Abstracts	69.0
Instructions	57.6
Specifications	55.7

The top five communications they recommended for coverage in a communications course are compared below with the top five (on the average) technical communications "produced" and "used" by aeronautical engineers and scientists on the job.

Communications Produced	Communications Used	Communications Recommended
Memos	Memos	Oral presentations
Letters	Letters	Use of information sources
A/V materials	Drawings/ specifications	Memos
Drawings/ specifications	Journal articles	Letters
Speeches	Trade/promotional literature	Abstracts

The recommended on-the-job communications compare quite favorably with the technical communications products "produced" and "used" by aeronautical engineers and scientists.

The aeronautical engineers and scientists in this study made various recommendations for the inclusion of certain principles, mechanics, and types of on-the-job communications to be included in an undergraduate technical communications course. Their recommendations compare quite favorably with the technical communications products the respondents produce and use.

Implications. What is the appropriate content for an undergraduate technical communications course and how should such a course be developed? To what extent should the views/opinions of "practitioners" be considered in developing curriculum content? Based on the findings, a convincing case can be made for including technical writing, oral presentation, skill in the preparation of artwork for visual aids, and use of information resources in an undergraduate technical communications course.

Should information resources and computer skills also be included?

Survey Objective 4: Use of Libraries, Technical Information Centers, and On-Line Databases

Summary. Although the frequency of use varies, approximately 94 percent of the aeronautical engineers and scientists in this study use a library or technical information center. Less than half use on-line databases. With minor exceptions, survey respondents seek information to solve technical problems from sources similar to those used by the engineers in Shuchman's (1981) study. Both groups begin with what Allen (1977) calls "informal research for information followed by the use of 'formal' information sources. Only as a last resort do they turn to librarians and technical information specialists and bibliographic tools for assistance."

Less than half of the aeronautical engineers and scientists in this study use on-line databases. Of those who do, 23 percent do all or most of their own searches, while approximately 65 percent use an intermediary to do most or all of their searches.

Implications. While 94 percent of the aeronautical engineers and scientists in this study use a library or technical information center, the frequency of use varies considerably among respondents. Only after they exhausted their personal/informal search for information did they use a library/technical information center or seek the services of a librarian/technical information specialist.

To what extent is the use of libraries and intermediaries (e.g., librarians) by aeronautical engineers and scientists affected by the nature of technology and social enculturation? Is the relative ranking of the library and the librarian in the problem-solving process an indication of a deliberate preference not to use such services, or is it best explained by the existence of certain institutional or organizational variables? If aeronautical engineers and scientists were exposed to information sources as part of their educational preparation, would this affect their familiarity with and use of these services?

Less than half or 44.1 percent of the aeronautical engineers and scientists in this study use on-line databases. On-line databases rank last on the list of information sources consulted by aeronautical engineers and scientists when solving technical problems. Of those who use on-line databases, 23 percent did all or most of their own searches. Why does on-line database use rank so low in the problem-solving process? Is it a question of awareness? If so, would seminars, workshops, and other promotional efforts by librarians and information specialists result in increased use by aeronautical engineers and scientists? Is it a question of accessibility; that is, are on-line databases available only through the library or technical information center? If so, would the ability to access these databases without coming to the library or technical information center result in increased use? Can other factors better explain the infrequent use of on-line databases? If so, do factors such as cost of use, skill in use, physical distance, and/or technical quality or reliability of the information retrieved better explain lack of on-line database use by aeronautical engineers and scientists?

Survey Objective 5: Use and Importance of Computer and Information Technology

Summary. Approximately 91 percent of the aeronautical engineers and scientists in this study use computer technology for preparing technical communications. They also use a variety of software tools for preparing written technical communications, with word processing and spelling checkers used most frequently. Less than half (45.5 percent) make use of an integrated graphics, text, and modeling engineering workstation, while approximately 59 percent use electronic or desk-top publishing for preparing written technical communications.

The aeronautical engineers and scientists in this study use a variety of information technologies to communicate technical information. The most frequently used information technologies, in descending order of use, for communicating technical information follow.

Information Technology	Percentage Use
FAX or TELEX	84.3
Floppy disks	74.5
Teleconferencing	58.7
Electronic databases	50.3
Electronic mail	46.6

The five information technologies receiving the highest percentage of the "I don't use it, and doubt if I will" responses appear below in descending order of non-use.

Information Technology	Percentage Non-Use
Motion picture film	54.8
Audiotapes and cassettes	50.1
Computer cassette/cartridge tapes	38.3
Micrographics and microforms	38.0
Laser disc/video disc/CD-ROM	29.0

The five information technologies receiving the highest percentage of "I don't use it, but may in the future" appear below in descending order of non-use.

Information Technology	Percentage Non-Use
Laser disc/video disc/CD-ROM	64.9
Video conferencing	62.4
Electronic bulletin boards	53.6
Electronic networks	52.8
Micrographics and microforms	44.0

The aeronautical engineers and scientists in this study make considerable use of computer and information technology. Their use compares quite favorably with the use of information technology by aeronautical engineers in Shuchman's study (1981).

Implications. The aeronautical engineers and scientists in this study make considerable use of computer technology (91 percent) and believe that the use of this technology has increased their ability to communicate technical information (95 percent). They also make considerable use of information technology. Their use compares quite favorably with the use of information technology by aeronautical engineers in Shuchman's (1981) study.

According to a report of the Committee on Science, Engineering, and Public Policy (1989), the use of computer and information technology has done much to improve the quality of research and scientific and technical productivity. However, while the development of new information technologies offers further opportunity for improvement, the widespread use of computer and information technology continues to be hampered by technical, financial, institutional, and behavioral constraints. Institutional constraints include access and availability, and behavioral constraints include use, education, and training.

To what extent do aeronautical engineers and scientists have access to computer and information technology as part of their educational preparation? If skill in the use of computer and information technology will increase the productivity and efficiency of these individuals, where and how should they acquire this skill? Should they come to the workplace computer and information literate? Will they come to the workplace computer and information literate and not have access to computer and information technology?

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16. Abstract

A study was undertaken that explored several aspects of technical communications in aeronautics. The study, which utilized survey research in the form of a self-administered questionnaire, was sent to 2,000 randomly selected members of the American Institute of Aeronautics and Astronautics (AIAA). Six hundred and six (606) usable questionnaires (30.3 percent) were received by the established cut off date.

The study had five objectives. The first was to solicit the opinions of aeronautical engineers and scientists regarding the importance of technical communications to thier profession; second, to determine their use and production of technical communications; third, to seek their views on the content of an undergraduate course in technical communications; fourth, to determine their use of libraries/technical information centers; and finally, to determine the use and importance of computer and information technology to them. The findings add considerable information to the knowledge of technical communications practices among aeronautical engineers and scientists and reinforce some of the conventional wisdom about technical communications and question other widely-held notions.

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