NASA-CR-201460

NASA/DoD Aerospace Knowledge Diffusion Research Project

Paper Fifty Six

Technical Communications in Engineering and Science: The Practices Within a Government Defense Laboratory

Reprinted from Special Libraries
Volume 87, Number 2 (Spring1996): 98-119.

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Technical Communications in Engineering and Science: The Practices within a Government Defense Laboratory

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- *Ces dernières années, les recherches ont identifié les différents besoins d'information des ingénieurs contre ceux des scientifiques. Alors que la plus grande partie de cette recherche a porté sur les différences entre les organisations, nous avons interrogé les ingénieurs et les scientifiques dans le cadre d'un seul laboratoire de recherche et développement de l'armée de l'air américaine sur la manière dont ils rassemblent, utilisent et produisent les informations. Les résultats du sondage de Phillips Laboratory confirme les suppositions antérieures relatives aux distinctions entre l'ingénierie et les sciences. Parce que le nombre de réponses provenant du personnel militaire était supérieur à celui du personnel civil, le sondage est également devenu une occasion d'établir le profil d'un segment peu connu de la population ingénieurs/scientifiques. Outre l'effet que la mission fixée par Phillips Laboratory pourrait avoir sur les ingénieurs et les scientifiques qui en sont membres, l'étude identifie d'autres facteurs qui causent des variations dans les communications techniques et les activités liées à l'information.*

- *La investigación en las décadas recientes ha identificado las necesidades diferentes de los ingenieros en comparación con los científicos. Mientras que la mayor parte de la investigación examinaba las diferencias entre las organizaciones, nosotros encuestamos a los ingenieros y científicos dentro de un único laboratorio de investigación de la Fuerza Aérea sobre sus prácticas de acumulación, uso, y producción de información. Los resultados de la encuesta del Laboratorio Phillips confirman las suposiciones previas sobre las diferencias entre la ingeniería y la ciencia. Porque los empleados militares respondieron con una tasa mucho mas alta que el personal civil, esta encuesta también presentó una oportunidad para describir un segmento poco conocido de la población de ingenieros/científicos. Además del efecto que pueda tener la misión declarada del Laboratorio Phillips sobre los ingenieros y científicos miembros del mismo, se identifican otros factores que causan las diferencias en la comunicación técnica y las actividades relacionadas con la información.*

Research in recent decades has identified the varied information needs of engineers versus scientists. While most of that research looked at the differences among organizations, we surveyed engineers and scientists within a single Air Force research and development laboratory about their information gathering, usage, and production practices. The results of the Phillips Laboratory survey confirm prior assumptions about distinctions between engineering and science. Because military employees responded at a much higher rate than civilian staff, the survey also became an opportunity to profile a little-known segment of the engineer/scientist population. In addition to the effect Phillips Laboratory's stated mission may have on member engineers and scientists, other factors causing variations in technical communication and information-related activities are identified.

Introduction

The technical communication and information-related activities of engineers and scientists have been a topic of study and discussion for more than 40 years. There is little to challenge the notion that both groups rely heavily on information, and engineers and scientists themselves generally acknowledge that information is their most significant product. Aside from these fundamental conclusions, there has been scant progress in studying the varied role of information for engineers in comparison with its role for scientists. Research into the functions of information for these groups has lagged behind other user studies largely because the majority of research on information needs and use has focused on scientists alone or on heterogeneous groups of engineers and scientists working together. Such studies have not contributed significantly to differentiating the information behaviors of the two groups. This unique study compares engineers and scientists at the same laboratory.

Additionally, there is little known about the technical communication and information-related activities of engineers and scientists working for the Department of Defense as military employees. Surveys and other studies have included this group with engineers and scientists working for industry, academic institutions, or other government organizations. In the few studies concerning defense engineers and scientists, the majority of respondents were civilian.[1,2] Because two-thirds of the respondents in the present survey are military engineers and scientists, preliminary conclusions can also be drawn concerning the technical communication and information-related activities of this segment of the research community.

Literature Summary

Previous studies have assumed that scientific discovery progressed smoothly and naturally to technological advancement and that the literature of both science and technology was similarly used and produced.[3] Kline writes that even the name given to the innovation process, *R&D*, "implies the linear model: the phrase itself suggests a direct and unique path from research to development and product."[4] This thinking links engineering and science, at times nearly equating the two. Engineers and scientists are seen as interacting, complementary forces driving the innovation process. Engineers and scientists are thus seen as comparable in their goals, work orientation, and communication practices—an assumption which became the foundation of current U.S. science and technology policies and practices. Closer examination, however, supports the position that the two fields of engineering and science and technology advance independently of each other, with the literature of each cumulating independently as well.[5,6] More significantly, it became apparent that engineers and scientists do not have the same information gathering and usage patterns.[7]

While acknowledging that scientific literature is unique from engineering literature, both are recognized as equal cornerstones of innovation. The two branches of knowledge are thus permanently linked together as *scientific and technical information* or *STI*. Questions about the use of STI have increased recently as a result of the "rising interest and concerns regarding industrial competitiveness and technological innovation."[8] These studies confirm what many have suspected—that communication of STI by engineers and scientists plays a critical role in the innovation process. The studies have also increased curiosity about how that information is gathered and used by engineers versus scientists. Several extensive reviews of the literature provide background and state-of-the-art research on communication by engineers.[9,10]

Differentiating Engineers from Scientists

Engineering is defined as "the application of scientific knowledge to the creation or improvement of technology for human use."[11] This explains the notion of engineering/technology as an *applied science*. In this process, engineers may engage in many diverse activities including the generation of new ideas, problem definition, problem solving, information seeking, experimentation, calculations, management of personnel and teams, and production of reports.[12] The work environment of the engineer is likely to be in industry or government where 1) project choice is determined not by the individual but by management, 2) teamwork may be required at many stages, and 3) goals focus on company or organizational success. The engineer tends to find professional success within the organization through increasingly responsible, challenging assignments or management positions.

Science is the search for knowledge through observing, thinking, experimenting, and validating.[13] Discovery is conducted for its own sake and is documented through the universally accepted published record, the literature of science. Scientists are likely to work in an independent environment where they 1) select questions for investigation based largely on personal interest, 2) publish results to claim discovery and gain personal recognition and status in the profession, and 3) participate in the broad exchange of ideas on scientific questions for the sake of knowledge itself.[14]

Studies show that, in general, engineers tend to rely on in-house information such as personal or colleagues' collections, informal sources, internal technical reports, technical handbooks, standards and specifications, and trade publications. Engineers rarely use the library to acquire information. Personal contacts and sources are likely to be inside the organization due to the proprietary or classified nature of the projects at hand. Easy access to sources of information, rather than quality of the information gathered, is a prime reason for their selection.

Important sources of information for scientists are the more traditionally "academic" information-gathering methods such as the use of references and bibliographies in key articles, tables of contents services, and abstracting/indexing systems. However, informal communication is also a critical source of information. Among scientists, information exchanges tend to take place with people outside their organization—the "invisible college" concept.[15] Accessing formal scientific literature through libraries plays a much larger role for scientists than for engineers. Scientists also spend more time reading and documenting research results for publication. The distinction between the information use patterns of scientists and engineers might most simply be stated: while scientists tend to focus on primary source information for generation of additional primary source conclusions, engineers tend to utilize and produce information which is farther removed from the basic scientific process.

Study Location, Design, and Methodology

The research reported here was conducted as a Phase I activity of the NASA/DoD Aerospace Knowledge Diffusion Research Project. This project was attempted in order to understand the flow of scientific and technical information at the individual, organizational, national, and international levels in the aerospace industry. The goal of Phase I activities has been the investigation of the technical communications in aerospace among aerospace engineers and scientists.[16] While similar studies have been conducted at two NASA Research Centers, the National Aerospace Laboratory in the Netherlands,[17] and Russia's Central Aero-Hydrodynamic Institute,[18] this particular study was designed to obtain data from one specific subpopulation of Defense Department engineers and scientists in aerospace research, those of the Phillips Laboratory.

Location

The Phillips Laboratory is part of the United States Air Force's Materiel Command, the Air Force agency responsible for research, design, testing, production, and procurement of all equipment and systems entering Air Force service, from uniforms to aircraft. Phillips Laboratory is responsible for designing and testing all space- and missile-related technologies of Air Force interest.

Phillips was established in late 1990 during the Department of Defense's resizing and mission realignment program as one of the Air Force's "super" laboratories. Phillips was created by merging the Air Force Space Technology Center and it's three subordinate laboratories: Astronautics, Geophysics, and Weapons. In 1994, Phillips had a workforce of just over 1,900 members (1,263 civilians and 638 military) with the engineer/scientist population numbering 994. Of these engineers and scientists, 631 were civilians and 363 were military. The annual laboratory operating budget for 1994 was $600 million.

Merging the older organizations to create Phillips resulted in a geographic dispersal of laboratory directorates which has a bearing not only on the day-to-day administration of the organization, but also on the types of research being done at each site. Headquartered at Kirtland Air Force Base in Albuquerque, NM, other major facilities of the laboratory are located at Hanscom Air Force Base, 20 miles northwest of Boston, MA and at Edwards Air Force Base in the Mojave Valley, CA. Other subsidiary facilities are as far-flung as on Maui, HI, and in the Florida panhandle.

The primary research areas of Phillips are aligned geographically with the parent organizations from which the laboratory descended. At the Kirtland Phillips site, where 1097 employees—approximately 60 percent of the laboratory—are located, work is conducted on high energy plasma and microwave technologies, electromagnetic pulse hardening, space systems survivability, aircraft-based technologies for acquiring and tracking ballistic missiles during their boost phase, applications for lasers and imaging systems, spacecraft structures and their power systems, space experiments, and space/launch environmental testing. The site at Hanscom, which has some 414 employees (making up nearly 25 percent of the laboratory), conducts research on the environment between the Earth and the Sun and the effects of that environment on space systems and operations. The final 15 percent of the laboratory are located at the Edwards site. The 368 employees located at Edwards conduct research and testing on advanced motors and propellants for space and launch vehicles.

Of the entire Phillips workforce, 53 percent of employees are identified as "engineers and scientists." A breakdown of engineers and scientists at each site is not available because the Air Force does not distinguish engineers from scientists when citing the number of employees assigned to an organization. Survey response, however, provides some information: the engineer/scientist ratio was 15/85 at Hanscom, 77/23 at Edwards, and 58/42 at Kirtland. The proportion of engineers and scientists to administrative, support, and management employees is fairly consistent at all three Phillips sites, with just over half of the workers at each location officially classified as engineers and scientists.

Research Design and Methodology

The study described here was conducted at Hanscom, Edwards, and Kirtland Air Force Bases using self-administered (self-reported) mail surveys. The instrument used to collect the data was tested and used previously in several other NASA/DoD Aerospace Knowledge Diffusion Research studies. It was slightly adapted for use at Phillips. The survey population included engineers and scientists at the three sites: 350 at Hanscom, 250 at Edwards, and 400 at Kirtland. A total of 305 surveys were distributed with 228 received for an overall response rate of 75 percent. The response rates of Hanscom, Edwards, and Kirtland were, respectively, 71 percent, 66 percent, and 79 percent. The survey was conducted during May, June, and July, 1994. Selected results from the survey are presented here.

Assumptions

Based on an analysis of the literature of technical communication and information-related activities of engineers and scientists, as well as what is known about the research environment of Phillips Laboratory, the following assumptions were made:

1. researchers at Edwards and Kirtland prefer working in groups more than researchers at Hanscom;
2. the library/TIC is more important (in terms of performing professional duties) to researchers at Hanscom than those at Edwards or Kirtland;
3. a higher percentage of researchers at Hanscom use the library/TIC than at Edwards or Kirtland; and
4. the primary research literature is relied on more by researchers at Hanscom than by those at Edwards and Kirtland.

Findings and Discussion

Demographics

To provide a respondent profile, survey participants were asked questions about educational training, present duties, educational level, years of professional work experience, employment affiliation, membership in professional/technical societies, and gender. These findings are in Table 1.

When asked to characterize their educational training by discipline, nearly 85 percent of Hanscom respondents consider themselves scientists. By contrast, 77 percent of Edwards respondents refer to themselves as engineers by training. At the Kirtland headquarters of Phillips, the response is more evenly divided, with 58 percent of respondents referring to themselves as engineers and 42 percent con-

Table 1

SURVEY DEMOGRAPHICS						
	Hanscom		Edwards		Kirtland	
Factors	%	(n)	%	(n)	%	(n)
Educational Preparation						
Engineer	15.2	(5)	77.2	(44)	58.0	(80)
Scientist	84.8	(28)	22.8	(13)	42.0	(58)
Current Duties						
Engineer	12.1	(4)	64.9	(37)	49.3	(68)
Scientist	84.8	(28)	21.1	(12)	40.6	(56)
Management	3.0	(1)	14.0	(8)	10.1	(14)
Professional Duties						
Research	84.8	(28)	43.9	(25)	52.9	(73)
Administration/Management	12.1	(4)	40.4	(23)	31.2	(43)
Design/Development	3.0	(1)	15.8	(9)	13.8	(19)
Other	0.0	(0)	0.0	(0)	2.1	(3)
Education						
Bachelor's degree or less	9.1	(3)	45.6	(26)	23.9	(33)
Master's degree	39.4	(13)	38.6	(22)	39.9	(55)
Ph.D/Post Ph.D	51.5	(17)	15.8	(9)	36.2	(50)
Professional work experience						
1-5 years	3.0	(1)	35.0	(20)	13.1	(18)
6-10 years	27.3	(9)	17.5	(10)	21.0	(29)
11-20 years	21.1	(7)	22.8	(13)	33.3	(46)
21-40 years	45.5	(15)	24.6	(14)	32.6	(45)
41 or more years	3.0	(1)	0.0	(0)	0.0	(0)
Mean years work experience	21.3		13.1		16.7	
Employment Affiliation						
DoD Military	69.7	(23)	73.7	(42)	62.3	(86)
U.S. Govt. (DoE and Other)	15.2	(5)	15.8	(9)	23.9	(33)
DoD Civilian	15.2	(5)	8.8	(5)	12.3	(27)
Other	0.0	(0)	1.8	(1)	1.4	(2)
Gender						
Female	6.1	(2)	7.0	(4)	8.0	(11)
Male	93.9	(31)	93.0	(53)	92.0	(127)
Member of a Professional/ Technical Society	87.9	(29)	64.9	(37)	63.0	(87)

sidering themselves scientists. When asked to describe their present duties as either "engineer" or "scientist," the answers were nearly identical to those regarding their academic preparation.

Responses differed among the three sites when participants were asked to designate their principal role within Phillips. At Hanscom, 85 percent stated that their primary duty was research, with 12 percent responding that it was administration/management. At Edwards, 44 percent stated their primary duty was research, while 40 percent said their duties were primarily administrative/management (the remainder said their focus was on design/development). At Kirtland, the duties were divided into 53 percent research, 31 percent administrative/management, and 14 percent design/development. While the overall Phillips workforce is fairly evenly divided into three segments with regard to educational level, the distribution of master's degree and Ph.D. employees varies significantly from base to base.

Differences in professional work experience among the bases were varied, with 35 percent of Edwards respondents having only 1-5 years of experience as opposed to 3 percent at Hanscom and 13 percent at Kirtland. Edwards and Kirtland otherwise show similar years of work experience, but vary considerably from Hanscom where 45 percent of engineers/scientists have 21-40 years of experience. In other respects, there is little to distinguish the populations at Hanscom, Edwards, and Kirtland from each other, with the exception of Hanscom, where there is a slightly higher number of memberships in professional societies. Also noteworthy is the DoD military employment affiliation of 70 percent of respondents at Hanscom, 74 percent at Edwards, and 62 percent at Kirtland. Overall, only 37 percent of engineers and scientists at Phillips Laboratory are military employees.

Regarding the professional alignment of the Phillips workforce, there appears to be a distinct relationship between the disciplinary focus and research behavior at each of Phillips' principal facilities and the geographic setting in which they are located. Situated in the richly academic area of New England, the Hanscom researchers overwhelmingly consider themselves scientists when describing their academic preparation. By contrast, the vast majority of the Edwards researchers, close to the more production-oriented, aerospace manufacturing mecca of southern California, refer to themselves as engineers by training. At the Kirtland headquarters of Phillips, the academic orientation of the workforce is more evenly divided between engineers and scientists. This split at Kirtland seems appropriate with Kirtland's close proximity to two of the Department of Energy's national laboratories, Los Alamos and Sandia—the former basic research-oriented and the latter (actually located on Kirtland Air Force Base) an advanced engineering facility. The primary orientation of the research population at each of the Phillips' sites is reflected in the libraries at each of the sites: a research library at Hanscom, and technical libraries at both Kirtland and Edwards.

The educational background of the Phillips workforce illustrates the fact that more scientists seek degrees to the Ph.D. level than do engineers. The educational level also seems to relate to the civilian/military mix at each site. Hanscom—where more than half of the respondents are holders of doctorates/post doctorates—is the Phillips site with the highest proportion of civilian employees. At both Edwards and Kirtland—which have younger, more predominantly military workforces—respondents most frequently reported bachelor's or master's degrees as their highest educational achievement. The most likely explanation for this difference is the historically validated tradition of the military as a youthful profession. On average, the military researchers of Phillips are younger than their civilian colleagues, and have not yet had the opportunity to reach the highest academic level of their chosen fields. The military education system's emphasis on engineering over other academic disciplines may also account for the higher percentage of self-identified engineers at Edwards and Kirtland than at Hanscom.

How education level relates to longevity within the Phillips workforce is unclear. However, it is clear that the Hanscom respondents have substantially more professional experience than their colleagues at either Edwards or Kirtland with nearly half reporting 21 or more years of professional experience. This may be a reflection of the history of the communities near which the bases are located. The northeastern United States is a long-stabilized area, while the southwest is still a region of rapid and radical growth.

It is not surprising that the greatest percentage of the Phillips workforce at each site is civilian, rather than military. There has been a trend within the Department of Defense for the past 25-30 years to centralize and stabilize research and development activities. Part of this stabilization effort has been to reduce the numbers of military workers in such settings since the military personnel are likely to be more transient members of the workforce. These engineers and scientists did not reply to the survey in proportion to their presence in the laboratory, however. While more than two-thirds of the Phillips workforce are civilians, 70 percent of survey respondents were military members of the laboratory. This response result was completely unanticipated and can best be explained by several factors. Among these factors are that the military members of Phillips tend, on average, to be younger than the civilian workers. Therefore, they may have fewer purely research responsibilities to take them away from the laboratory premises, affording more time to complete the survey. Also, the military training and mindset of these respondents may make them more likely to complete any surveys as they would look upon it as more a requirement than an option.

Communicating and Producing Technical Information

Phillips respondents are largely in agreement about the importance of effective communication of technical information. As indicated in Table 2a, about 94 percent of participants at Hanscom, 93 percent at Edwards, and 91 percent at Kirtland responded that it is important. About half of the respondents at all bases report that there had been an increase in the amount of time spent producing technical information compared to five years ago. Only 12 percent at Hanscom thought the amount of time had decreased, while about a quarter of respondents at the other two bases thought it had decreased. More than 50 percent of respondents overall said that as they advanced professionally, the amount of time spent working with technical information received from others has increased as well.

In this survey, technical communication was defined as both the time spent producing oral and written communication, as well as time spent working with written and oral communication received from others. Phillips respondents noted that overall, this communication occupies approximately 32 hours, or 83 percent of a 40-hour work week. These findings appear in Table 2b. Results show a mean of 16.3 hours per week at Edwards and 18.3 hours per week at Kirtland being spent producing technical information. Hanscom respondents spend a mean of 14.9 hours per week working with technical information received from others compared to the high at Edwards of 16.1 hours per week.

Responses on collaborative writing practices at Phillips (Table 2c) indicate that Edwards engineers and scientists prefer writing alone more than the engineers and scientists at Hanscom or Kirtland. A mean of 69 percent of written technical communications at Edwards involve writing alone, and 33 percent of respondents write alone only. Hanscom participants write alone a mean of 57 percent of their written technical communications and prefer writing with a group of 2-5. Group writing is seen as more productive by those at Hanscom (45.5 percent) than at Kirtland (36 percent) or at Edwards (26 percent).

Little distinguishes the engineers and scientists from each base in terms of the respondents' assessment of the importance of technical information to their research or the amount of time spent preparing or working with technical information. The significant amount of time spent is possibly a reflection of the Phillips administration's emphasis on generating technical information, particularly in the form of technical reports, conference papers, and journal articles.

Although the characterizations of engineers and scientists previously noted would suggest that scientists are more likely to work independently than are engineers, the results of the Phillips survey do not support this assumption. It is clear that the Hanscom respondents greatly prefer to work in groups when producing any type of technical information, compared to the more engineering-oriented populations at both Edwards and Kirtland. A possible explanation for this unexpected finding might be that Hanscom has a more collegial atmosphere than the settings at the other two Phillips sites. Not only is Hanscom located in the previously noted highly academic region, but the entire Hanscom contingent is also housed in just a few buildings which are within easy walking distance of each other. The physical setting at Hanscom is highly conducive to collaboration. This is in marked contrast to both Edwards and Kirtland where the elements of Phillips at each base are widely dispersed, with some related facilities as much as 40 miles from each other.

Another possible explanation for the tendency of the Hanscom respondents to produce technical information in groups more often relates again to the longevity of the Hanscom workforce. As noted earlier, nearly half of Hanscom's respondents have 21 or more years of experience in their given field. Based on this and their advanced academic credentials, it is possible to assume the Hanscom respondents feel more comfortable in their professional status, having spent earlier working years establishing their credentials and niche in the

Table 2a

TECHNICAL COMMUNICATION PRACTICES OF PHILLIPS LAB ENGINEERS AND SCIENTISTS: IMPORTANCE AND CHANGE OVER TIME

	Hanscom		Edwards		Kirtland	
Factors	%	(n)	%	(n)	%	(n)
In your work, communicating technical information effectively is:						
Important	93.9	(31)	93.0	(53)	91.3	(126)
Neither important nor unimportant	0.0	(0)	0.0	(0)	2.2	(0)
Unimportant	6.1	(2)	7.0	(4)	5.8	(8)
Mean*	4.6		4.6		4.5	
Compared to 5 years ago, the amount of time you spend producing technical information has:						
Increased	48.5	(16)	43.9	(25)	44.2	(61)
Stayed the same	36.4	(12)	21.1	(12)	29.0	(40)
Decreased	-12.1	(4)	26.3	(15)	23.9	(33)
Not applicable	3.0	(1)	8.8	(5)	2.9	(4)
As you have advanced professionally, the amount of time you spend working with technical information received from others has:						
Increased	54.5	(18)	57.9	(33)	58.7	(81)
Stayed the same	36.4	(12)	24.6	(14)	29.7	(41)
Decreased	9.1	(3)	17.5	(10)	10.9	(15)
Not applicable	0.0	(0)	0.0	(0)	0.7	(1)

*A 1 to 5 point scale with 1=unimportant and 5=very important.

organization. Thus, they are less motivated to produce information independently to substantiate their professional reputations and are more willing to work with others. Also, the previously noted collegial atmosphere of the Hanscom area may contribute to a climate in which Hanscom's senior scientists spend a higher portion of their time mentoring their junior colleagues. The result of such cooperation may be the increased amount of group work on technical publications and presentations. By contrast, the professionally younger members of the Phillips workforce are clustered at Edwards and Kirtland, where the necessity of independent work to solidify professional reputations is likely higher. While Phillips management certainly encourages collaborative efforts in technical information production, it is generally not a requirement based on work assignments. As is likely in non-DoD research settings, some projects are more appropriate for group effort than others. This is reflected in Phillips' information production practices.

Types of Information Produced and Used

Respondents were asked the number of times in the past 6 months they had written or prepared various information types, alone or in a group (See Table 3a). Letters, memoranda, technical talks/presentations, and audio-visual materials are most frequently prepared individually at all three bases. More differences appear in information products prepared in groups. Hanscom respondents indicated that abstracts, letters, technical talks/presentations, DoD technical reports, and audio-visual materials are prepared in groups averaging 2 to 3.5 people. At Edwards and Kirtland, with only slight variations, group preparation centers on technical talks/presentations, letters, memoranda, and audio/visual materials. Group size at Edwards ranges on average from 2 to 6. Average size of work groups at Kirtland is 2 to 5 people.

Table 2b

TECHNICAL COMMUNICATION PRACTICES OF PHILLIPS LAB ENGINEERS AND SCIENTISTS: HOURS SPENT WEEKLY PRODUCING AND RECEIVING INFORMATION

	Hanscom		Edwards		Kirtland	
Factors	%	(n)	%	(n)	%	(n)
Hours spent weekly producing technical information:						
0	0.0	(0)	1.8	(1)	1.4	(2)
1-5	9.1	(3)	12.3	(7)	7.8	(11)
6-10	18.2	(6)	19.3	(11)	18.8	(26)
11-20	45.5	(15)	42.1	(24)	39.1	(54)
21-40	27.3	(9)	24.6	(14)	31.9	(44)
Mean	16.9		16.3		18.3	
Hours spent weekly working with technical information received from others:						
0	0.0	(0)	0.0	(0)	0.7	(1)
1-5	12.1	(4)	12.4	(7)	7.2	(10)
6-10	18.2	(18)	47.4	(27)	44.9	(62)
11-20	54.5	(18)	47.4	(27)	44.9	(62)
21-40	15.2	(5)	21.1	(12)	18.8	(26)
Mean	14.9		16.1		15.5	

The three bases showed a marked difference in usage of varied types of information (Table 3b). Hanscom respondents in a six-month period use an average of 39 journal articles, 19 letters, 18 abstracts, 12 memoranda, and 13 conference/meeting papers, while Edwards' participants use an average of 26 letters, 25.5 audio/visual materials, 19 memoranda, 19 journal articles, and 17 technical talks/presentations. Those surveyed at Kirtland reported using an average of 20 letters, 19 journal articles, 14 memoranda, 12 abstracts, and 9 technical talks/presentations in a six-month period.

As with scientists and engineers in other Phase I studies, the majority of Phillips respondents at all three sites reported that they most frequently prepared letters and memoranda when working alone. Since these types of materials may be considered the least formal types of technical communication, it seems logical that they are the result of independent, as opposed to group, effort. Such items are also more likely to be for internal use within the organization, as opposed to more formal communications such as technical talks/presentations, technical reports, specifications, and other materials intended for wider audiences. It seems reasonable that as technical information products rise higher on a scale of formality—with an increase in potential audience—there will be a higher likelihood of group effort in preparing the information. Consensus among colleagues within the organization is an important validation of opinion/thought prior to its release outside the organization. This is perhaps especially true in a government setting, where it is essential that all information must meet strict review standards prior to public release.

The varied information product usage patterns at the three bases seem to reinforce the differences noted between scientists and engineers. At Hanscom, with its predominance of self-identified scientists, there appears to be a distinct preference for the most formal, and often most timely, form of technical information—journal articles. This preference may be related to the Hanscom respondents' heavier reliance on their library/TIC, indicating the scientists' overall habits of seeking information from formal, traditional information sources. The emphasis on journal articles as an information source at Hanscom may also be related to the increased likelihood that technical information is produced as the result of group effort. The sharing of information sources with collaborators is simplified in that

Table 2c

COLLABORATIVE WRITING PRACTICES OF PHILLIPS LAB ENGINEERS AND SCIENTISTS

Factors	Hanscom X̄%	Hanscom (n)	Edwards X̄%	Edwards (n)	Kirtland X̄%	Kirtland (n)
Write alone 57.1	(19)	68.9	(39)	65.7	(91)	
Write with one other person	14.4	(5)	16.1	(9)	14.6	(20)
Write with a group of 2-5	26.4	(9)	13.5	(8)	15.8	(21)
Write with a group of more than 5	2.4	(1)	1.4	(1)	4.1	(6)
	%	(n)	%	(n)	%	(n)
Group is more productive than writing alone	45.5	(15)	26.3	(15)	36.2	(50)
Group is as productive as writing alone	27.3	(9)	19.3	(11)	18.8	(26)
Group is less productive than writing alone	18.2	(6)	21.1	(12)	22.5	(31)
I write alone (only)	9.1	(3)	33.3	(19)	22.5	(31)

library information is easily available to all members of the work group. By contrast, at Edwards, where group effort occurs less frequently, the emphasis on letters as information sources is understandable. Independent effort—and effort by researchers who have less professional experience and less access to a library/TIC than at Hanscom—may necessitate more correspondence with colleagues outside of the organization. As with other factors, while Hanscom and Edwards appear to diverge somewhat in their collective answers to this portion of the survey, the Kirtland respondents, with their even mixture of scientists and engineers, seem to strike the middle ground of relying almost equally on informal communications (letters) and formal technical communications (journal articles).

Undergraduate Coursework in Technical Communications

Respondents were asked if they have ever taken a course in technical communications/writing (Table 4a). Overall, 28 percent said they had taken a course as an undergraduate (12 percent at Hanscom as opposed to 47 percent at Edwards and 23 percent at Kirtland). After graduation, 33 percent at Hanscom, 7 percent at Edwards, and 15 percent at Kirtland had taken a course in technical communications/writing. An additional 18 percent overall had taken courses both as an undergraduate and graduate (18 percent at Hanscom, 21 percent at Edwards, and 16 percent at Kirtland). Overall, 38 percent of survey respondents indicated they had never taken such a course. Of the 61 percent overall who had taken a

Table 3a

MEAN NUMBER OF TECHNICAL INFORMATION PRODUCTS PRODUCED IN THE PAST 6 MONTHS BY PHILLIPS LAB ENGINEERS AND SCIENTISTS

	Hanscom			Edwards			Kirtland		
Information Products	Alone	In a group	Avg. no. in group	Alone	In a group	Avg. no. in group	Alone	In a group	Avg. no. in group
Abstracts	1.0	1.4	3.5	0.5	0.7	2.6	0.9	0.7	2.8
Journal articles	0.3	0.8	3.2	0.2	0.2	2.5	0.3	0.4	2.7
Conference/Meeting papers	0.5	0.9	3.3	0.8	0.5	2.6	0.7	0.7	3.1
Trade/Promotional literature	0.0	0.0	0.0	0.0	0.1	3.5	0.3	0.2	4.4
Drawings/Specifications	0.8	0.5	2.5	2.0	0.4	4.2	2.4	0.3	3.1
Audio/Visual materials	2.5	1.0	3.0	5.6	0.9	2.5	4.3	1.9	3.4
Letters	13.6	1.4	2.2	11.5	1.3	2.0	16.7	1.6	2.5
Memoranda	7.7	0.4	2.3	9.9	1.2	3.2	11.9	1.6	2.5
Technical proposals	0.2	0.6	2.5	0.3	0.3	2.6	1.0	0.3	3.0
Technical manuals	0.0	0.0	0.0	0.2	0.1	3.7	0.1	0.1	4.7
Computer program documentation	1.0	0.0	0.0	0.2	0.0	2.5	2.3	0.1	2.6
DoD technical reports	0.5	1.0	2.9	0.2	0.3	3.1	0.2	0.3	3.5
DoE technical reports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NASA technical reports	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0
Technical talks/Presentations	2.7	1.1	3.1	4.5	1.4	2.6	4.8	1.9	3.0

course, about a quarter of Hanscom and Edwards respondents and 17 percent of respondents at Kirtland said that this course had helped a lot to communicate technical information while from 33 to 44 percent said it helped a little and from 3 to 7 percent said it didn't help at all. When asked if undergraduate engineering and science students should have training or coursework in technical communications, 93 percent overall said yes and 4 percent no.

Respondents were also asked to select (from a list) which on-the-job skills should be included in an undergraduate technical communications course for science and engineering students (Table 4b). Those at Hanscom prioritized the most important topics as technical reports, oral (technical) presentations, journal articles, abstracts, and conference/meeting papers. Edwards respondents said oral (technical) presentations, technical reports, abstracts, conference/meeting papers, and journal articles, while Kirtland reported oral (technical) presentations, technical reports, abstracts, use of information sources, and journal articles as their choice of on-the-job skills to be included in a course.

The number of Phillips researchers who have had some formal coursework in technical communications is substantially lower than the number reported for NASA researchers in another Phase I study.[19] The most likely explanation for this variation may have to do with differences between the structures and missions of the Department of Defense and NASA. It may be that NASA places more emphasis on their employees having such coursework. The predominance of a younger workforce at both Edwards and Kirtland may account for some of the variation in this qualification for workers at the different bases (the availability of such courses at the undergraduate level may be too new a phenomena for the older researchers at Hanscom to have taken advantage of it during their early education). Also, required military schools which many of the Edwards and Kirtland researchers have attended usually include coursework on technical and busi-

Table 3b

MEAN NUMBER OF TECHNICAL INFORMATION PRODUCTS USED IN THE PAST 6 MONTHS BY PHILLIPS LAB ENGINEERS AND SCIENTISTS

Information Products	Hanscom	Edwards	Kirtland
Abstracts	18.4	7.5	11.7
Journal articles	39.4	18.6	19.1
Conference/Meeting papers	13.4	5.9	8.9
Trade/Promotional literature	3.2	8.0	5.8
Drawings/Specifications	2.1	7.4	4.2
Audio/Visual Materials	6.4	25.5	7.8
Letters	19.4	26.5	19.9
Memoranda	12.2	18.7	13.6
Technical proposals	6.3	2.5	2.9
Technical manuals	4.8	3.5	4.1
Computer program documentation	5.4	5.3	6.6
DoD technical reports	4.2	4.0	3.4
DoE technical reports	0.2	0.1	0.5
NASA technical reports	0.2	1.5	0.6
Technical talks/Presentations	8.2	16.8	8.9

ness writing not found in a typical college or university curriculum. The fact that Hanscom's civilian researchers were far more likely to have taken technical communications courses after completing their bachelors' degrees suggests that the importance of such formal training became apparent to the Hanscom researchers as they advanced in their careers.

The virtual unanimity of the Phillips respondents on the need for formal undergraduate coursework in technical communications echoes the same sentiments expressed by the NASA researchers.[20] Considering the emphasis placed on technical information as "an essential element of successful engineering practice"[21] and a primary product of scientific research, this is not a surprising finding. Knowing that the significance of their findings can best be judged through their communication of those findings, the only surprise is that some of the Phillips respondents felt that formal coursework in technical communications was unnecessary.

Use of Computer and Information Technology

Survey participants were asked if they use computer technology to prepare technical information (Table 5a). One hundred percent of the respondents use computer technology to prepare technical information. This agrees with other Phase I study results which found that 98 percent of U.S. (i.e. NASA) engineers and scientists used computers to process technical information.[22,23] At Hanscom, 67 percent always use it and 27 percent usually it, while at Edwards, 70 percent reported they always use it and 22 percent usually use it. At Kirtland, 75 percent reported always using computer technology and 21 percent reported usually using it.

Table 4a

COURSEWORK IN TECHNICAL COMMUNICATIONS/WRITING

Factors	Hanscom %	(n)	Edwards %	(n)	Kirtland %	(n)
Have you taken a course in technical communications/writing?						
Yes, as an undergraduate	12.1	(4)	47.4	(27)	23.2	(32)
Yes, after graduation	33.3	(11)	7.0	(4)	15.2	(21)
Yes, both	18.2	(6)	21.1	(12)	16.7	(23)
Presently taking	0.0	(0)	0.0	(0)	0.7	(1)
No	36.4	(12)	24.6	(14)	44.2	(61)
How much did it help you communicate technical information?						
A lot	24.2	(8)	24.6	(14)	16.7	(23)
A little	36.4	(12)	43.9	(25)	33.3	(46)
Not at all	3.0	(1)	7.0	(4)	5.1	(7)
Have never taken	36.4	(12)	24.6	(14)	44.9	(62)
Do you think engineering and science undergraduates should have training or coursework in technical communications?						
Yes	97.0	(32)	93.0	(53)	93.5	(129)
No	3.0	(1)	3.5	(2)	5.1	(7)
I don't know	0.0	(0)	3.5	(2)	1.4	(2)

When asked if computer technology had increased their ability to communicate technical information, 79 percent overall responded, "yes, a lot" while only 3.5 percent said it had not.

Choosing from eight types of computer software, respondents indicated (as shown in Table 5b) that they used word processing software the most (99 percent) followed by spelling checkers (90 percent), and scientific graphics (81 percent). Thesauri, desktop publishers, business graphics, and grammar and style checkers are used moderately. Usage patterns were virtually identical among the three Phillips sites. Respondents were also asked about their use of electronic/information technologies in communicating technical information. At all three bases, fax or Telex was used most heavily (91 to 98 percent) with electronic mail the next most frequently used (85 to 88 percent).

The nearly identical patterns of usage of computers and information technology at all three Phillips facilities is not surprising. Since R&D organizations and federal agencies both support and encourage the use of the latest technologies, any agency such as Phillips which is a government research center is more likely than most organizations to make the latest technologies available to its employees. As common office automation tools become easier to use—while having increasingly sophisticated capabilities—their use is likely to become so widespread that future studies may not focus on their use to such a degree.

Use of Libraries/Technical Information Centers

The survey asked a series of questions concerning the existence, importance, and use of libraries/technical information centers (TICs) at the three Phillips sites. All Hanscom respondents have access to a library/TIC although it is not in their building, while at Edwards, 7 percent have access in their building and 93 percent do not have in their building (Table 6a). At Kirtland, 1.4 percent have access in their building, 96.4 percent do not have access

Table 4b

RECOMMENDED ON-THE-JOB SKILLS TO BE INCLUDED IN A TECHNICAL COMMUNICATIONS COURSE FOR ENGINEERING AND SCIENCE UNDERGRADUATES

	Hanscom		Edwards		Kirtland	
On-the-job communications	**%**	**(n)**	**%**	**(n)**	**%**	**(n)**
Abstracts	81.8	(27)	87.7	(50)	78.3	(108)
Letters	66.7	(22)	68.4	(39)	60.1	(83)
Memoranda	57.6	(19)	61.4	(35)	56.5	(78)
Technical instructions	69.7	(23)	68.4	(39)	67.4	(93)
Journal articles	87.9	(29)	71.9	(41)	71.7	(99)
Conference/Meeting papers	78.8	(26)	77.2	(44)	68.8	(95)
Literature reviews	60.6	(20)	59.6	(34)	52.9	(73)
Technical manuals	48.5	(16)	63.2	(36)	54.3	(75)
Newsletter/newspaper articles	24.2	(8)	31.6	(18)	23.9	(33)
Oral (technical) presentations	87.9	(29)	94.7	(54)	92.8	(128)
Technical specificaitons	51.5	(17)	54.4	(31)	53.6	(74)
Technical reports	90.9	(30)	89.5	(51)	83.3	(115)
Use of information sources	63.6	(21)	70.2	(40)	73.2	(101)
Other scurces*	3.0	(1)	1.8	(1)	0.7	(1)

* Hanscom: Literature searches; Edwards: Multimedia presentations; Kirtland: Program plans.

in their building, and 2.2 percent responded that they did not have a library/TIC within their facility. When asked about the importance of the library/TIC in terms of performing professional duties, about 73 percent of Hanscom respondents said it was important, compared to 49 percent at Edwards and 56.5 percent at Kirtland. Nearly 37 percent at Edwards felt it was unimportant as opposed to 15 percent at Hanscom and 13 percent at Kirtland.

Table 6b shows results on use of the library/TIC. Library usage at Hanscom is the highest of the three sites with a mean use of 16.5 times in the past 6 months, while Kirtland respondents had used their library/TIC a mean of 8.9 times, and Edwards 6.6 times. Respondents were asked to what extent the proximity of their work setting affects their use of the library/TIC. Overall, 41 percent of respondents indicated that it is important, 24 percent said it was neither important nor unimportant, and 33 percent said it was unimportant. Forty-seven percent of the Edwards respondents—who have access to a small branch library at their immediate worksite but must travel 40 miles to visit the main, more comprehensive, technical library on base—agreed that their proximity to a library/TIC (or, in their case, lack of proximity) had an important effect on their use of that library/TIC. In contrast, at Hanscom, where 87 percent of respondents said they could walk to their library/TIC in 5 minutes or less, over 57 percent of the respondents said the library/TIC's location had moderate to low influence on their use of its resources. Kirtland's respondents, whose work campus is neither as compact as Hanscom's nor as far-flung as Edwards', were more evenly divided on the importance of the library/TIC's proximity; 38 percent thought the location was very important, 27 percent thought it neither important nor unimportant, and 32 percent thought the location was not at all important.

The higher library/TIC usage rate and higher importance attached to the library/TIC among Hanscom respondents might be attributed to their self-identification as "scientists" rather than engineers as well as to the previously mentioned academic climate of the Hanscom environs. The years of experience in Hanscom's workforce (more than 50 percent of the survey respondents have more than 20 years of professional work experience in comparison with only a quarter of Edwards' respondents and a third of Kirtland's respondents) also suggests that a longer ingrained habit of research may be a factor leading toward increased library/TIC use.

Table 5a

USE OF COMPUTER TECHNOLOGY BY PHILLIPS LAB ENGINEERS AND SCIENTISTS

Factors	Hanscom %	Hanscom (n)	Edwards %	Edwards (n)	Kirtland %	Kirtland (n)
Use of computer technology to prepare technical information						
Always	66.7	(22)	70.2	(40)	75.4	(104)
Usually	27.3	(9)	22.8	(13)	20.3	(28)
Sometimes	6.1	(2)	7.0	(4)	4.3	(6)
Never	0.0	(0)	0.0	(0)	0.0	(0)
Has computer technology increased your ability to communicate technical information?						
Yes, a lot	87.9	(29)	77.2	(44)	78.3	(109)
Yes, a little	12.1	(4)	19.3	(11)	17.4	(24)
No	0.0	(0)	3.5	(2)	4.3	(6)

Our assumption that library/TIC usage at Hanscom will be higher can be explained by differences among engineers and scientists in information-seeking, information use, and research habits. However, it can also be explained by another widely-acknowledged information-gathering characteristic: the tendency for both engineers and scientists to view accessibility and convenience as a primary factor in gathering information.[24,25] The influence of the library/TIC's location on its usage cannot be overlooked in any of the Phillips settings, in spite of the near consensus at all sites that the proximity of the workplace to the library only moderately affects library usage.

The fact that Hanscom's workforce is almost entirely housed in a single complex of buildings just across the street from their research library is an obvious explanation for higher library use by the Hanscom respondents. Lower use rates by survey respondents at Edwards are likely a result of the limited resources on hand at their branch library, which can only be supplemented by a 40 mile drive to the main technical library on base. The more moderate library/TIC use rates by Kirtland respondents can be explained, in part, by their dispersion among dozens of buildings, only a small percentage of which are within walking distance of their technical library. These effects of

Table 5b

SOFTWARE/INFORMATION TECHNOLOGIES USED BY PHILLIPS LAB ENGINEERS AND SCIENTISTS

	Hanscom		Edwards		Kirtland	
	%	(n)	%	(n)	%	(n)
Software						
Word processing	100.0	(33)	98.2	(56)	98.6	(136)
Outliners and prompters	12.1	(4)	14.0	(8)	13.0	(18)
Grammar and style checkers	36.4	(12)	35.1	(20)	37.7	(52)
Spelling checkers	81.8	(27)	93.0	(53)	90.6	(125)
Thesaurus	51.5	(17)	66.7	(38)	56.5	(78)
Business graphics	24.2	(8)	45.6	(26)	39.9	(55)
Scientific graphics	78.8	(26)	71.9	(41)	85.5	(118)
Desktop publishing	42.4	(14)	50.9	(29)	41.3	(57)
Information Technologies						
Audio tapes and cassettes	18.2	(6)	17.5	(10)	17.4	(24)
Motion picture film	9.1	(3)	19.3	(11)	14.5	(20)
Video tape	60.6	(20)	66.7	(38)	55.8	(77)
Desktop/electronic publishing	57.6	(19)	70.2	(40)	51.4	(71)
Computer cassette/cartridge tapes	63.6	(21)	45.6	(26)	42.0	(58)
Electronic mail	84.8	(28)	87.7	(50)	86.2	(119)
Electronic bulletin boards	48.5	(16)	70.2	(40)	46.4	(64)
FAX or TELEX	90.9	(30)	98.2	(56)	95.7	(132)
Electronic data bases	75.8	(25)	66.7	(38)	58.0	(80)
Video conferencing	42.4	(14)	52.6	(30)	50.0	(69)
Computer conferencing	0.0	(0)	5.3	(3)	5.8	(8)
Micrographics and microforms	21.2	(7)	24.6	(14)	24.6	(34)
Laser disc/video disc/CD-ROM	54.5	(18)	29.8	(17)	27.5	(38)
Electronic networks	69.7	(23)	77.2	(44)	61.6	(85)

proximity might also contribute to the slightly higher likelihood of the Edwards and Kirtland respondents to use computer networks to search their library's catalogs and/or library materials via computer; a time-consuming trip to the library can be better justified if a prior check indicates that the materials needed are indeed available for use in the library and not already on loan to a colleague. Also, while researchers have online access to their libraries via the SIRSI Corporation's STILAS at each site, the systems were not installed simultaneously and do not have the benefit of identical LAN architectures at each base, which would account for much of the variation in usage.

Sources of Information

Survey participants were also asked to indicate from a given list which information sources were consulted in solving a technical problem (Table 7). The source consulted most frequently at all bases was "personal store of technical information, including sources I keep in my office" (Hanscom 97 percent, Kirtland 99 percent, and Edwards 100 percent). In descending order the next most frequently used sources at Hanscom were co-workers at their organization, literature sources in the organization's library, colleagues outside the organization, an electronic database in the library, and a librarian or technical information specialist. After their personal store of information, the descending importance of other sources used at both Edwards and Kirtland were co-workers in the organization, colleagues outside the organization, literature sources in the organization's library, databases in the library, and a librarian/technical information specialist.

The consistent finding that personal information resources are used before consulting other sources is not surprising. This trend has been noted as common with the majority of all scientists and engineers in a variety of settings. The fact that DoD researchers are required to maintain comprehensive project files may even reinforce this tendency. A large store of rel-

Table 6a

ACCESS AND IMPORTANCE OF THE LIBRARY/TECHNICAL INFORMATION CENTER TO PHILLIPS LAB ENGINEERS AND SCIENTISTS

	Hanscom		Edwards		Kirtland	
Factors	%	(n)	%	(n)	%	(n)
Does your organization have a library/technical information center?						
Yes, in my building	0.0	(0)	7.0	(4)	1.4	(2)
Yes, but not in my building	100.0	(33)	93.0	(53)	96.4	(133)
No	0.0	(0)	0.0	(0)	2.2	(3)
Importance in terms of performing professional duties						
Important	72.7	(24)	49.2	(28)	56.5	(78)
Neither important nor unimportant	12.1	(4)	14.0	(8)	28.3	(39)
Unimportant	15.2	(5)	36.9	(21)	13.0	(13)
Does not have library/TIC	0.0	(0)	0.0	(0)	2.2	(3)
Mean*	4.1		3.2		3.7	

*A 1 to 5 point scale with 1=unimportant and 5=very important.

evant information ready at hand in the official files seems an obvious first resource. The use of other informal information sources prior to consulting a librarian/technical information specialist follows the already noted pattern of scientists and engineers overall.

Use of Technical Reports, Domestic and Foreign

In identifying which categories of technical reports were used most frequently in performing their present professional duties, the respondents ranked U.S. Department of Defense

Table 6b

USE OF THE LIBRARY/TECHNICAL INFORMATION CENTER BY PHILLIPS LAB ENGINEERS AND SCIENTISTS

Factors	Hanscom %	Hanscom (n)	Edwards %	Edwards (n)	Kirtland %	Kirtland (n)
Use in the past 6 months						
0 times	3.0	(1)	17.5	(10)	14.1	(19)
1-5 times	33.4	(11)	47.4	(27)	44.1	(61)
6-10 times	21.2	(7)	24.6	(14)	17.4	(24)
11-25 times	33.3	(11)	7.0	(4)	14.5	(20)
26-50 times	3.0	(1)	1.8	(1)	7.2	(10)
51 times or more	6.1	(2)	1.8	(1)	0.7	(1)
Mean	16.5		6.6		8.9	
How does proximity affect your use?						
Important	42.4	(14)	47.3	(27)	38.4	(53)
Neither important nor unimportant	27.3	(9)	15.8	(0)	26.8	(37)
Unimportant	30.4	(10)	36.9	(21)	32.6	(45)
Does not have library/TIC	0.0	(0)	0.0	(0)	2.2	(3)
Mean*	3.2		2.9		3.1	

*A 1 to 5 point scale with 1=unimportant and 5=very important

Table 7

INFORMATION SOURCES USED IN PROBLEM SOLVING BY PHILLIPS LAB ENGINEERS AND SCIENTISTS

Sources	Hanscom %	Hanscom (n)	Edwards %	Edwards (n)	Kirtland %	Kirtland (n)
Personal store of technical information	97.0	(32)	100.0	(57)	99.3	(137)
Spoke with a coworker or people inside my organization	97.0	(32)	100.0	(57)	99.3	(137)
Spoke with colleagues outside my organization	90.9	(30)	94.7	(54)	92.8	(128)
Used literature resources found in my organization's library	93.9	(31)	80.7	(46)	89.9	(124)
Searched an electronic database in the library	75.8	(25)	77.2	(43)	70.3	(97)
Spoke with a librarian or technical information specialist	63.6	(21)	64.9	(37)	60.1	(83)

reports highest at all three Phillips sites (see Table 8.) The second most heavily used technical reports at all three are NASA reports. Technical reports from the U.K. and U.S. Department of Energy rank third and fourth in importance, respectively, for respondents at Hanscom and Edwards, while the ranking of these two categories is reversed by Kirtland researchers. Technical reports from AGARD, ESA, China, India, France, Germany, Japan, the Netherlands, and Russia are of lesser significance according to all survey respondents, and their ranking varies only slightly from one Phillips site to another. While nearly all of the

Table 8

USE AND IMPORTANCE OF FOREIGN AND DOMESTICALLY PRODUCED TECHNICAL REPORTS TO PHILLIPS LAB ENGINEERS AND SCIENTISTS

	Hanscom		Edwards		Kirtland	
Use	**%**	**(n)**	**%**	**(n)**	**%**	**(n)**
Country/Organization						
U.S. DoD	90.0	(30)	82.5	(47)	78.3	(108)
U.S. NASA	81.80	(27)	73.7	(42)	50.7	(70)
U.K.	69.70	(23)	45.6	(26)	41.3	(57)
U.S. DoE	45.50	(15)	43.9	(25)	45.7	(63)
NATO AGARD	27.30	(9)	38.6	(22)	8.7	(12)
ESA	33.30	(11)	14.0	(8)	12.3	(17)
China	12.10	(4)	8.8	(5)	5.1	(7)
India	18.20	(6)	5.3	(3)	4.3	(6)
France	36.40	(12)	31.6	(18)	23.2	(32)
Germany	45.50	(15)	26.3	(15)	31.2	(43)
Japan	33.30	(11)	28.1	(16)	26.1	(36)
The Netherlands	24.20	(8)	5.3	(3)	10.9	(15)
Russia	45.50	(15)	35.1	(20)	31.2	(43)
	Hanscom		**Edwards**		**Kirtland**	
Importance	**$\bar{X}$**	**(n)**	**$\bar{X}$**	**(n)**	**$\bar{X}$**	**(n)**
Country/Organization						
U.S. DoD	4.1	(33)	4.0	(57)	3.9	(134)
U.S. NASA	3.30	(33)	3.80	(56)	3.2	(133)
U.K.	2.6	(33)	2.5	(54)	2.2	(132)
U.S. DoE	2.4	(32)	2.4	(56)	2.6	(134)
NATO AGARD	1.5	(32)	2.1	(53)	1.4	(128)
ESA	1.7	(32)	1.8	(52)	1.6	(130)
China	1.4	(32)	1.60	(48)	1.3	(127)
India	1.6	(32)	1.5	(49)	1.3	(129)
France	2.0	(33)	2.1	(52)	1.7	(131)
Germany	2.2	(33)	1.90	(51)	1.9	(132)
Japan	1.9	(33)	2.0	(51)	1.8	(131)
The Netherlands	1.70	(33)	1.5	(51)	1.5	(130)
Russia	2.30	(33)	2.4	(51)	2.1	(132)

respondents reported that they had access to materials from all countries listed in the survey, over half noted that they did not use them. In assessing the importance of the various report categories on a scale of 1 (very unimportant) to 5 (very important) to their work, the respondents made the same preferences, ranking U.S. DoD reports as most important with a mean importance of 3.91, followed by NASA reports (3.37), and then U.S. DoE reports (2.52). Foreign materials were all rated as having lesser importance, with scores varying from a high of 2.36 for U.K. materials to a low of 1.38 for Indian reports.

Because the primary product of Phillips is technical reports, it is not surprising that U.S. DoD technical reports are used most often and are considered most important by the Phillips workforce. Their ready availability at the Phillips Research and Technical Libraries may have some influence on this preference. Also contributing to the preference for DoD reports is the likelihood that many are also housed in the personal libraries of the researchers who make these office collections of technical information readily available to their colleagues as previously noted. The importance of NASA technical reports over DoE reports at both Hanscom and Edwards is explained by the geophysics and astronautics foci at these sites. In contrast, DoE reports are justifiably more important to the Kirtland respondents who interact frequently with researchers from Sandia and Los Alamos National Laboratories as well as the Defense Nuclear Agency which are located on or near Kirtland Air Force Base. The most likely explanation for the preference for domestic over foreign technical reports is the fact that 95 percent of the respondents overall recorded English as their native language. Another explanation is that foreign reports are obtained through other channels than a library/TIC.

Conclusion

The responses obtained from survey respondents at Phillips Laboratory tend to support earlier research indicating that different technical communications and information-related activities exist for engineers and scientists. Because Phillips is a unique organization in that the majority of its scientists are grouped together, away from the majority of its engineers, it is easier to distinguish some of the variations in information gathering and usage behaviors than if this survey looked at multiple organizations. As reported elsewhere, scientists have a closer affinity for libraries and traditional information sources than do engineers. As also noted previously, there are a wide variety of reasons for this. Because of its special heritage and heterogeneous composition, Phillips highlights some of the more clearly delineated distinctions between the two disciplines. Fortunately, the evolution of Phillips Laboratory as a consolidation of older laboratories has permitted a concurrent evolution of the libraries at each site. As a result, these libraries ideally suit the specialized requirements of their particular clients.

Acknowledgements

The authors express their thanks to Dr. Thomas E. Pinelli and the NASA/DoD Aerospace Knowledge Diffusion Research Project for their support of this survey. Special thanks to Elizabeth A. Duffek, Hanscom Research Library; Jolaine Lamb, Edwards Technical Library; and Jo Janet Dean, Kirtland Technical Library.

* *The views expressed in this article are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.*

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References

[1] Berul, Lawrence H. et al. *Final Technical Report, DoD User Needs Study: Phase I. Report 1151-TR-3.* Philadelphia, PA: Auerbach Corp., 1965. (Available from NTIS, Springfield, VA AD-615 501.)

[2] Goodman, Arnold F., John D. Hodges, Jr., and Forrest G. Allen. *Final Report, DoD User-Needs Study, Phase II.* Anaheim, CA: North American Aviation, Inc., 1966. (Available from NTIS, Springfield, VA NTIS AD-647 111.)

[3] Pinelli, Thomas E. "The Information-Seeking Habits and Practices of Engineers." *Science & Technology Libraries* 11(3): 5-25 (1991).

[4] Kline, Stephen J. "Innovation is Not a Linear Process." *Research Management* 27(4): 36-45 (1985).

[5] Ibid.

[6] Shapley, Deborah and Rustum Roy. *Lost at the Frontier: U.S. Science and Technology Policy Adrift.* Philadelphia, PA: ISI Press, 1985.

[7] Allen, Thomas J. "Distinguishing Engineers from Scientists." *Managing Professionals in Innovative Organizations*, ed. R. Katz. Cambridge, MA: Ballinger, 1988.

[8] Pinelli, Thomas E. "The Information-Seeking Behavior of Engineers." *Encyclopedia of Library and Information Science.* 52, supp. 15 (1993).

[9] King, Donald W., Jane Casto, and Heather Jones. *Communication by Engineers: A Literature Review of Engineers' Information Needs, Seeking Processes, and Use.* Washington, DC: Council on Library Resources, 1994.

[10] Pinelli, "The Information-Seeking Behavior of Engineers."

[11] Kemper, J.D. *Engineers and Their Profession.* Philadelphia, PA: W.B. Saunders, 1990.

[12] Ibid.

[13] "Science." *Compton's Interactive Encyclopedia* (version 2.02VWF, 1994).

[14] Ritti, R. Richard. *The Engineer in the Industrial Corporation.* New York, NY: Columbia University Press, 1971.

[15] Crane, Diana. *Invisible Colleges: Diffusion of Knowledge in Scientific Communities.* Chicago: University of Chicago Press, 1972.

[16] Pinelli, T.E., J.M. Kennedy, and R.O. Barclay. "The NASA/DoD Aerospace Knowledge Diffusion Research Project." *Government Information Quarterly* 8(2): 112-114 (1991).

[17] Barclay, Rebecca O., Thomas E. Pinelli, and John M. Kennedy. "Technical Communication Practices of Dutch and U.S. Aerospace Engineers and Scientists: International Perspectives on Aerospace," *IEEE Transactions on Professional Communication* 37(2): 97-107 (1994).

[18] Pinelli, Thomas E. et al. "The Technical Communication Practices of Russian and U.S. Aerospace Engineers and Scientists." *IEEE Transactions on Professional Communication* 36(2): 95-104 (1993).

[19] Ibid, 99.

[20] Ibid.

[21] Mailloux, E.N. "Engineering Information Systems." *The Annual Review of Information Science and Technology* 25: 239-266 (1989).

[22] Barclay, et al. "Technical Communication Practices of Dutch and U.S. Aerospace Engineers and Scientists." 102.

[23] Pinelli, et al. "The Technical Communication Practices of Russian and U.S. Aerospace Engineers and Scientists." 101.

[24] Young, J.F. and L.C. Harriott. "The Changing Technical Life of Engineers." *Mechanical Engineering* 101(1): 20-24 (1979).

[25] Soper, Mary Ellen. "Characteristics and Use of Personal Collections." *Library Quarterly* 46(4): 397-415 (1976).