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*The U.S. Government Technical Report and the  
Transfer of Federally Funded Aerospace R&D*

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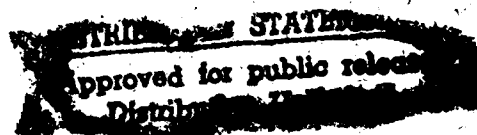
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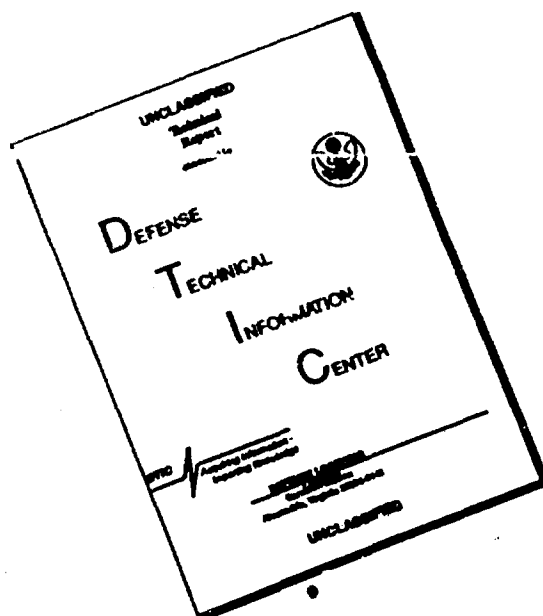
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## THE U.S. GOVERNMENT TECHNICAL REPORT AND THE TRANSFER OF FEDERALLY FUNDED AEROSPACE R & D \*

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**Abstract** — This article discusses the U.S. government technical report and the transfer of federally funded aerospace research and development in a conceptual framework of the federal government as a producer of scientific and technical information. The article summarizes current literature and research and discusses U.S. government technical report use and the importance of using data obtained from the NASA/DoD Aerospace Knowledge Diffusion Research Project. The authors make a case for changing existing U.S. technology policy and present a research agenda for the U.S. government technical report.

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### INTRODUCTION

The U.S. aerospace industry is the nation's leading exporter, sending abroad products worth \$38 billion in 1990 to 135 countries around the world. Aerospace produces the largest trade surplus of any U.S. industry (\$26 billion in 1990), which significantly reduces the U.S. trade deficit. In short, the U.S. aerospace industry is a national and global leader and a critical element of the U.S. economy. However, this industry, in particular the commercial aviation sector, is in the midst of profound change created by a combination

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of domestic and international circumstances. While the implications of the change are of national importance, the implications are not well understood [1].

The U.S. aerospace industry, principally the commercial aviation sector, exhibits certain characteristics that make it unique among U.S. industries. First, the U.S. aerospace sector leads all other industries in expenditures for research and development. Second, "total factor productivity in this [the commercial aviation sector] industry has grown more rapidly than in virtually any other U.S. industry during the postwar period" [2]. Third, the aerospace industry, in particular the commercial aviation sector, is characterized by the high degree of systemic complexity and uncertainty embodied in its products. Aerospace companies appear to be unique in their use of information to overcome the adverse consequences of technological and marketplace uncertainty. Fourth, the commercial aviation sector of the U.S. aerospace industry has been the beneficiary of federally funded research and development (R & D) for nearly a century. "The commercial aircraft industry is virtually unique among U.S. manufacturing industries in that a federal research organization, the National Advisory Committee for Aeronautics (NACA), and subsequently the National Aeronautics and Space Administration (NASA), has for many years conducted and funded research on airframe and propulsion technologies" [3]. The U.S. government technical report is a primary means by which the results of this research are transferred to the aerospace community.

There is, however, some historical, but little empirical, evidence to support the claim that U.S. government technical reports have played a major role in transferring federally funded aerospace R & D. Roland points out that "the NACA published more than 16,000 technical reports which were sought after and exploited by aeronautical engineers [and scientists] throughout the U.S. and abroad" [4]. Many of these reports are classics in the field of aerodynamics and are still used and referenced [5]. The simple truth is, however, that little is known about the role and impact of U.S. government technical reports in terms of their use, importance, and value vis-à-vis the transfer of federally funded aerospace R & D, technological innovation, and productivity.

In an attempt to establish a "body of knowledge" useful for policy formulation and technology management, the role of the U.S. government technical report in the diffusion of federally funded aerospace R & D is being investigated as part of the "NASA/DoD Aerospace Knowledge Diffusion Research Project." This four-phase project is providing descriptive and analytical data regarding the diffusion of aerospace knowledge at the individual, organizational, national, and international levels. It is examining both the channels used to communicate and the social system of the aerospace knowledge diffusion process. Phase 1 investigates the information-seeking behavior of U.S. aerospace engineers and scientists and places particular emphasis on their use of federally funded aerospace R & D and U.S. government technical reports. Phase 2 examines the industry-government interface and emphasizes the role of information intermediaries in the aerospace knowledge diffusion process. Phase 3 concerns the academic-government interface and focuses on the relationship among the information intermediary, faculty, and student. Phase 4 explores the information-seeking behavior of non-U.S. aerospace engineers and scientists in selected countries [6].

This article places the U.S. government technical report in a conceptual framework of the federal government as a producer of scientific and technical information (STI). The article summarizes the literature and research relevant to U.S. government technical reports. It examines the existing federal STI transfer mechanism and explores its limitations. Last, this article presents selected results pertaining to U.S. government technical reports from Phase 1 of the Project.

## BACKGROUND

The federal government has been involved in producing and transferring STI for nearly 200 years. Traditionally, the federal government has limited itself to activities either directly or explicitly tied to an existing responsibility of a specific government agency. Major changes in that involvement have usually coincided with times of crisis and military conflict.

World War II resulted in an expanded federal role in science and technology and signaled the "beginning of the era in which it was assumed that the government had the primary responsibility to support and control STI" [7]. The primary argument for this assumption stems from the role of the federal government as a major funder of R & D and the corresponding need for a uniform federal approach to transferring the results of federally funded R & D.

The post-World War II period marked a sharp departure from the role previously played by the federal government in science and technology with respect to financial support for research not directly or explicitly tied to a specific federal agency or program. "In spite of the permissive implications of the 'general welfare' clause of the U.S. Constitution, federal support for science and technology prior to World War II had been limited sharply by a strict interpretation of the role of the government" [8]. Rosenberg provides the following historical note:

What has emerged since the Second World War is a system in which the federal government has become the dominant purchaser of R & D, but without, at the same time, becoming the dominant performer of R & D. Thus, the unique institutional development has been the manner in which the federal government has accepted a vastly broadened financial responsibility for R & D without arranging simultaneously for its in-house performance. Rather, private industry has become the main performer of federal R & D, and the university community the main performer of the basic research component. Thus, the enlarged role of the federal government in the support of R & D has been carried out within an institutional framework dominated by contractual relationships between the federal and private performers [9].

According to Teich, the successful completion of such large-scale endeavors as the Manhattan Project "ushered in the age of truly big science. Also, it shaped the postwar imagination about the more constructive possibilities of science [and technology] when it could be applied in an organized and systematic way to the pursuit of human goals" [10]. Further justification for federally funded science and technology follows the argument advanced in *Science: The Endless Frontier* [11] that government funded research in science and technology serves as a means to improve health, defend the nation, fuel economic growth, and provide jobs in new industries. Events such as the Korean War and the launch of Sputnik, the increased use of science and technology by the federal government to solve social problems in the late 1960s and 1970s, the energy crisis, the "war on cancer," the Vietnam War, and, more recently, a widening concern over the apparent decline in U.S. international competitiveness account for the growth of federally funded research in science and technology [12].

The post-World War II expansion of the federal government into science and technology resulted in significant changes in STI activities in the United States. These changes, which were necessary to handle the increased production of federally funded R & D, included new methods of publishing, disseminating, storing, and retrieving STI. According to Adkinson, "a significant change occurred during this period in the way the results of federally funded research were disseminated. In the past, there had been almost complete reliance

on dissemination through traditional journals and monographs; now, with the growth of federally funded science and technology, the use of the U.S. government technical report became widespread" [13]. According to McClure, U.S. government technical reports "may constitute the single most important storehouse of R & D results in the world. These reports are a primary means by which the results of federally funded R & D are made available to the scientific and technical (S & T) community" [14].

## THE U.S. GOVERNMENT TECHNICAL REPORT

Although they have the potential for stimulating technological innovation and improving productivity and economic competitiveness, U.S. government technical reports may not be utilized because of limitations in the existing transfer mechanism. According to Ballard, the current system "virtually guarantees that much of the federal investment in creating STI will not be paid back in terms of tangible products and innovations." He further states that "a more active and coordinated role in STI transfer is needed at the federal level if technical reports are to be better utilized" [15].

### *Characteristics of Technical Reports*

The definition of the technical report varies because the report serves different roles in communication within and between organizations. The technical report has been defined etymologically, according to report content and method; behaviorally [16], according to the influence on the reader [17]; and rhetorically, according to the function of the report within a system for communicating STI [18]. The boundaries of technical report literature are difficult to establish because of wide variations in the content, purpose, and audience being addressed. The nature of the report—whether it is informative, analytical, or assertive—contributes to the difficulty.

Fry points out that technical reports are heterogeneous, appearing in many shapes, sizes, layouts, and bindings [19]. According to Smith, "Their formats vary; they might be brief (two pages) or lengthy (500 pages). They appear as microfiche, computer printouts or vugraphs, and often they are loose leaf (with periodic changes that need to be inserted) or have a paper cover, and often contain foldouts. They slump on the shelf, their staples or prong fasteners snag other documents on the shelf, and they are not neat" [20].

Technical reports may exhibit some or all of the following characteristics:

- Publication is not through the publishing trade.
- Readership/audience is usually limited.
- Distribution may be limited or restricted.
- Content may include statistical data, catalogs, directions, design criteria, conference papers and proceedings, literature reviews, or bibliographies.
- Publication may involve a variety of printing and binding methods [21].

The SATCOM report lists the following characteristics of the technical report:

- It is written for an individual or organization that has the right to require such reports.
- It is basically a stewardship report to some agency that has funded the research being reported.
- It permits prompt dissemination of data results on a typically flexible distribution basis.
- It can convey the total research story, including exhaustive exposition, detailed tables, ample illustrations, and full discussion of unsuccessful approaches [22].

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

The development of the technical report as a major means of communicating the results of R & D, according to authorities such as Godfrey and Redman [23], dates back to 1941 and the establishment of the U.S. Office of Scientific Research and Development (OSRD). The growth of the U.S. government technical report coincides with the post-World War II era and the expanding role of the federal government in science and technology. However, U.S. government technical reports have existed for some period of time. The Bureau of Mines *Reports of Investigation* [24], the *Professional Papers of the United States Geological Survey*, and the *Technological Papers of the National Bureau of Standards* [25] are early examples of U.S. government technical reports. The first U.S. government publications identified as technical reports may have been those published by the NACA.

Auger states that "the history of technical report literature in the U.S. coincides almost entirely with the development of aeronautics, the aviation industry, and the creation of the NACA, which issued its first report in 1917" [26]. In her study, *Information Transfer in Engineering*, Shuchman [27] reports that 75 percent of the engineers surveyed used technical reports; that technical reports were important to engineers doing applied work; and that aerospace engineers, more than any other group of engineers, referred to technical reports. However, in many of these studies, as is the case in Shuchman's study, it is often unclear whether U.S. government technical reports, non-U.S. government technical reports, or both are included [28].

The U.S. government technical report is a primary means by which the results of federally funded R & D are made available to the S & T community and are added to the literature of science and technology [29]. McClure points out that "although the [U.S.] government technical report has been variously reviewed, compared, and contrasted, there is no real knowledge base regarding the role, production, use, and importance [of this information product] in terms of accomplishing this task" [30]. Analyses of the literature support the following conclusions regarding U.S. government technical reports:

- The body of available knowledge is simply inadequate and noncomparable to determine the role played by the U.S. government technical report in transferring the results of federally funded R & D.
- Further, most of the available knowledge is largely anecdotal, is limited in scope and dated, and is unfocused in the sense that it lacks a conceptual framework.
- The available knowledge does not lend itself to developing "normalized" answers to questions regarding U.S. government technical reports [31].

### **THE TRANSFER OF FEDERALLY FUNDED R & D**

Three models or approaches have dominated the *transfer* of federally funded R & D [32]. Although variations of the models have been tried, federal STI transfer activities continue to be driven by a *supply-side*, dissemination model. Scholars such as Branscomb argue, however, that this approach and the *trickle-down* benefits associated with the funding of basic research and mission-oriented R & D are inadequate in terms of stimulating technological innovation and competitiveness [33]. Branscomb advocates the adoption of a "Diffusion Oriented U.S. Technology Policy" to gain a competitive advantage in the emerging global economy [34].

#### *Three Transfer Models*

The "appropriability model," which is the oldest of applicable models, emphasizes the production by the federal government of knowledge that would not otherwise be produced

by the private sector and competitive market pressures to promote the use of that knowledge. This model emphasizes the production of basic research as the driving force behind technological development and economic growth and assumes that the federal provision of R & D will be rapidly assimilated by the private sector. Deliberate transfer mechanisms and intervention by information intermediaries are viewed as unnecessary. Appropriability emphasizes the supply (production) of knowledge in sufficient quantity to attract potential users. Good technologies, according to this model, sell themselves and offer clear policy recommendations regarding federal priorities for improving technological development and economic growth. This model incorrectly assumes that the results of federally funded R & D will be acquired and used by the private sector, ignores the fact that most basic research is irrelevant to technological innovation, and dismisses the process of technological innovation within the firm.

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

The "knowledge diffusion model" is grounded in theory and practice associated with the diffusion of innovation and planned change research and the clinical models of social research and mental health. Knowledge diffusion emphasizes *active* intervention as opposed to dissemination and access; stresses intervention and reliance on interpersonal communications as a means of identifying and removing interpersonal barriers between users and producers; and assumes that knowledge production, transfer, and use are equally important components of the R & D process. This approach also emphasizes the link between producers, transfer agents, and users and seeks to develop user-oriented mechanisms (e.g., products and services) specifically tailored to the needs and circumstances of the user. It makes the assumption that the results of federally funded R & D will be underutilized unless they are relevant to users and ongoing relationships are developed among users and producers. The problem with the knowledge diffusion model is that (1) it requires a large federal role and presence and (2) it runs contrary to the dominant assumptions of the established federal R & D policy system. Although U.S. technology policy efforts rely on a dissemination-oriented approach to STI transfer, other industrialized nations, such as Germany and Japan, are adopting diffusion-oriented policies that increase the power to absorb and employ new technologies productively [35].

#### *The U.S. Government Technical Report and the Transfer of Federally Funded Aerospace STI*

A model depicting the transfer of federally funded aerospace R & D through the U.S. government technical report appears in Figure 1. The model is composed of two parts—the "informal," which relies on collegial contacts, and the "formal," which relies on surrogate



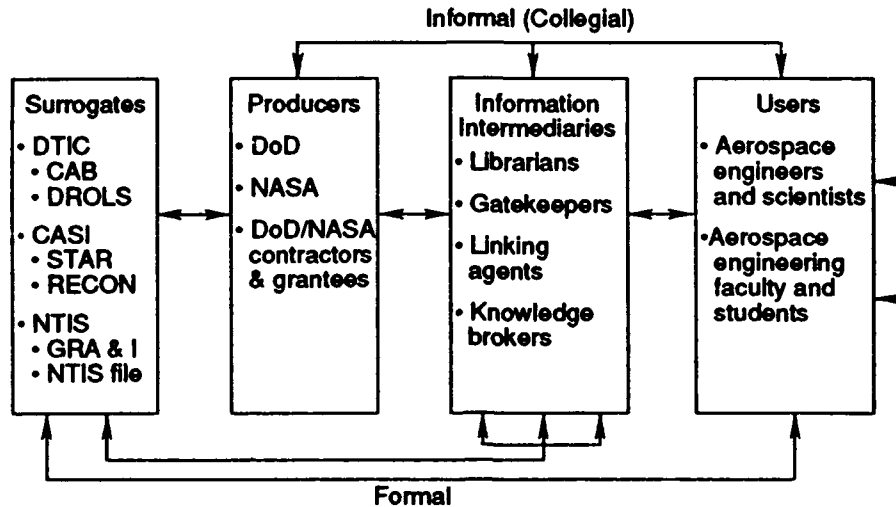


Figure 1. The U.S. Government technical report in a model depicting the dissemination of federally funded aerospace R & D.

information products and information intermediaries to complete the “producer-to-user” transfer process.

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

Surrogates serve as technical report repositories or clearinghouses for the producers and include the Defense Technical Information Center (DTIC), the NASA Center for AeroSpace Information (CASI), and the National Technical Information Service (NTIS). These surrogates have created a variety of technical report announcement journals such as CAB (Current Awareness Bibliographies), STAR (Scientific and Technical Aerospace Reports), Government Reports Announcement and Index (GRA&I), and computerized retrieval systems such as DROLS (Defense RDT&E Online System) and RECON (REmote CONsole) that permit online access to technical report databases. Information intermediaries are, in large part, librarians and technical information specialists in academia, government, and industry. Those representing the producers serve as what McGowan and Loveless describe as “knowledge brokers” or “linking agents” [36]. Information intermediaries connected with users act, according to Allen, as “technological entrepreneurs” or “gatekeepers” [37]. The more “active” the intermediary, the more effective the transfer process becomes [38]. Active intermediaries take information from one place and move it to another, often face-to-face. Passive information intermediaries, on the other hand, “simply array information for the taking, relying on the initiative of the user to request or search out the information that may be needed” [39].

The overall problem with the total federal STI system is that “the present system for transferring the results of federally funded STI is passive, fragmented, and unfocused” [40]. Effective knowledge transfer is hindered by the fact that the federal government “has no coherent or systematically designed approach to transferring the results of federally funded R & D to the user” [41]. In their study of issues and options in federal STI, Bikson and her colleagues found that many of the interviewees believed “dissemination activities were afterthoughts, undertaken without serious commitment by federal agencies

whose primary concerns were with [knowledge] production and not with knowledge transfer"; therefore, "much of what has been learned about [STI] and knowledge transfer has not been incorporated into federally supported information transfer activities" [42].

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

Two problems exist with the formal part of the system. First, the formal part of the system employs one-way, source-to-user transmission. The problem with this kind of transmission is that such formal, one-way, supply-side transfer procedures do not seem to be responsive to the user context [43]. Rather, these efforts appear to start with an information system into which the users' requirements are retrofitted [44]. The consensus of the findings from the empirical research is that interactive, two-way communications are required for effective information transfer [45].

Second, the formal part of the system relies heavily on information intermediaries to complete the knowledge transfer process. However, a strong methodological base for measuring or assessing the effectiveness of the information intermediary is lacking [46]. In addition, empirical findings on the effectiveness of information intermediaries and the role(s) they play in knowledge transfer are sparse and inconclusive. The impact of information intermediaries is likely to be strongly conditional and limited to a specific institutional context. Furthermore, according to Roberts and Frohman, most federal approaches to knowledge utilization have been ineffective in stimulating the diffusion of technological innovation. They claim that the numerous federal STI programs are "highest in frequency and expense yet lowest in impact" and that federal "information dissemination activities have led to little documented knowledge utilization" [47]. Roberts and Frohman also note that "governmental programs start to encourage utilization of knowledge only after the R & D results have been generated" rather than during the idea development phase of the innovation process [48]. David [49], Mowery [50], and Mowery and Rosenberg [51] conclude that successful [federal] technological innovation rests more with the transfer and utilization of knowledge than with its production. Critiquing federal innovation policy, David states that "innovation has become our cherished child, doted upon by all concerned with competitiveness; whereas diffusion has fallen into the woeful role of Cinderella" [52].

### **THE TRANSFER OF FEDERALLY FUNDED AEROSPACE R & D AND U.S. GOVERNMENT TECHNICAL REPORTS**

Data regarding U.S. government technical reports and U.S. aerospace engineers and scientists presented here were obtained as a Phase I activity of the NASA/DoD Aerospace Knowledge Diffusion Research Project. Two self-administered mail questionnaires, sent to members of the American Institute of Aeronautics and Astronautics (AIAA), were used for data collection. Study 1 was exploratory and investigated several aspects of technical communication in aerospace and was used to validate questions used in Study 2 [53]. Study 2 investigated the relationship between the use of U.S. government technical reports

and selected institutional and sociometric variables [54]. The data from both studies were analyzed using SPSS (SPSS, Inc., Chicago, IL), a statistical software package.

The sample frame for Study 1 consisted of approximately 25,000 AIAA members with U.S. mailing addresses and academic, government, or industrial affiliations. Simple random sampling was used to select 2,000 individuals from the sample frame to participate in the survey. Three hundred fifty-three (353) usable questionnaires (a 30 percent response rate) were received by the established cutoff date. The 30 percent response rate is reasonable in that Study 1 was exploratory and, therefore, not considered to be either conclusive or representative. The study spanned the period from July 1988 to November 1988 [55].

The approximately 34,000 members of the AIAA served as the population for Study 2. The sample frame consisted of 6,781 AIAA members (1 out of 5) who resided in the U.S. and who were employed in academia, government, and industry. Systematic sampling was used to select 3,298 members from the sample frame to participate in the study. Two thousand and sixteen (2,016) usable questionnaires (a 70 percent response rate) were received by the established cutoff date. The study spanned the period from May 1989 to June 1990 [56].

### *Use and Importance of U.S. Government Technical Reports*

Researchers such as Ballard and McClure speculate that U.S. government technical reports may not be well utilized [57]. The reasons given for underutilization include the limitations of the federal STI dissemination system, uneven technical quality due to lack of peer review, and a general lack of awareness on the part of users.

The discussion to follow is limited to the U.S. aerospace industry and U.S. aerospace engineers and scientists. Given the unique and long-standing relationship between the U.S. aerospace industry and the federal government, it is assumed that U.S. government technical reports would be used by and should be important to U.S. aerospace engineers and scientists. Underutilization, of course, is a subjective measure. A 70 percent use rate was established as the benchmark for underutilization; below 70 percent would represent underutilization. Importance was also compared with use. It was assumed that use and importance were statistically related. In other words, for the assumption to be accepted, a relatively high use rate and a relatively high rate of importance would have to be found.

Within the context of other forms of literature, approximately 78 percent of the participants in Study 1 [58] used NASA technical reports. In Study 2 [59], approximately 97 percent of the respondents used U.S. government technical reports. Study 2 [60] participants were asked to indicate the number of times they had used each of the four information products during a six-month period in the performance of their professional duties (Table 1). Data are presented both as means and medians. On the average, in-house technical

Table 1. Frequency of use of technical information products

| Information product               | Average number of times (median)<br>product used in 6-month period for<br>respondents in— |                              |                        | Overall average<br>number of times<br>(median)<br>product used<br>(n = 1839) | Total<br>respondents |
|-----------------------------------|-------------------------------------------------------------------------------------------|------------------------------|------------------------|------------------------------------------------------------------------------|----------------------|
|                                   | Academia<br>(n = 341)                                                                     | Govern-<br>ment<br>(n = 454) | Industry<br>(n = 1044) |                                                                              |                      |
| Conference-Meeting papers         | 17.98 (7.00)                                                                              | 13.41 (4.00)                 | 9.23 (4.00)            | 12.02 (4.00)                                                                 | 1527                 |
| Journal articles                  | 26.60 (10.00)                                                                             | 15.41 (5.00)                 | 9.99 (4.00)            | 14.74 (5.00)                                                                 | 1503                 |
| In-house technical reports        | 9.22 (5.00)                                                                               | 17.91 (6.00)                 | 23.91 (8.00)           | 20.30 (6.00)                                                                 | 1535                 |
| U.S. government technical reports | 10.01 (5.00)                                                                              | 12.41 (5.00)                 | 11.49 (4.00)           | 11.45 (5.00)                                                                 | 1495                 |

reports are used to a much greater extent than are the remaining three information products. Conference/meeting papers and journal articles are used to a far greater extent by academically affiliated participants. In-house technical reports are used to a far greater extent by government- and industry-affiliated participants. The average use of U.S. government technical reports is about equal for all three groups.

The 22 percent of the participants in Study 1 were asked to indicate, from a list of choices, their reason for not using NASA technical reports. Reasons for nonuse, in decreasing order of frequency, include (1) not relevant to my research, (2) not used in my discipline, and (3) not available or accessible. Study 1 participants who use NASA technical reports (78 percent) were asked how they usually use them. The responses, which appear in Table 2, show that NASA technical reports serve three general purposes: education/professional development, research, and management. Approximately 64 percent indicate that they use NASA technical reports for research purposes, while about 16 percent indicate that they use NASA technical reports for education/professional development [61].

Few studies have focused exclusively on U.S. government technical reports. King conducted a study designed to determine the value of the Department of Energy database [62]. Roderer conducted a similar study to determine the use and value of Defense Technical Information Center (DTIC) products and services [63]. Both studies included questions on the "use" of U.S. government technical reports. A comparison of data from Study 1 [64] with data from the King [65] and Roderer [66] studies on U.S. government technical report use appears in Table 3.

A comparison of the data from the King [67] and Roderer [68] studies indicates very similar patterns for the use of Department of Defense technical reports (57 percent) and Department of Energy technical reports (58 percent) that are used primarily for research. To a lesser extent they are used for educational purposes (32 and 31, percent respectively), and for management (9 and 11 percent respectively). NASA technical reports, by comparison, were used to a greater extent for research (78 percent), followed by educational purposes (17 percent), and for management (only 5 percent).

Using a 5-point scale, Study 2 participants noted the importance of the four information products (Table 4). Of the four information products, the overall mean importance rating is highest for in-house technical reports.

The overall mean importance rating, although lower, does not differ considerably for conference-meeting papers, journal articles, and U.S. government technical reports. Statistically, academically affiliated respondents attribute a higher importance rating to conference-meeting papers and journal articles. Government- and industry-affiliated respondents attribute a higher importance rating to in-house technical reports. (It is assumed that

Table 2. Use of NASA technical reports

| Use                                                                  | Number | Percentage |
|----------------------------------------------------------------------|--------|------------|
| Apply findings to current project(s)                                 | 114    | 41.9       |
| Apply methodology to current project(s)                              | 61     | 22.5       |
| To prepare a research proposal                                       | 10     | 3.7        |
| To prepare a conference paper/journal article/technical report       | 14     | 5.1        |
| As a citation in a conference paper/journal article/technical report | 14     | 5.1        |
| Personal/professional development                                    | 44     | 16.2       |
| To prepare a lecture/presentation                                    | 2      | 0.7        |
| To plan, budget, or manage research                                  | 13     | 4.8        |
| Totals                                                               | 272    | 100.0      |

Table 3. Use of U.S. government technical reports by engineers and scientists

| Categories                                                                | NASA      |            | Department of Defense |            | Department of Energy |            |
|---------------------------------------------------------------------------|-----------|------------|-----------------------|------------|----------------------|------------|
|                                                                           | Number    | Percentage | Number                | Percentage | Number               | Percentage |
| Educational                                                               |           |            |                       |            |                      |            |
| Self—For professional development, current awareness, or general interest | 44        |            | 74                    |            | 75                   |            |
| Others—In preparation of a lecture or presentation                        | <u>2</u>  |            | <u>39</u>             |            | <u>40</u>            |            |
|                                                                           | 46        | 17         | 113                   | 32         | 115                  | 31         |
| Research                                                                  |           |            |                       |            |                      |            |
| In preparation of a research proposal                                     | 10        |            | 27                    |            | 38                   |            |
| To apply its findings to a current project                                | 114       |            | 75                    |            | 77                   |            |
| To apply its methodology to a current project                             | 61        |            | 53                    |            | 50                   |            |
| In preparation of an article, book, review, or report                     | 14        |            | —                     |            | —                    |            |
| As a citation in an article, book, review, or report                      | <u>14</u> |            | <u>50</u>             |            | <u>48</u>            |            |
|                                                                           | 213       | 78         | 205                   | 57         | 213                  | 58         |
| Management                                                                |           |            |                       |            |                      |            |
| For the planning, budgeting, and management of research                   | <u>13</u> |            | <u>33</u>             |            | <u>40</u>            |            |
|                                                                           | 13        | 5          | 33                    | 9          | 40                   | 11         |
| Other                                                                     | —         |            | <u>6</u>              |            | —                    |            |
|                                                                           |           |            | 6                     | 2          |                      |            |
| Totals                                                                    | 272       | 100        | 357                   | 100        | 368                  | 100        |

government-affiliated respondents probably view U.S. government technical reports as synonymous with in-house technical reports.)

The data indicate that U.S. government technical reports are used, with the majority of NASA technical reports being used for research. Reasons given for nonuse are understandable. NASA technical reports are important to U.S. aerospace engineers and scientists in the performance of their professional duties. A positive and significant correlation coefficient (Pearson  $r = 0.175$ ), although low, is found when NASA technical report use and importance are compared. Collectively, these data support the argument that NASA technical reports are not underutilized. To the contrary, these reports are used, they are important to the U.S. aerospace community, and they do play a significant role in transferring the results of federally funded aerospace R & D to the aerospace community.

Table 4. Importance of technical information products

| Information product               | Average <sup>a</sup> (mean) importance rating in — |                      |                     | Overall average (mean) importance rating (n = 1839) | Total respondents |
|-----------------------------------|----------------------------------------------------|----------------------|---------------------|-----------------------------------------------------|-------------------|
|                                   | Academia (n = 341)                                 | Government (n = 454) | Industry (n = 1044) |                                                     |                   |
| Conference-Meeting papers         | 4.04                                               | 3.64                 | 3.31                | 3.53                                                | 1777              |
| Journal articles                  | 4.35                                               | 3.49                 | 3.26                | 3.52                                                | 1775              |
| In-house technical reports        | 3.02                                               | 3.98                 | 4.05                | 3.84                                                | 1766              |
| U.S. government technical reports | 3.45                                               | 3.73                 | 3.44                | 3.51                                                | 1778              |

<sup>a</sup> A 1- to 5-point scale was used to measure importance, with 1 being the lowest possible importance and 5 being the highest possible importance. Hence, the higher the average (mean), the greater the importance of the product.

### *Factors Affecting Use of U.S. Government Technical Reports*

The relevant literature overwhelmingly favors accessibility as the single most important (variable) determinant of use. Buckland cites accessibility as an area for "potentially productive future research in order to better understand the dynamics of why and how information services come to be used" [69]. Gerstberger and Allen report that among R & D engineers, accessibility rather than technical quality influenced use [70]. Gerstberger and Allen state, "There is apparently some relationship between their perceptions of technical quality and channel accessibility, but it is the accessibility component that almost exclusively determines frequency of use" [71]. Rosenberg, in a study of research and nonresearch personnel in industry and government, finds that both groups exhibited similar information-seeking behavior. Of the eight variables investigated by Rosenberg, both groups indicate that accessibility had the greatest influence on information use [72].

Orr, on the other hand, disagrees, stating that quality of information was the most important consideration in selecting an information product, service, or source [73]. Although this proposition has not been subjected to empirical verification, some evidence supports Orr's position. In his study of the use of technical information in engineering problem solving, Kaufman reports that engineers identified technical quality or reliability followed by relevance as the criteria for selecting the most useful information source [74]. However, accessibility appears to be the most frequently used factor in selecting an information source, even if that source proved to be the least useful.

Given the results of the related research and literature, it appears that accessibility is the single most important factor or determinant of use. It is, therefore, hypothesized that the influence of accessibility on information use in general would carry over to U.S. government technical reports. The Study 2 participants who used U.S. government technical reports were asked to indicate the extent to which seven sociometric factors influenced their use of them (Table 5).

In terms of organizational affiliation, relevance exerts the greatest influence on the use of U.S. government technical reports by academics, followed by technical quality or reliability and accessibility. Relevance, followed by accessibility and technical quality or reliability, exerts the greatest influence on the use of U.S. government technical reports by government-affiliated U.S. aerospace engineers and scientists. Relevance, followed by technical quality or reliability and accessibility, exerts the greatest influence on use by the industry-affiliated survey respondents.

Table 5. Factors affecting the use of U.S. government technical reports

| Selection factor                 | Average <sup>a</sup> (mean) influence of factor on use for respondents in – |                      |                     | Overall average (mean) influence of factor (n = 1839) | Total respondents |
|----------------------------------|-----------------------------------------------------------------------------|----------------------|---------------------|-------------------------------------------------------|-------------------|
|                                  | Academia (n = 341)                                                          | Government (n = 454) | Industry (n = 1044) |                                                       |                   |
| Accessibility                    | 3.72                                                                        | 3.81                 | 3.54                | 3.65                                                  | 1576              |
| Ease of use                      | 3.36                                                                        | 3.58                 | 3.28                | 3.38                                                  | 1573              |
| Expense                          | 2.72                                                                        | 2.47                 | 2.45                | 2.51                                                  | 1569              |
| Familiarity or experience        | 3.62                                                                        | 3.64                 | 3.42                | 3.52                                                  | 1575              |
| Technical quality or reliability | 3.80                                                                        | 3.77                 | 3.68                | 3.73                                                  | 1581              |
| Comprehensiveness                | 3.57                                                                        | 3.65                 | 3.49                | 3.55                                                  | 1514              |
| Relevance                        | 3.87                                                                        | 4.03                 | 3.84                | 3.90                                                  | 1577              |

<sup>a</sup> A 1- to 5-point scale was used to measure influence with 1 being the lowest possible influence and 5 being the highest possible influence. Hence, the higher the average (mean), the greater the influence of the product.

Based on these data, relevance, technical quality or reliability, and accessibility all appear to be important determinants of the overall use of U.S. government technical reports. Of these, relevance, rather than accessibility, appears to be the single most important determinant of the overall extent to which U.S. aerospace engineers and scientists use U.S. government technical reports. These data also suggest, however, that these variables vary in importance relative to each other, depending on the particular product and type of user. This suggests that certain products tend to be used to satisfy certain work-related needs, and that these needs distinguish types of users. For example, the need of U.S. aerospace engineers and scientists in academia for materials of high technical quality may determine their relatively frequent use of journal articles.

### *Information-Seeking Behavior and U.S. Government Technical Reports*

A review of the literature reveals certain general characteristics about the information-seeking behavior of engineers [75]. They are not interested in guides to the literature nearly so much as they are in reliable answers to specific questions. They prefer informal sources of information, especially conversations with individuals within their organization [76]. Engineers may have psychological traits that predispose them to solve problems alone or with the help of colleagues rather than seeking answers in the literature [77]. According to Allen, "engineers like to solve their own problems by drawing on past experiences, using the trial and error method, and asking colleagues known to be efficient and reliable instead of searching or having someone search the literature for them" [78]. Engineers seldom use information services that are directly oriented to them. When they use a library, it is more in a personal search mode, generally not involving the professional (but "nontechnical") librarian [79].

To the extent that a generalization can be formed, U.S. engineers in general and the U.S. aerospace engineers and scientists in these studies [80] appear to be a relatively homogeneous group in terms of their information-seeking behavior. Their search strategy begins with an examination of their personal store of knowledge and includes information kept in the office or workplace. Discussions with coworkers mark the next phase of the strategy, followed by a personal search of formal information products and services in the library or technical information center. If they fail to obtain the needed information, at this point they turn to the librarian or technical information specialist.

Nothing was found in the literature that led to the conclusion that U.S. aerospace engineers' and scientists' approaches to finding out about U.S. government technical reports would be different from their general information-seeking behavior. They would check their personal collection, talk with coworkers, go to the library and look for themselves, and, if all else failed, ask a librarian or technical information specialist.

To test this assumption, Study 2 participants were asked if they had used U.S. government technical reports to complete their most recent technical project, task, or problem. Next, the approximately 65 percent who did use them were asked how they found out about these reports. The responses to this question in Study 2 were compared with the responses to the question in Study 1 concerning the sources used in problem solving. The data used in making the comparison appear in Table 6.

In completing their most important technical project, task, or problem, the U.S. aerospace engineers and scientists in these studies used their personal collection of technical information first, followed by discussions with a coworker or key individuals. Next, they searched the library or a database and, lastly, asked a librarian. The sources used by U.S. aerospace engineers and scientists to find out about U.S. government technical reports

Table 6. Sources used by U.S. aerospace engineers and scientists to solve technical problems and to find out about U.S. government technical reports

| Sources                           | Percentage of respondents |                                   |
|-----------------------------------|---------------------------|-----------------------------------|
|                                   | Problem solving           | U.S. government technical reports |
| Personal store                    | 88.1                      | 83.1                              |
| A coworker in my organization     | 78.8                      | 57.7                              |
| Library search                    | 68.4                      | 49.7                              |
| Colleague outside my organization | 55.6                      | 49.9                              |
| Data base search                  | 53.3                      | 30.5                              |
| My supervisor                     | 49.7                      | 22.8                              |
| Librarian in my organization      | 36.1                      | 27.1                              |

were very similar to those sources used to solve technical problems. Based on these data, it is concluded that the information sources used by U.S. aerospace engineers and scientists in problem solving and those used to find out about U.S. government technical reports are similar.

### U.S. TECHNOLOGY POLICY AND FEDERALLY FUNDED STI

There is far more to stimulating technological innovation, improving economic competitiveness, and transferring the results of federally funded R & D than information dissemination programs [81]. A coordinated information policy and transfer infrastructure are necessary and essential to successful innovation. However, federally funded R & D in and of itself does not successful innovation make. Innovation-adoption decisions are seldom made on the basis of "advances in systemic knowledge of the useful arts," otherwise known as STI. They are, for the most part, investment decisions and are influenced, to a large extent, by monetary and fiscal policy, laws, and regulations. There is general agreement that the United States does not have a well-articulated set of innovation-adoption policy goals, much less a coherent, integrated program directed at attaining such goals [82].

The United States, in fact, has no coherent innovation or technology policy. What the United States does have, however, are "many programs and numerous policies which cut across political jurisdictions and the idiosyncratic missions and mandates of single agencies which are more or less responsive to a series of shifting political alliances and imperatives" [83]. Unlike Japan, which has a managed and centralized approach to R & D, the United States funds R & D using various methods through numerous agencies of the executive branch. Federal R & D activities are undertaken by thousands of engineers and scientists in academia, government, and industry, and receive oversight, but not coordination, from many committees and subcommittees in both the executive and legislative branches of government [84]. Despite the fact that countries such as Germany and Japan have adopted "diffusion-oriented" technology policies, United States technology policy continues to be driven by a supply-side, "mission-oriented" model. Existing federal technology policy is product- not process-oriented; it emphasizes knowledge production but not its transfer and utilization; and it relies on "applications and demonstration" projects for commercializing technology prototyped by the federal government.

There is general agreement among policymakers that the results of federally funded R & D can be used to enhance technological innovation and improve economic competitiveness.



This agreement is based on the results of studies that show a positive relationship between R & D and successful innovation, technical performance, and increased productivity. However, the United States lacks a coherent or systematically designed approach to transferring the results of federally funded R & D to the user [85]. Policy instruments such as the Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96-480), the Federal Technology Transfer Act of 1986 (P.L. 99-502), the Japanese Technical Literature Act of 1986 (P.L. 99-382), and Executive Order (E.O. 12591), "Facilitating Access to Science and Technology" (April 10, 1987), and Office of Management and Budget (OMB) Circular A-130 have shaped the legislative and regulatory environment for federal STI policy.

Excluding Circular A-130, the intent of these instruments is to (1) develop a predominant position for the U.S. in international markets by facilitating technology transfer from government laboratories and (2) provide the inducements for federal engineers and scientists to nurture the transfer process. In addition, some of these instruments provide a mechanism for the collection and dissemination of foreign STI in the U.S. The scope of Circular A-130, which is concerned with the management of information as a resource, includes federal STI. According to OMB, STI conforms to a standard information life cycle and does not exhibit any unique attributes calling for the formation and implementation of a separate information policy framework. Attempts by OMB to regulate STI with a single policy instrument fail to recognize the linkages between federal technology policy and federally funded STI; thus, from a policy standpoint, Circular A-130 negates congressional attempts to promote innovation and competitiveness [86].

A holistic approach to technological innovation and economic competitiveness must be adopted at the federal level. The current "supply-side" dissemination policy emphasizing knowledge production and the "trickle-down" benefits associated with the funding of basic research and mission-oriented R & D are inadequate for developing a much-needed U.S. technology policy. The current approach will simply not restore the United States to a more competitive footing with other industrialized countries. The new approach to U.S. technology policy would be based on the assumption that the production, transfer, and use of STI is inextricably linked to successful technological innovation; that a positive relationship exists between federal attempts to stimulate technological innovation and federally funded STI; that the process of technological innovation is best served by a "knowledge diffusion" based model; and that an STI transfer infrastructure, funded and coordinated as a partnership between American industry, academia, and the federal government, is required for the nation to become competitive in the global market place of the 1990s and beyond. Consequently, federal policy with respect to technological innovation and economic competitiveness would, by definition, include an STI component. In other words, STI policy would be tied to technology policy, not to a generic information policy instrument such as OMB Circular A-130 or to a particular information processing technology.

This approach recognizes the need to maximize the diffusion of federally funded STI and to coordinate federal STI activities using a mechanism similar to the now defunct Committee on Scientific and Technical Information (COSATI). A strong technology policy would commit the United States to building and maintaining a technology infrastructure that includes an STI transfer component based on a knowledge diffusion model. This model should have an "activist" component that emphasizes both domestic and imported STI, and it should be responsive in a "user" context.

U.S. technology policy would view the structure, organization, and management of STI as a strategic resource. The need for more frequent and more effective use of STI

characterizes the strategic version of today's competitive marketplace. STI policy should also reflect this same strategic vision for the following reasons. Information technology is making the same STI available at the same time to all competitors. The marketplace is increasingly characterized by a growing number of stakeholders who are constantly changing. This implies that a broader array of STI will be needed for decision making and that simply providing STI retrieval and access without providing interpretation and analysis is meaningless. The need to provide STI interpretation and analysis is critical because less time is available for making decisions and the half-life of information is getting shorter [87]. Increasing U.S. collaboration with foreign producers will result in a more international manufacturing environment. These alliances will result in a more rapid diffusion of technology, increasing pressure on U.S. companies to push forward with new technological developments and to take steps designed to maximize the inclusion of recent technological developments into the R & D process [88].

Empirically derived knowledge is needed to formulate an appropriate model for developing a holistic and conceptual U.S. technology and STI policy. Policy research is needed to understand the process of technological innovation and the relationship between STI and technological innovation. The existing federal STI transfer mechanism should be studied, and descriptive and analytical data regarding the producer, information intermediary and end-user interfaces should be collected and analyzed.

### **A RESEARCH AGENDA FOR U.S. GOVERNMENT TECHNICAL REPORTS**

Finally, research undertaken as part of an established agenda should be conducted to determine the role and impact of the U.S. government technical report vis-à-vis the transfer of federally funded R & D and technological innovation. The results of this research should be generalizable and would form a basis for the development of theory-based practice as well as a significant body of knowledge that can be used for policy, practice, product, and systems development. Although McClure has developed a research agenda for studying U.S. government technical reports [89], a modest research agenda based on this study is proposed focusing on structural issues.

- I. Previous research regarding U.S. government technical reports is noncumulative, has been variously criticized, and is limited and dated.
  - A. Conduct a critical review, analysis, and evaluation of previous research; identify and remove spurious research findings; and establish a starting point or foundation for "what is known and accepted as fact" vis-à-vis U.S. government technical reports.
  - B. Identify the criticisms and deficiencies of previously used research designs and methodologies and compile the "lessons learned" to guard against committing the same or similar mistakes.
  - C. Consider the lessons learned in the context of existing research designs and methodologies and identify those that correct or compensate for previous mistakes.
- II. Previous research regarding U.S. government technical reports has been limited to a particular system, product, or service in a particular organization or environment. Hence, the results are often confusing, conflicting, and insufficient to form the basis for the development of theory.
  - A. Develop standard definitions, terms, and terminologies.
  - B. Develop, test, and validate research tools, instruments, and techniques.
  - C. Develop a standard set of variables.

- III. What is known about U.S. government technical reports seems not to explain their use and nonuse. Therefore, there is little knowledge that can be used for testing existing paradigms and developing new paradigms.
- A. Conduct research about the U.S. government technical report within a conceptual framework that embraces the production, transfer, use, and management of information. One possible outcome could be the identification of barriers that prohibit or restrict its use.
  - B. Seek to understand the diffusion of knowledge as a precursor to describing and explaining U.S. government technical report use.
  - C. Develop and test hypotheses, the results of which can lead to the formation of theory that can be used to predict U.S. government technical report use.
  - D. Develop a series of experiments, the results of which will lead to the formation of paradigms, models, and radically new conceptualizations of technological innovation, information transfer, and U.S. government technical report use.

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