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NASA/DoD Aerospace Knowledge Diffusion Research Project

Paper Five:

Aerospace Librarians and Technical Information Specialists as Information Intermediaries:
A Report of Phase 2 Activities of the NASA/DoD Aerospace Knowledge Diffusion Research Project

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NASA
National Aeronautics and Space Administration

Department of Defense

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INTRODUCTION

Although the U.S. aerospace industry continues to be the leading positive contributor to the balance of trade among all merchandise industries, it is experiencing significant changes whose implications may not be well understood.[1] Increasing U.S. collaboration with foreign producers will result in a more international manufacturing environment, which will allow for a more rapid diffusion of technology, increasing pressure on U.S. aerospace companies to push forward with new technological developments, and to take steps designed to maximize the inclusion of recent technological developments into the research and development (R&D) process.

To remain a world leader in aerospace, the U.S. must take the steps necessary to improve and maintain the professional competency of aerospace engineers and scientists, and enhance innovation and productivity. How well these objectives are met, and at what cost, depends on a variety of factors, but largely on the ability of aerospace engineers and scientists to acquire and process the results of NASA/DoD funded R&D.

The ability of U.S. aerospace engineers and scientists to identify, acquire, and use scientific and technical information (STI) is of paramount importance to the efficiency of the R&D process. Testimony to the central role of STI in the R&D process is found in numerous studies (Fischer, 1980). These studies show, among other things, that U.S. aerospace engineers and scientists devote more time, on the average, to the communication of technical information than to any other scientific or technical activity (Pinelli, et al., 1989). We concur, therefore, with Fischer's (1980) conclusion that the "role of scientific and technical communication is thus central to the success of the innovation process, in general, and the management of R&D activities, in particular."

The **NASA/DoD Aerospace Knowledge Diffusion Research Project** was developed because, in terms of empirically derived data, very little is known about the diffusion of knowledge in the aerospace industry both in terms of the channels used to communicate the ideas and the information-gathering habits and practices of the members of the social system (i.e., aerospace engineers and scientists). Even less is known about the system through which the results of federally-funded aerospace R&D is diffused throughout the aerospace community. Understanding how STI is communicated through certain channels over time among members of the social system would contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of U.S. aerospace engineers and scientists.

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[1] "Aerospace" includes aeronautics, space science, space technology, and related fields.

PROJECT OVERVIEW

The **NASA/DoD Aerospace Knowledge Diffusion Research Project** is a cooperative effort that is sponsored by NASA, Codes RF and NTT, and the DoD, Office of the Assistant Secretary of the Air Force, Deputy for Scientific and Technical Information. The research project is a joint effort of the Indiana University Center for Survey Research and the NASA Langley Research Center.

The project will provide descriptive and analytical data regarding the flow of STI at the individual, organizational, national, and international levels. It will examine both the channels used to communicate information and the social system of the aerospace knowledge diffusion process. The results of the project should provide useful information to R&D managers, information managers, and others concerned with improving access to and use of STI.

Several major barriers to effective knowledge diffusion exist in the U.S. **First**, the very low level of monetary support for knowledge transfer compared with knowledge production suggests that dissemination efforts are not viewed as an important component of the R&D process. **Second**, there are mounting reports from users about difficulties in getting appropriate information useful for problem solving and decision making. **Third**, rapid advances in many areas of STI knowledge can be fully exploited only if they are quickly translated into further research and application. **Fourth**, current mechanisms are often inadequate to help the user assess the quality of available information. **Fifth**, the characteristics of actual usage behavior are not considered in making available useful and easily retrieved information.

These deficiencies must be remedied if the results of federally funded R&D are to be successfully applied to innovation, problem solving, and productivity. Only by maximizing the R&D process can the U.S. maintain its international competitive edge in aerospace.

Project Assumptions

1. Rapid diffusion of technology and technological developments requires an understanding of the aerospace knowledge diffusion process.

2. Knowledge production, transfer, and utilization are equally important components of the aerospace knowledge diffusion process.

3. Understanding the channels; the information products involved in the production, transfer, and utilization of aerospace information; and the information-seeking habits, practices, and preferences of aerospace engineers and scientists is necessary to understand aerospace knowledge diffusion.

4. The knowledge derived from federally funded aerospace R&D is indispensable in maintaining the vitality and international competitiveness of the U.S. aerospace industry and essential in maintaining and improving the professional competency of U.S. aerospace engineers and scientists.

5. The U.S. government technical report plays an important, but as yet undefined, role in the transfer and utilization of knowledge derived from federally funded aerospace R&D.

6. Librarians, as information intermediaries, play an important, but as yet undefined, role in the transfer and utilization of knowledge derived from federally funded aerospace R&D.

Project Objectives

1. Understanding the aerospace knowledge diffusion process at the individual, organizational, and national levels, placing particular emphasis on the diffusion of federally funded aerospace STI.

2. Understanding the international aerospace knowledge diffusion process at the individual and organizational levels, placing particular emphasis on the systems used to diffuse the results of federally funded aerospace STI.

3. Understanding the roles NASA/DoD technical reports and aerospace librarians play in the transfer and utilization of knowledge derived from federally funded aerospace R&D.

4. Achieving recognition and acceptance within NASA, DoD and throughout the aerospace community that STI is a valuable strategic resource for innovation, problem solving, and productivity.

5. Providing results that can be used to optimize the effectiveness and efficiency of the Federal STI aerospace transfer system and exchange mechanism.

Project Design

The initial thrust of the aerospace knowledge diffusion research project is largely exploratory and descriptive; it focuses on the information channels and the members of the social system associated with the Federal aerospace knowledge diffusion process. It provides a pragmatic basis for understanding how the results of NASA/DoD research diffuse into the aerospace R&D process. Over the long term, the project will provide an empirical basis for understanding the aerospace knowledge diffusion process at the individual, organizational, national, and international levels. An outline of the descriptive portion of the project is contained in Table 1 as "A Five Year Program of Research on Aerospace Knowledge Diffusion."

Table 1. A Five Year Program of Research on Aerospace Knowledge Diffusion

	Phase 1 1989 1991	Phase 2 1990 1992	Phase 3 1990-1991	Phase 4 1991-1994
Level	•National •Individuals •U.S. Aerospace Engineers and Scientists	•National •Individuals and Organizations •Aerospace librarians in gov't and industry •U.S. gov't and aerospace industries	•National •Individuals and Organizations •U.S. academic faculty, students, and engineering libraries	•International •Individuals and Organizations
Focus	•Knowledge production and use	•Knowledge transfer and use	•Knowledge transfer and use	•Knowledge production, transfer, and use
Emphasis	•Use, importance, and production of NASA/DOD STI (e.g., technical reports) •Impediments to access, transfer, and use of NASA/DOD STI •Use and importance of AGARD and non-U.S. STI •Use and importance of information technology •Information sources used in problem solving	•Use, importance, and production of NASA/DOD STI (e.g., technical reports) •Impediments to access, transfer, and use of NASA/DOD STI •Use and importance of AGARD and non-U.S. STI •Use and importance of information technology •Effectiveness of system used to transfer U.S. gov't funded STI	•Use, importance, and production of NASA/DOD STI (e.g., technical reports) •Impediments to access, transfer, and use of NASA/DOD STI •Use and importance of AGARD and non-U.S. STI •Use and importance of information technology •Effectiveness of system used to transfer U.S. gov't funded STI	•Use and importance of NASA/DOD STI •Use of AGARD and non-U.S. STI •Impediments to access, transfer, and use of aerospace STI •Use of information technology •System used to transfer results of gov't funded aerospace STI non-U.S. aerospace STI, and systems, policies, and practices
Subjects	•AIAA membership •SAE membership	•U.S. aerospace librarians in gov't and industry •Selected U.S. gov't facilities and aerospace companies	•U.S. aerospace faculty, academic engineering libraries, and U.S. aerospace students (seniors) in USRA capstone design courses	•RAeS •DGLR •JSASS •aerospace faculties and students •aerospace librarians
Method	•Pilot study •Self-administered mail questionnaires •Telephone follow-ups	•Self-administered mail questionnaires •Personal interviews •Telephone follow-ups	•Self-administered mail questionnaires •Personal interviews •Telephone follow-ups	•Pilot study •Self-administered mail questionnaires
Desired Outcomes	•Understanding of individual information-seeking behaviors of U.S. aerospace engineers and scientists •Explain use/non-use of U.S. gov't funded STI products and services by U.S. aerospace engineers and scientists	•Understanding of the internal flow of aerospace STI in gov't and industry •Understanding of the system used to transfer results of U.S. gov't funded aerospace STI	•Understanding of the internal flow of aerospace STI in academia •Understanding of the system used to transfer results of U.S. gov't funded aerospace STI	•Understanding of individual information-seeking behavior •Understanding of the system used to transfer results of gov't funded aerospace STI •Understanding of non-U.S. aerospace STI systems, policies, and practices

Phase 1 of the 4-phase project is concerned with the information-seeking habits and practices of U.S. aerospace engineers and scientists, with particular emphasis being placed on their use of federally funded aerospace STI products and services. The conceptual model shown in figure 1 assumes a consistent internal logic that governs the information-seeking and processing behavior of aerospace engineers and scientists despite any individual differences they may exhibit.

The results of the **Phase 1 Pilot Study** indicate that U.S. aerospace engineers and scientists spend approximately 65 percent of a 40-hour work week communicating STI. The types of information and the information products used and produced in performing professional duties are similar, with basic STI and in-house technical data most frequently reported. **Internal** STI to the organization, which includes NASA/DoD technical reports, journal articles, and conference/ meeting papers is preferred over **external** STI. Respondents identified informal channels and personalized sources as the primary methods of seeking STI, followed by the use of formal information sources when solving technical problems. Only after completing an informal search, followed by using formal information sources, do they turn to librarians and technical information specialists for assistance.

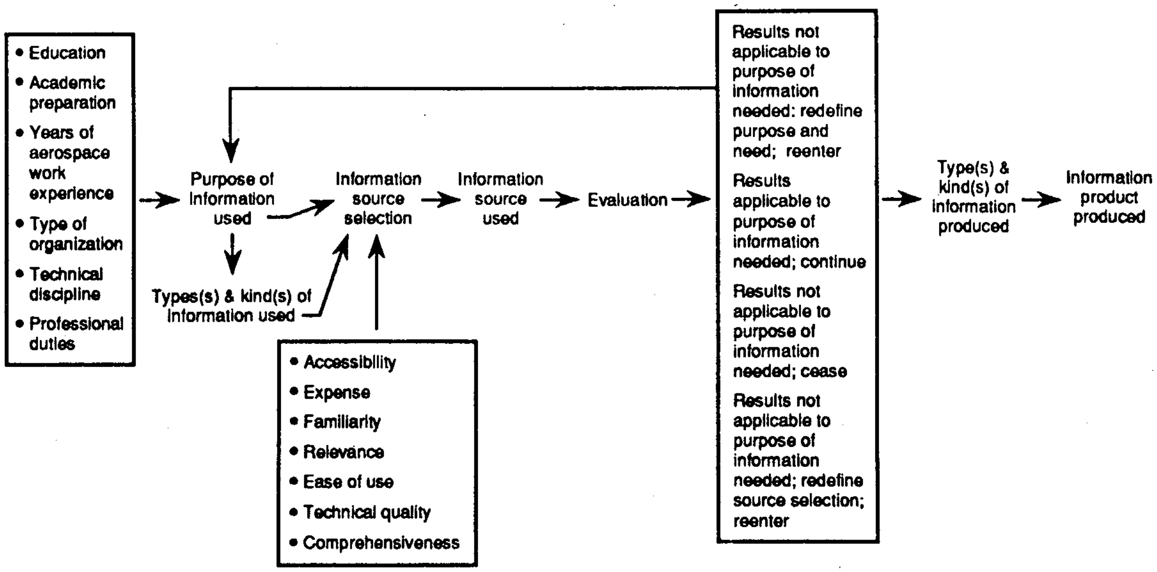

Figure 1. A Conceptual Model for the Use, Transfer, and Production of STI by U.S. Aerospace Engineers and Scientists

Phase 2 focuses on aerospace knowledge transfer and use within the larger social system, placing particular emphasis on the flow of aerospace STI in government and industry and the role of the information intermediary (i.e., the aerospace librarian/technical information specialist) in knowledge transfer. In Phase 2, the process of innovation in the U.S. aerospace industry is conceptualized as an information processing system which must deal with work-related uncertainty through patterns of technical communications. Information processing in aerospace R&D (figure 2) is viewed as an ongoing problem solving cycle involving each activity within the innovation process, the larger organization, and the external world.

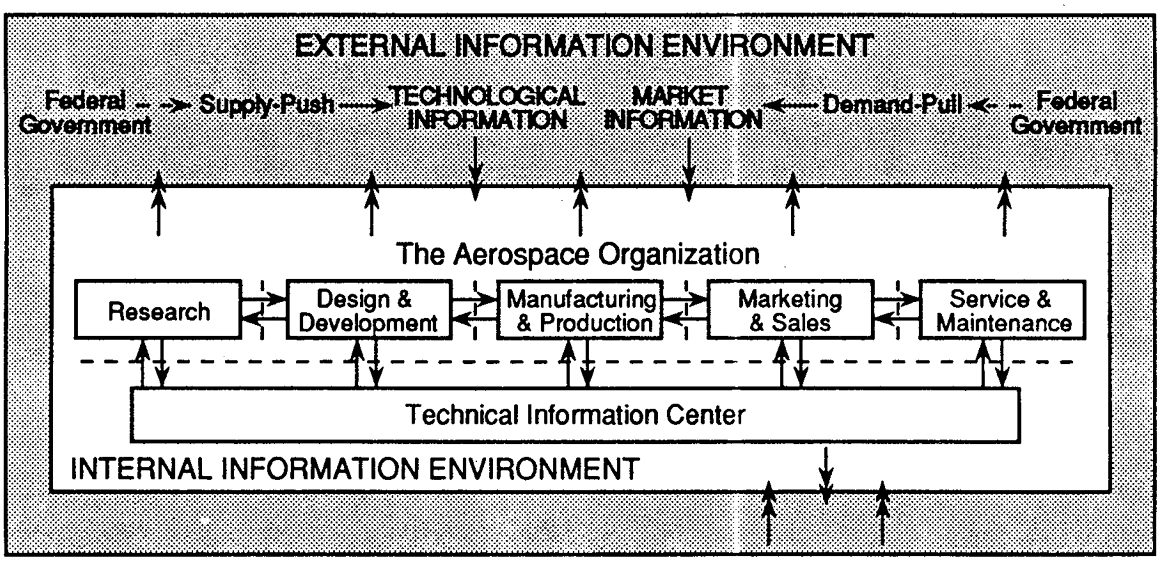

Figure 2. The Aerospace R&D Process as an Information Processing System.

Phase 3 focuses on knowledge use and transfer at the individual and organizational levels in the academic sector of the aerospace community. Faced with shrinking enrollments, particularly at the graduate level, university aerospace programs must find ways to maintain the talent pool that will advance aerospace technological development and guarantee U.S. competitiveness.

Phase 4 examines knowledge production, use, and transfer among non-U.S. individuals and aerospace organizations, specifically in Western Europe and Japan. As U.S. collaboration with foreign aerospace technology producers increases, a more international manufacturing environment will arise, fostering an increased flow of U.S. trade. To cooperate in joint ventures as well as to compete successfully at the international level, U.S. aerospace industries will need to develop methods to collect, translate, analyze, and disseminate the best of foreign aerospace STI.

OVERVIEW OF THE FEDERAL AEROSPACE KNOWLEDGE DIFFUSION PROCESS

A model (figure 3) that depicts the transfer of federally funded aerospace R&D from "producer to user" is composed of two parts -- the **informal** that relies on collegial contacts and the **formal** that relies on surrogates, information products, and information intermediaries to complete the transfer process.

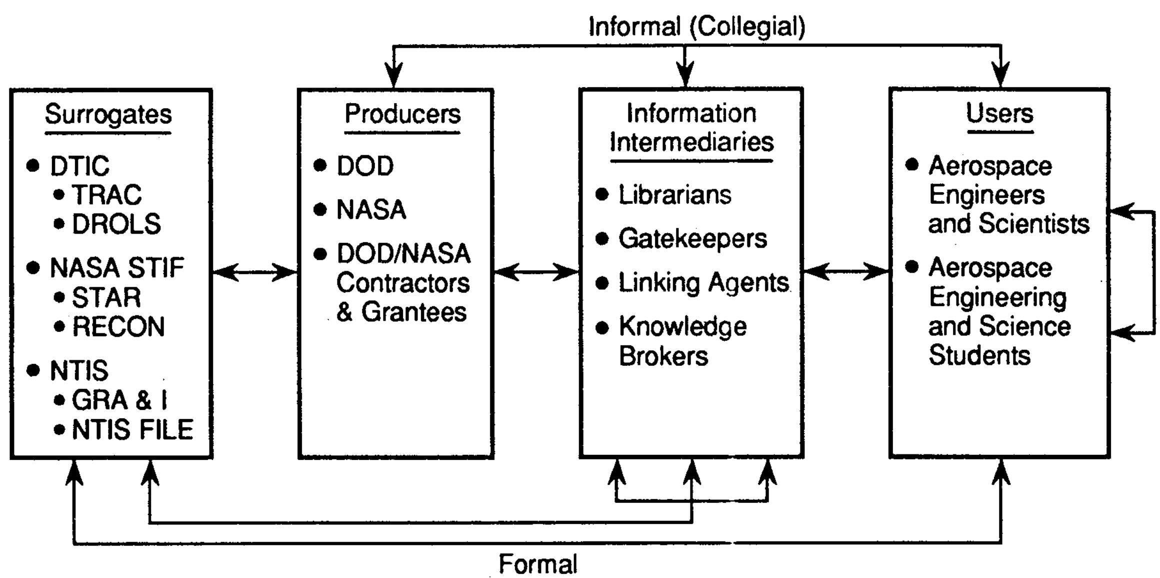

Figure 3. A Model Depicting the Transfer of Federally Funded Aerospace R&D.

Surrogates serve as technical report repositories or clearinghouses for the producers and include the Defense Technical Information Center (DTIC), the NASA Scientific and Technical Information Facility (NASA STIF), and the National Technical Information Service (NTIS). These surrogates have created a variety of technical report announcement journals such as TRAC (Technical Report

Announcement Circular) and STAR (Scientific and Technical Aerospace Reports) and computerized retrieval systems such as DROLS (Defense RDT&E Online System) and RECON (REmote CONsole) that permit online access to technical report databases.

The producers are NASA and the DoD and their contractors and grantees. Producers depend upon surrogates and information intermediaries to complete the knowledge transfer process. When U.S. government 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 individual level.

Information intermediaries are, in large part, librarians and technical information specialists in academia, government, and industry. Information intermediaries represent the producers and serve as what McGowan and Loveless (1981) describe as "knowledge brokers" or "linking agents." The more "active" the intermediary, the more effective the transfer process becomes (Goldhar and Lund, 1985). 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" (Eveland, 1987).

Two problems exist with the **formal** part of the system. First, the **formal** part of the system uses one-way producer-to-user transmission. The problem with this kind of transmission is that such formal one-way "supply side" transfer procedures do not seem to be responsive to the user context (Bikson, et al., 1984). Second, the **formal** part relies heavily on information intermediaries to complete the knowledge transfer process. Empirical findings on the effectiveness of information intermediaries and the role(s) they play in knowledge transfer are sparse and inconclusive.

The problem with the **informal** part of the system is that 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 of 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 -- information that is becoming more interdisciplinary in nature and more international in scope.

PHASE TWO PRELIMINARY RESULTS

The results of the **Phase 2** aerospace library survey contain the analysis of selected questions from preliminary data based on 83 questionnaires that were returned to the Indiana University Center for Survey Research on June 12, 1990.

Because the preliminary results are based on only a portion of the sample, readers should be careful when interpreting the data.

Libraries in government and industry (G&I) were selected to receive a questionnaire through the following procedures. First, all North American (G&I) libraries in the Directory of Special Libraries and Information Centers (Darney, 1990) who were listed under aerospace, aerodynamics, or related fields were selected. A questionnaire was sent to each library that had a NASA technical report collection. The questionnaires were sent to the contact person listed in the Directory. Second, all state libraries that had NASA technical report collections received a questionnaire. Questionnaires were sent to the Head Librarians in the state libraries. Third, the membership list of the Aerospace Division of the Special Libraries Association (SLA) was used to determine G&I aerospace libraries not previously identified. The questionnaire was sent to the SLA member. In those libraries where there was more than one SLA member, only one person was sent a questionnaire.

One factor that was thought to distinguish the operating modes of industrial/government libraries was their method of funding. About three-fourths of libraries described themselves as cost centers (figure 4). That is, the libraries were funded from the overhead of the organization (see Tweed, 1984 for definitions of the various types of centers). Only a small proportion (4.2 percent) are described as profit centers. About 10 percent are self-sufficient cost centers and about 8 percent are cost-justified centers.

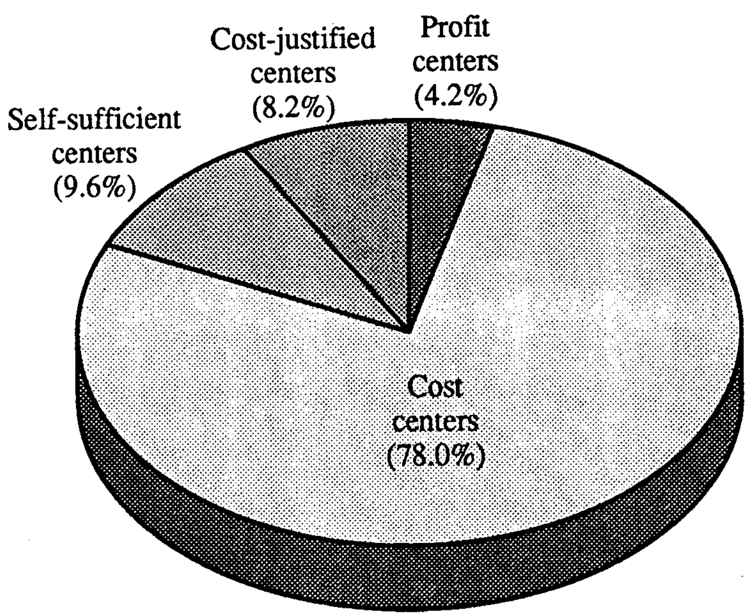

Figure 4. How U.S. Aerospace Libraries in Government and Industry are Organized.

As the aerospace industry becomes more international, it becomes more important for aerospace researchers to have access to international aerospace technical reports. The preliminary data from the aerospace library survey indicates that over 25 percent of the technical libraries regularly receive European Space Agency and British RAE and ARC technical reports (figure 5). About 18 percent receive German DFVLR, DLL, and MBB reports. Only a small portion of the libraries receive other international reports (French, Japanese, Swedish) that are usually not available in English translations.

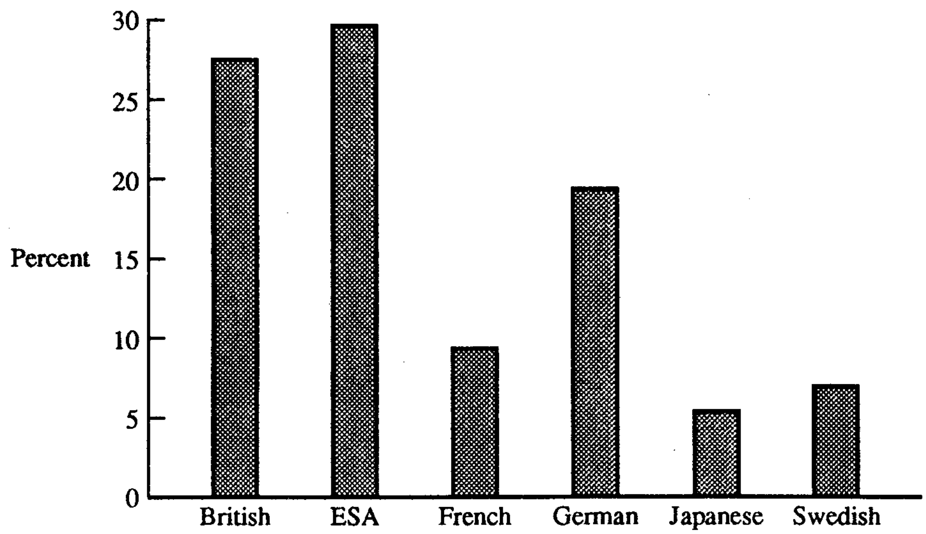

Figure 5. U.S. Government and Industry Aerospace Libraries that Receive Non-U.S. Technical Reports.

The questionnaire also asked about the relative use of NACA and NASA technical reports. The librarians were asked to rate, on a five-point scale, the use of these reports (figure 6). The preliminary data indicate that NASA technical

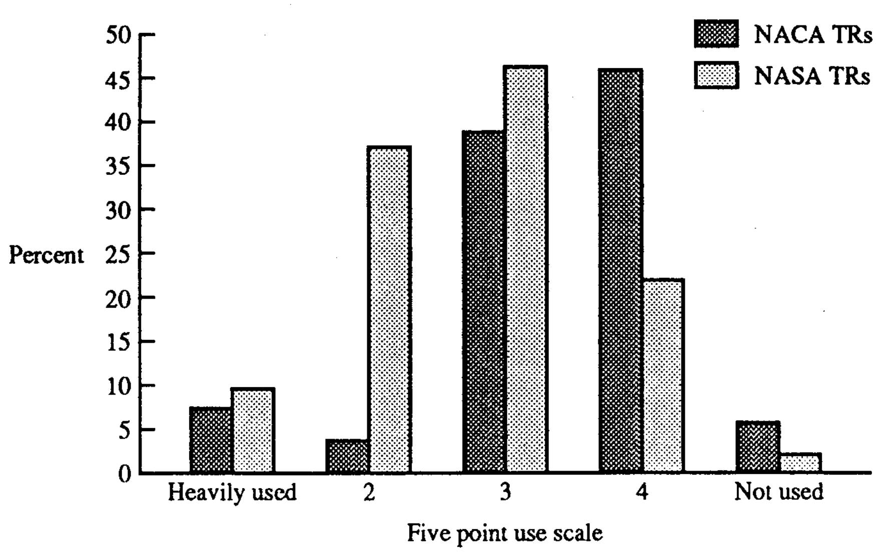

Figure 6. Use of NASA/NACA Technical Reports in U.S. Government and Industry Aerospace Libraries.

reports are used more heavily than NACA reports. Further, almost no one said that NACA reports are not used at all. Overall, these data demonstrate that NACA reports are still used but not as heavily as NASA reports.

Figure 7 describes how U.S. aerospace librarians in government and industry libraries assess the reasons that management and research personnel have for using NASA technical reports. The bars in the figure reflect the proportion who rated these qualities as one or two on a five-point scale. The librarians feel that accessibility and technical quality are more important reasons for researchers than management using NASA technical reports. In contrast, they feel that timeliness is more important for management. The relevance and familiarity of NASA technical reports were assessed as having about equal importance for management and researchers in explaining their use.

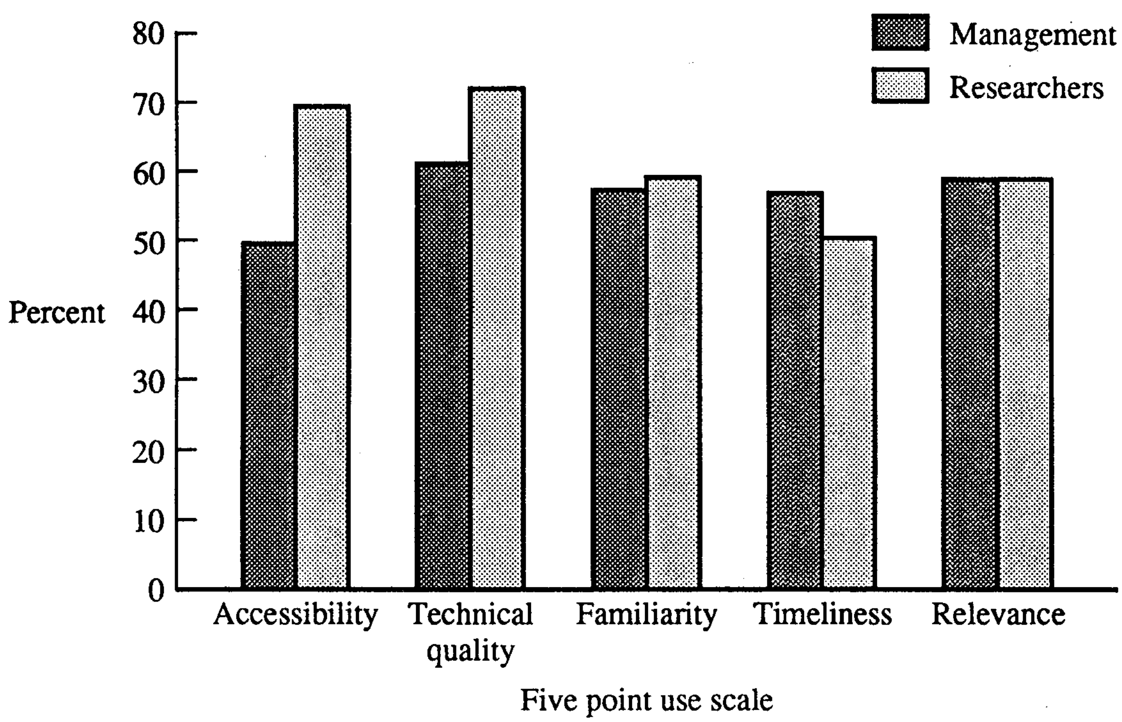

Figure 7. Assessment of U.S. Government and Industry Aerospace Librarians Concerning the Use of NASA Technical Reports by Management and Research Personnel.

The librarians were also asked to rate NASA technical reports on a variety of selected characteristics. Figure 8 lists the same characteristics as described in figure 7 and uses a similar five-point scale. Overall, the librarians gave NASA technical reports the highest rating on technical quality. Of the characteristics described in figure 8, only timeliness had fewer than 60 percent of the librarians rate it highly. The ratings the librarians gave are ordered similarly to the ratings they used in figure 7 to explain how researchers use NASA technical reports.

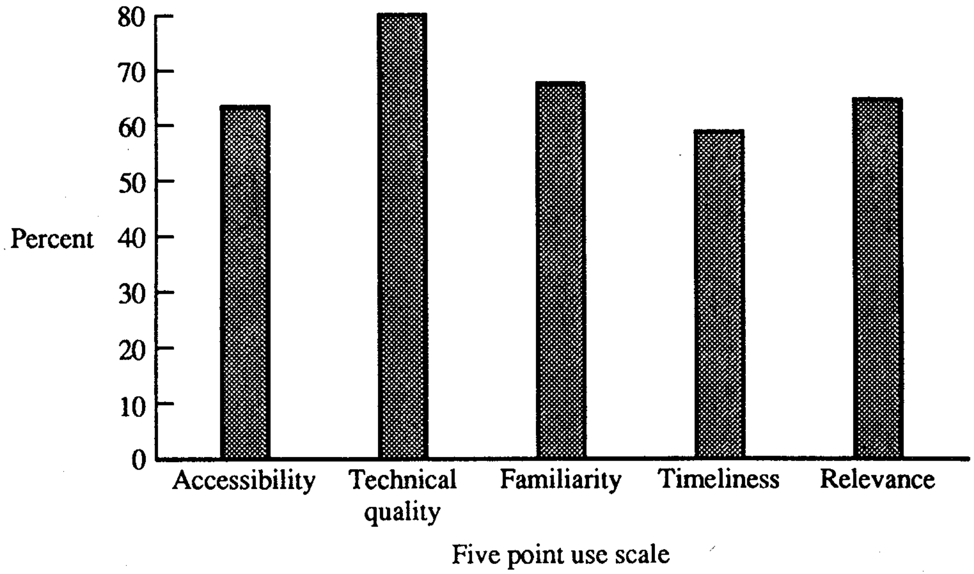

Figure 8. Assessment of U.S. Government and Industry Aerospace Librarians Concerning the Use of NASA Technical Reports.

A question that is often asked of librarians is why the research staff does not use the libraries more often. As shown in figure 9, the librarians feel that engineers and scientists often find needed information in their personal collections of books, technical reports, and other data sources instead of using library services. About 60 percent of the librarians feel that the potential library users are not aware of the services offered. Only a small proportion think that non-use is explained by management discouraging use of the libraries.

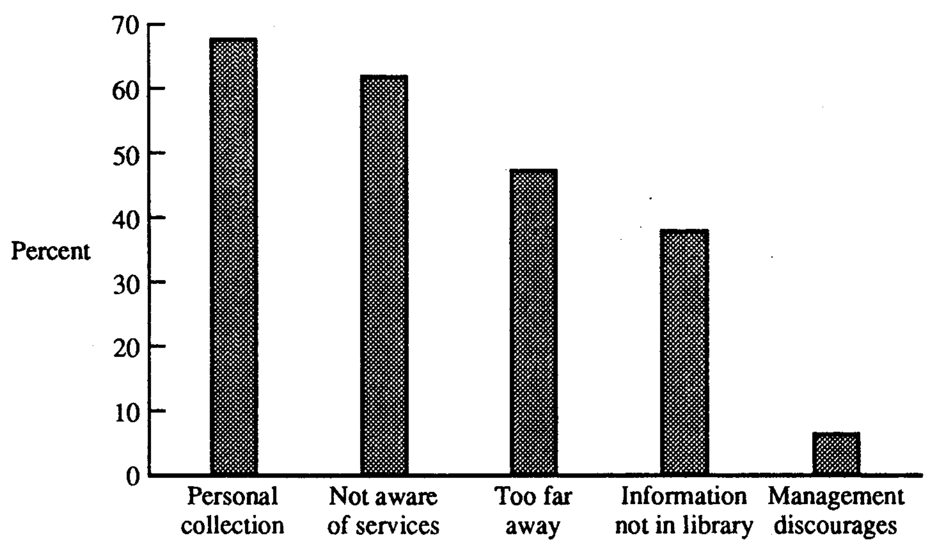

Figure 9. Assessment of U.S. Government and Industry Aerosapce Librarians Concerning Nonuse of Libraries by U.S. Aerospace Engineers and Scientists.

The aerospace librarians were also asked about the reasons why they could not meet a request from a user for a NASA technical report. The data shown in figure 10 show the proportion of librarians who reported that in the past six months, they could not meet a request for a variety of selected reasons. The reason given most often was that their library did not own the report. The reason offered next most often was that the report was classified, restricted, or had a limited distribution. About one-fourth reported that they did not have enough information to track the reports.

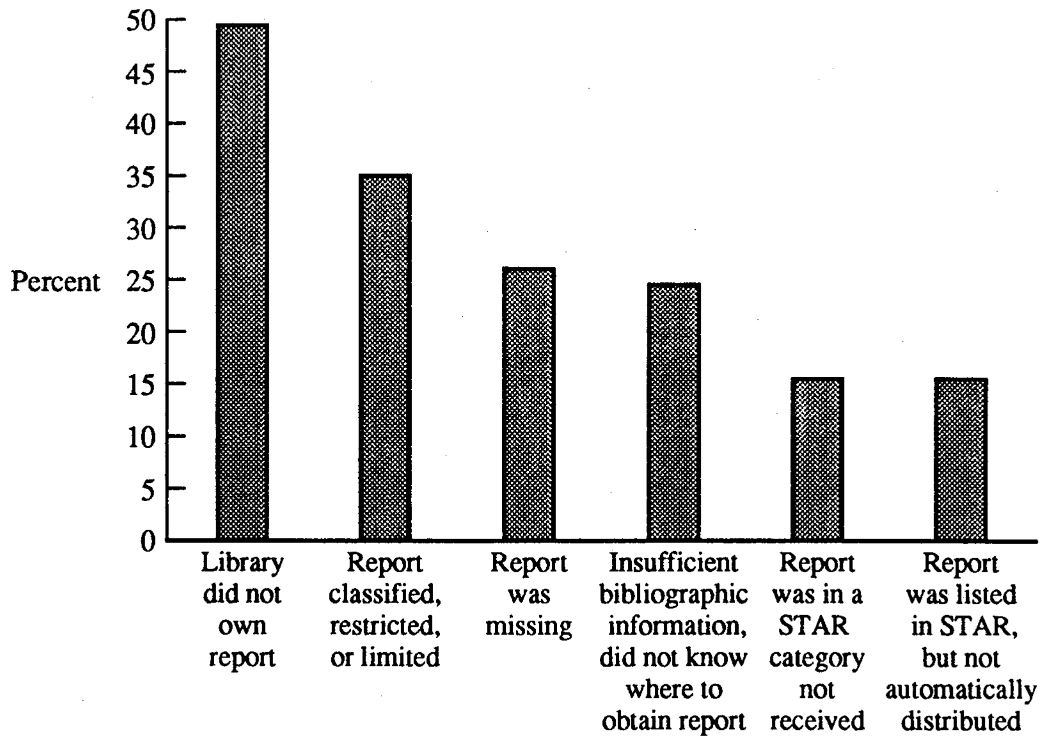

Figure 10. Reasons U.S. Government and Industry Librarians Cannot Obtain NASA Technical Reports Requested by U.S. Aerospace Engineers and Scientists.

Overall, these preliminary data indicate that NASA (and NACA, to some extent) technical reports are important to the aerospace research community. They are used primarily because of their accessibility and their technical quality. Librarians do report some difficulty in meeting user needs for NASA technical reports. This finding should be analyzed further.

CONCLUDING REMARKS

Little is known, in an empirical sense, about the Federal Aerospace Knowledge Diffusion Research Process (figure 3) and the interaction between the formal and informal parts of the system. It is assumed that information intermediaries play an important role as linking agents between the two parts of the system. However, the absense of defensible methodological studies prevents the validation of this hypothesis. Nevertheless, this is an area that should be subjected to further investigation.

Data from Phase 2 of the NASA/DoD Aerospace Knowledge Research Project will be used to help establish the validity of this assumption. The preliminary data reveals some interesting points. The major of government and industry aerospace libraries are operated as cost centers and are funded as overhead operations. This helps to support Bikson's, et al., (1984) claim that knowledge transfer and utilization are not integral part of the R&D process.

In a broader sense, it appears that aerospace librarians in government and industry may have a good "sense" of the information-seeking habits, practices, and preferences of U.S. aerospace engineers and scientists. Their assessment of how U.S. aerospace engineers and scientists rate NASA technical reports closely matches that provided by the research staff. Further, their reasons for library nonuse by the research staff also closely match those provided by U.S. aerospace engineers and scientists. These findings will be subjected to further analysis.

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