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# NASA/DoD Aerospace Knowledge Diffusion Research Project

*Paper Nine*

## *Information Intermediaries and the Transfer of Aerospace Scientific and Technical Information (STI): A Report from the Field*

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# INFORMATION INTERMEDIARIES AND THE TRANSFER OF SCIENCE AND TECHNOLOGY: A REPORT FROM THE FIELD

In recent years there has been an increasing degree of attention given to issues of the generation, management, and use of scientific and technical information. In part this attention can be attributed simply to the ever-increasing volume of data emerging from the nation's laboratories, libraries, and field sites, and to the amount of public and private resources going in to these facilities. In part, it results from a simultaneously growing uneasy feeling that we are failing to make the best use of this rapidly developing and changing resource. As we contemplate the increasing disadvantages experienced by American manufacturers in field after field of both low and high technology development, we are forced to ask ourselves why we seem to be unable to leverage our scientific expertise into equally significant economic payoffs.

There is no shortage of explanations -- or prescriptions -- to be offered. Those of an economic bent tend to stress the role of tax incentives, of regulatory influence and uncertainty, and problems associated with capital formation and deployment (e.g., Mansfield, 1968). Those of a managerial turn of mind criticize the emphasis in American companies on short-term performance and limited financial planning criteria (e.g., Hayes and Abernathy, 1980). Some look to political solutions, such as the creation of "enterprise zones" or subsidies for small high-technology businesses (e.g., Watkins and Wills, 1986). Others look to the development and expansion of industry/university consortia, either with or without public participation (e.g., Gray et al., 1986).

One common denominator in most analyses of the relationship of science and technology to economic performance and competitiveness is a perception that the mechanisms for moving information from place to place in the overall system of knowledge generation and application are functioning at something less than an optimal level of efficiency and effectiveness (Bikson et al., 1984; Tornatzky and Fleischer, 1990). This concern tends to be expressed as a problem of "technology transfer" -- that is, "Why can't we get all that technology out of the universities and research labs and into industry?" While there are a number of other terms applied to the problem -- "knowledge utilization" and "information dissemination" are probably the best known -- "technology transfer" remains the predominant metaphor by which the issue is understood in the U.S. today.

For a variety of reasons, "technology transfer" as a metaphor can be significantly misleading (Eveland, 1985). "Technology" in this context often implies products -- at the least, physical objects -- that can somehow be put into a vehicle and moved or "transferred" to some other point in physical space. In reality, the vast majority of interesting technology consists not of objects but information. And even that information is often not even *about* physical objects as such, but rather about the social environment within which the objects are deployed and the processes by which they are to be used. "Transfer" in this sense thus means much less actual movement than *learning* new information. In short, to speak of the problem as one of "technology transfer" can systematically represent what is, in fact, a complex problem of linking the *information environments* within which participants in the science and technology process must function.

This concept of the "information environment" can be particularly helpful. All of us are surrounded by enormously complex -- and increasingly complex -- webs of information, some of which is immediately germane to our lives, some of which is not. The mechanisms by which we sort and attend selectively to that information we need at particular points in time are beyond our scope here. The key point for our purposes is to recognize that the information environment is dynamic and continually being reshaped in response to perceptions of need and value.

## Information Environments and Boundaries

The purpose of any transfer mechanism or strategy is to increase the interaction of two or more information environments. Essentially, we learn new things when our information space connects with that of another individual (or institution) which has access to information we do not have.[1] Sometimes this interaction is deliberate search, sometimes it is an accidental encounter. Sometimes we know what we are looking for; often we do not, although we usually have some criteria in mind for determining when we have found it. Sometimes we have immediate access to the new information; often we simply store it away against the possibility of needing it at some future point.

The key element in this transactional view is the idea of a *boundary* between the information environment of the holder of the information and that of the potential user. By definition, if there is no information to flow between the two systems, there is no boundary. Boundaries form when two information-managing systems interpenetrate each other. The process may be by mutual consent, or it may be by force.[2] This interpenetration may take a variety of forms; usually one organization moves farther into the other than the other moves into the first. A salesman who expects to sell his products to a particular customer must know considerably more about that customer's context than the customer can be expected to know about his. On the other hand, a customer who knows reasonably well what he wants may wind up knowing considerably more about the potential products available and those who sell them than any of the potential suppliers know about the client.

In a technology transfer boundary situation, the information involved is generally information about the technology, both its technical and behavioral dimensions (note that the information may be either questions or answers). This information, once received, must of course be interpreted in terms of the receiving context. Both sides tend to hear what they want to hear. Since developers are generally more comfortable with the technical context of their

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[1] We also learn, clearly, when we rearrange existing information in new patterns that give us new insights into things we already know. This creative process is at this point beyond our attention here.

[2] Being sued is an excellent example of forcible creation of an interorganizational interaction.

innovations than the behavioral component, they usually tend to hear most questions as technical issues and respond with technical answers. Users, by contrast, tend to be more preoccupied with what they are going to do with the innovation than what it looks like or what its structure is, and frequently fail to get satisfactory answers.

The nature of the processes of organizational management of information creates some predictable barriers to effective interpenetration. These barriers are of several types:

> Structural: Those barriers posed by organizational arrangements and the need to achieve internal organizational maintenance criteria.
>
> Cultural: Those barriers posed by the basic frame of reference of the parties involved. They may involve general cultures (e.g., American firms trying to do business in Japan and encountering unfamiliar practices), or the professional and technical cultures either within or across organizational lines (e.g., manufacturing trying to talk to R&D; university professor talking to industrial researcher; economist talking to anyone else).
>
> Geographical: Those barriers posed by separation in space or time; despite the advances of information technology in helping achieve asynchronous communication, the fact remains that it is still a lot easier to share a lot of information with those close by than those farther away.
>
> Procedural: Those barriers posed by different ways of defining and conducting operations. Frequently what this amounts to is a failure to appreciate that words have different meanings in different contexts, and what seems normal and logical to one organization in terms of procedures may not seem equally logical to everyone else.

The key point here is that all these "barriers" are in fact not physical or even organizational, but cognitive. That is, they are created by people operating within their own contexts for reasons that make sense within that context. By the same token, they can by modified or removed by the same cognitive processes that brought them into being. The critical dimension is not who people are, or even where they are -- it is how they think and feel. At bottom, creating effective technology transfer systems that take full advantage of the capabilities of parties on both sides is as much a process of reeducating people as it is of doing anything at the organizational level.

In sum, the ability of a boundary between two organizational contexts to be permeated effectively with technology transfer information depends on where it lies and who is available to preside over the information transfer activity. The further the boundary lies within the user context -- the more the developer context has penetrated into the user -- the easier the process is likely to be. But any boundary-spanning activity is of course mediated by inter-institutional mechanisms, and it is now appropriate to consider some key dimensions of such mediating points in the system.

## Intermediaries and Transaction Mechanisms

While much information exchange is carried out through direct person-to-person interaction, the set of information transactions that involve *intermediary* individuals or institutions are of increasing importance. Our society has evolved a vast range of information intermediaries of varying degrees of formality, generality, and effectiveness -- television, libraries, conferences, on-line databases, just to name a few. In fact, probably the vast bulk of information transactions among individuals in our society are mediated in some way and to some degree. Moreover, the capacities of information intermediaries have been augmented in recent years through a vast array of new electronic tools. Yet we still know very little overall about how intermediaries function -- and still less about how their new capacities have changed what little we think we know.

Intermediaries are effective to the degree that they are able to translate information from the frame of reference of one individual to that of another(Bishop and Boissey, 1989). Sometimes little translation is required, if for example the two individuals concerned happen to be much alike; sometimes rather extensive translation may be required. The intermediary process is not just translation but creative editing and reinterpretation.

Eveland (1987) has outlined a three-dimensional framework for characterizing intermediary mechanisms in STI exchange:

> *Active/Passive*: This dimension refers to the modes of communication involved. *Active* systems have some kind of "transfer agents" whose job it is to take information from one place and move it to another; the classic example is agricultural extension. *Passive* systems simply array information for the taking, relying on the initiative of the user to search out that part of the information s/he may need. On-line data bases such as NTIS are good examples.
>
> *Formal/Informal*: This dimension reflects the channels of communication. *Formal* systems are those established explicitly to transfer information; *informal* systems are those that transfer information while serving some other formal purpose. This distinction is often mirrored in the roles of the individuals involved. In formal systems (such as extension) the roles of the transferror and recipient are specified and understood; in informal systems (for example, a cocktail party at a professional society meeting) roles are not defined clearly, and often shift.
>
> *Direct/Indirect*: This dimension reflects the relationships of the participants and the distance between them. *Direct* systems put producer and user in relatively immediate contact (for example, a journal article written by a researcher); *indirect* systems generally transfer the information to some intermediate point, often with intervening analytical stages (for example, a journal article summarizing and commenting on a body of others' research).

It is important to remember that these *functional* differences are not necessarily mirrored directly in *institutional* differences. Most information-transferring institutions do play both active and passive, formal and informal, roles at various times and through various individuals. Some structures are inherently less flexible; it is hard, for example, to make a traditional on-line database behave like an active or an informal medium. In general, institutions that can behave flexibly have a definite advantage over those that have only one mode of operation.

Obviously, the relative effectiveness of any intermediary mechanism in facilitating information interpenetration will depend on the nature of the boundary to be crossed and the resources available to cross it. It is also critically influenced by the guiding assumptions and underlying ideological predispositions of those who operate within it. At this point, let us turn attention to some of the mechanisms that the Federal government has been involved with, and to a framework for looking at how guiding principles influence institutional evolution of transfer mechanisms.

## Technology Transfer Strategies and Institutions

The Federal government has in recent years become increasingly involved with arrangements intended to promote the more effective utilization of technology through exchange of scientific and technical information. A wide range of programs, policies, and systems have been experimented with to varying degrees of thoroughness. In general, it is useful to distinguish between the government's *market-oriented* approaches and those that do *not* involve market mechanisms.

Market mechanisms are all those that involve reciprocal transactions of value exchange. These include direct **sales**, technology **licensing**, **partnership** and cooperative arrangements of various types, and similar exchange processes. They are appropriate when both parties operate in a market environment, where the balance of value given and received is close enough to even that the relationship is sustainable, and where the parties both command sufficient resources to carry the relationship long enough to make it work without outside help.

Non-market arrangements primarily involve units of government as one of the parties, and include **commercialization** programs (for technologies with potential market value); **dissemination** programs (for technologies either without market value or intended for use by other government units), either with or without associated **demonstration** projects; **technology mandating** (where the government requires the use of particular technologies); and **economic levers** (regulation, tax and patent policies, and direct subsidy). There is considerable debate in the literature over when particular non-market arrangements are and are not helpful, and how they interact with market mechanisms. In general, the consensus seems to be that non- market interventions are appropriate where "market failures" exist either because the government is the only buyer (or seller) or because the market is structurally imbalanced in some critical way.

There are also some mechanisms that can operate in either a market or non-market context. These include **library-type** systems (e.g., NTIS, DIALOG), **research consortia** (particularly those involving universities and industrial firms), **publication** in the open or not-so-open literature, and **personnel exchange**, either among developers, among users, or between developers and users. These arrangements are frequently part of other, more structured mechanisms.

The degree of enthusiasm of the government for each of these approaches has waxed and waned as political fashions have changed. In general, however, there has been a trend over the years to move toward more specific focus of involvement, and more specific focus on information management. Williams and Gibson (1990) have outlined an interesting framework that categorizes technology transfer in terms of three models of increasing interactivity:

> *Appropriability* models: Under this approach, research knowledge is generally treated as a commodity, to be procured/purchased by a user in accordance with his/her judgments of its utility. Good research will sell itself; the "better mousetrap" will find utilization. Transfer mechanisms emphasize publication in the research literature and, to a lesser extent, direct interpersonal interaction initiated by the user. The user bears the primary responsibility for utilization.
>
> *Dissemination* models: Under this approach, technical experts have a responsibility to identify good ideas and bring them to the attention of potential users. The experts, who may be either the producers of the knowledge or third parties, establish linkages that presumably ensure a continuous flow of ideas. Responsibility for use is thus shared between producer and user.
>
> *Knowledge utilization* models: Under this approach, the flow of ideas moves toward bidirectionality. That is, the user accepts a responsibility to interact creatively with the producer to ensure a more precise targeting of the knowledge to real problems. Information exchange becomes more of a transaction and less a linear flow.

Clearly there is an intersection between these models and the typology of mechanisms outlined earlier. Appropriability models tend to emphasize passive and indirect strategies, while dissemination models tend to center on more active and direct strategies. Knowledge utilization models more or less require active approaches, but can be either direct or indirect in operation. Each model employs a mix of formal and informal approaches.

The bulk of the Federal government's attention to technology transfer has been divided between appropriability and dissemination strategies. As we noted earlier, there has been a heavy emphasis on market mechanisms, which are largely based on appropriability models, and some limited attention to dissemination in fields such as agriculture and education.[3] Certainly virtually all of what currently exists in the aerospace science and technology area would fall into one or another of these two models.

At this point the question logically arises: "What's best? What works? And shouldn't the Federal government be doing more of it?" The answer, unfortunately, tends to be contingent -- "It depends...on the contexts, on the information, on the participants, on the criteria for success of the

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[3] There have also been quite limited and sporadic efforts in the areas of manufacturing technology and energy technology that have occasionally contemplated a knowledge utilization framework, although with very limited success.

encounter." Moreover, the evidence on which even such contingent conclusions are based tends to be anecdotal and impressionistic (Bikson et al., 1974; Eveland, 1987). There is a significant need for well- structured empirical research to begin to disentangle the issues involved in the relative advantages and disadvantages of different approaches to technology transfer.

## Investigating Knowledge Use: Going to the Sources

Recognizing the general shortage of empirical knowledge in this area -- particularly with reference to the aerospace community -- NASA and DOD launched in 1987 the *NASA/DOD Aerospace Knowledge Diffusion Research Project*, aimed at systematically investigating how the results of NASA and DOD research find homes in the wider aerospace R&D process (Kennedy and Pinelli, 1990). As an early part of its research, this project surveyed in 1989 three samples of aerospace scientists and engineers and a parallel sample of technical librarians and other formal information intermediaries. These surveys were aimed at gathering some basic data on how scientific and technical information (particularly that generated by the government) is being used, how its use fits into broader issues of R&D, and how the information infrastructure supports (or fails to support) this process. In this section of the paper, we present some findings from these surveys as they relate to the issues posed earlier of how an effective knowledge diffusion system might work.

The sample for the survey of scientists and engineers was drawn from the membership lists of the American Institute of Aeronautics and Astronautics (AIAA). Overall, 3946 responses were received to the three different questionnaires, with 2016 of those being to the first and longest questionnaire. 51% of the respondents worked in industry, 22% for the government, and 12% in academia. 84% classified themselves as engineers by training, 12% as scientists.[4]

The survey of information intermediaries gathered data from 156 technical librarians and related personnel. The list of U.S. and Canadian government and industrial libraries was compiled from several sources. One source was the Directory of Special Libraries and Information Centers. Additional libraries were compiled from the members of the Aerospace Division of the Special Libraries Association. All libraries held aerospace, aeronautical or related collections. In addition to the industry libraries, government libraries, including both regional depositories and armed services libraries, were included on the list.

In the remainder of this paper we present some findings from these surveys that shed light on how scientists and engineers actually use scientific and technical information to carry out research and solve problems. We then return to some implications of these findings for the design of effective knowledge transfer systems, and some ideas for further research that should help flesh out the picture in more detail.

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[4] Full reports on the data from these studies can be found in Kennedy, Pinelli, and White (1990). In our discussion, we draw data from the first scientist/engineer survey and from the library survey.

What the Data Show

One of the most intriguing sets of questions in the scientist/engineer survey addressed directly the issue of their information gathering behavior. Respondents were asked to think back on their most important recent technical project or task in the last six months, and to rank in order the steps they went through to gather information relative to it. The nine possible information gathering modes fell into three general classes:

*Formal data sources*: Searching databases, consulting library sources, etc.

*Information intermediary sources*: Consulting with librarians and technical information specialists

*Informal network sources*: Consultation with colleagues, supervisors, "gatekeepers", etc.

Ranking nine steps is inherently a rather difficult task, and it is hard to be fully confident in the rankings at later stages. However, it is probably that at least the first couple of steps would be recalled with some precision. Accordingly, respondents were grouped in terms of whether they employed data, information specialist, or network sources at the first and second steps of the process.[5] Table 1 gives the frequencies for these usage patterns. In the analyses that follow, these groups

TABLE 1
SOURCES OF PROJECT INFORMATION

| | | SECOND STAGE | |
|---|---|---|---|
| | | DATA SOURCES | NETWORK SOURCES |
| FIRST STAGE | DATA SOURCES | 416 | 519 |
| | NETWORK SOURCES | 281 | 430 |

will be referred to as "Data-to-Data" (D/D), "Data-to-Network" (D/N), "Network-to-data" (N/D), and "Network-to-Network" (N/N) depending on which source

[5] Since there was relatively little reported use of information intermediary sources at these stages, they were combined with "data" sources for the rest of this analysis. Thus, references to "data people" should be interpreted as referring to both those who chose formal data sources and those who relied on information intermediaries.

they took first and which they subsequently resorted to.[6]

There are some interesting differences between the four groups in terms of composition. The scientists in the sample are disproportionally D/D's (33% vs 24% across the sample) and low in N/N's; however, the engineers distribute themselves across all four groups more or less in proportion. Perhaps as a consequence of this concentration, the D/D's tend to be better educated (an average of one more degree than the other groups), and to be employed in education and research; the N/N group is disproportionately higher among the administrators. D/D's are somewhat more likely to use basic science and technical information than are N/N's (95% vs 85%), but N/N's use more in- house technical data. D/D's get a higher percent of their information from conference papers and journal articles than do the other groups.[7]

A series of questions was asked relating to use of libraries and technical information sources. There were no differences among the groups in terms of the availability of library resources (over 90% across the board). However, D/D's were, not surprisingly, more likely to have visited the library in the past six months (95% vs. 80% for N/N's), and to have sought help from a specialist (85% vs 67%). On average, D/D's rated the library one full point higher on a 5-point scale of importance than did N/N's; 63% rated it as "very important", as opposed to only 25% of N/N's.

Another series of questions asked for opinions about the severity of a series of potential barriers to library use. The eleven specific barriers broke down into four general classes of factors: lack of help, lack of information needs, administrative barriers, and availability of other sources of information.[8] D/D's tended to react most strongly to administrative barriers, while N/N's tended simply to have no information needs or to have other sources of information.

The barrier questions offer an interesting opportunity to compare the opinions of information users with those of the information specialists, since parallel questions were asked in both surveys. Table 2 shows the similarities and differences. A significantly large proportion of librarians felt that users were

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[6] Of the 416 D/D's, 210 were what might be called "hardcore D/D's", in that they remained with data sources even to the third iteration. The behavior of this hardcore group seldom differs from that of the rest of the D/D group significantly, though they do tend to exhibit the D/D properties with a bit more strength than do the "softcore" D/D's.

[7] In general, the D/N's and the N/D's are remarkably like each other, and usually about halfway between the D/D's and the N/N's. When there are exceptions to this pattern, they will be noted; otherwise, it can be assumed to hold.

[8] This grouping, and that reported subsequently for information technologies, was accomplished through principal components factor analysis with varimax rotation. In both cases, the four-factor solution accounted for about 80% of the variance of the original variables.

TABLE 2
BARRIERS TO LIBRARY USE
(PROPORTION OF EACH GROUP ANSWERING "YES")

| | SCIENTISTS/ENGINEERS | LIBRARIANS |
|---|---|---|
| DISCOURAGED FROM USING | 1.2% | 11.1% |
| HAVE TO PAY | 4.8 | 5.6 |
| OWN PERSONAL COLLECTION | 30.3 | 71.5 |
| LIBRARY TOO SLOW | 15.8 | 31.3 |
| LIBRARY NOT HAVE INFO | 23.6 | 42.8 |
| LIBRARY TOO FAR AWAY | 23.6 | 49.6 |
| INFO NEEDS MET MORE EASILY ELSEWHERE | 38.2 | 37.6 |

"discouraged from using the library"; by contrast, this was identified by an extremely small number of users. Almost twice as many librarians as users saw "personal information sources" as a barrier. In general, the librarians tended to see a much higher incidence of barriers to use than did the users themselves.

Both groups were also asked about seven factors that might influence use of NASA technical reports (Table 3). Here, there was a generally high degree of agreement between the two groups. The only major differences resulted from the librarians' underestimating the importance of accessibility to technical managers, and relevance to engineers. In general, the information specialists seem to have a good understanding of this aspect of their clientele.

TABLE 3
AVERAGE RANK OF IMPORTANCE OF FACTORS INFLUENCING USE OF TECHNICAL REPORTS
("1" = "MOST IMPORTANT")

| | JUDGMENTS OF: | | JUDGMENTS BY LIBRARIANS ABOUT OPINIONS OF: | |
|---|---|---|---|---|
| | TECH.MGT. | ENGR. | TECH MGT. | ENGR. |
| ACCESSIBILITY | 3 | 3 | 5 | 2 |
| EASE OF USE | 7 | 6 | 6 | 6 |
| EXPENSE | 6 | 7 | 7 | 7 |
| FAMILIARITY | 5 | 5 | 3 | 4 |
| QUALITY | 2 | 2 | 2 | 1 |
| COMPREHEN-SIVENESS | 4 | 4 | 4 | 5 |
| RELEVANCE | 1 | 1 | 1 | 3 |

One other area where parallel items were asked related to the use of a series of fourteen specific information technologies (Table 4). Some interesting differences emerged here. Librarians tended to report higher involvement with electronic databases, CD/ROM, and fiche. By contrast, the users tended to report higher involvement with desktop publishing, film, audio, and teleconferencing. These distinctions make sense; the librarians' preferred technologies are all archival media, while the users' technologies tend to be more interactive. Oddly, there were no notable differences between the groups in terms of use of electronic networks, fax, electronic BBS's, or videotape.

TABLE 4
USE OF INFORMATION TECHNOLOGIES
[PROPORTION ANSWERING 'I CURRENTLY USE IT']

| | USERS | LIBRARIANS |
|---|---|---|
| ELECTRONIC DATABASES | 57 | 92 |
| ELECTRONIC NETWORKS | 43 | 55 |
| CD/ROM ETC. | 8 | 53 |
| FICHE, MICROGRAPHICS | 63 | 91 |
| TELECONFERENCING | 50 | 29 |
| VIDEO TELECONFERENCING | 20 | 15 |
| FAX | 88 | 90 |
| ELECTRONIC BBS'S | 29 | 39 |
| ELECTRONIC MAIL | 53 | 65 |
| CARTRIDGE TAPE | 40 | 34 |
| DESKTOP PUBLISHING | 54 | 31 |
| VIDEOTAPE | 60 | 65 |
| FILM | 28 | 23 |
| AUDIOTAPE | 37 | 61 |

Among the user group, the D/D's tended to report higher use of electronic databases, fiche, video and audio tape, and film than did the other groups. N/N's were disproportionately higher users of video and audio teleconferencing. This is consistent with an overall pattern in which the D/D group tends to prefer more archival media, while the N/N group prefers technologies that enhance networking.

In general, then, the data support a picture of a rather diverse user community, one generally in touch with its information needs, but ready to meet those needs in a variety of divergent ways. Those who prefer specific information gathering strategies tend to be different in other ways as well. While there is clearly structure to information acquisition and use in this sample of information users, it is a structure of diversity rather than uniformity.

## Conclusions and Future Research

We have suggested earlier in this paper that there is potentially an enormous range of arrangements that might be considered for knowledge transfer systems, varying along several different dimensions. Some are susceptible to formal creation and management; others are simply a matter of not getting in the way of something that is working. All have met some needs at some places and some times, for some people.

From the NASA/DOD survey data, there can be no way of inferring what strategy is "best"; indeed, given the fact that the respondents were all presumably well qualified professionals, the data tend to call into serious question the idea that any one model might meet the needs of more than a distinct minority of possible users. Thus, we have empirical reinforcement for the idea of the value of diversity in knowledge transfer strategies.

One point that does emerge loud and clear from these data is that the traditional strategy of essentially passive information distribution through formal channels -- under an appropriability or even a dissemination model -- appears to be the preferred approach of only about one-quarter of this large and diverse population of users. That is, over three-quarters of the respondents preferred to use a networking approach early in their information gathering process, rather than relying on the data and information intermediary systems to produce what they needed.

Surely this constitutes an argument for a movement toward a more comprehensive information utilization model, in which formal sources of data can be used in creative combination with interpersonal and interactive media to produce a more situation- and person-responsive operation. Such an approach, which one might call an "interactive information intermediary" system, would lend itself to effective use by a significantly higher number of individuals than are now comfortable with any one component of our present highly disaggregated and generally reactive arrangements for knowledge transfer.

It is clear that the technological infrastructure to support such a system, if not wholly developed, is at least feasible. The data indicate quite high overall levels of use of a significant number of the interactive information technologies that would be required by this approach. With some additional augmentation -- for example, expert system tools to assist in literature search, or object-oriented databases that link text, graphics, and audio in searchable patterns -- existing knowledge transfer systems would find themselves reaching vastly more individuals, and vastly better.

Attention to the technology *of* transfer should not lead us to forget, however, that the underlying issues of quality and utility of data are paramount. On-line data retrieval is paced by the ability of the searcher to bound the problem; computer or video conferencing is no better than the quality of the participants and the time they can afford to devote to the exchange. The "new media" (Rice et al., 1984) can best be seen as "multipliers", affecting the power and magnitude of the exchanges they facilitate rather than their basic nature.

We have by no means exhausted the research needed to understand this problem, even within the limited compass of NASA/DOD research publications and the aerospace community. For one thing, it would be particularly interesting to have follow-up data that reflect more directly the *networks* of relationships among information providers, intermediaries, and users. The present data, while extremely informative, do not allow us to link, for example, the opinions of users and those of the intermediaries that serve them. More systematic attention to the patterns of interaction that characterize this extremely diverse and heterogenous community of participants in the research process would be extremely helpful in estimating the need that remain to be met by such an interactive strategy.

In sum, the evidence to date appears to reinforce the concept that individuals' "information environments" take many different shapes, and interact with each other and with formal data transmisssion sources in many different and equally valuable ways. Any overall strategy for improving the effectiveness and efficiency of scientific and technical information sharing must take this divergence into account, and work toward the creation of systems that reinforce true interactive knowledge *utilization* rather than simply "disseminating" data. We have a long way to go before we can specify what such a strategy would look like, but studies such as this can help point the way.

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