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PROGRAM IN INFORMATION POLICY

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IMPROVING NASA'S TECHNOLOGY TRANSFER PROCESS THROUGH INCREASED SCREENING AND EVALUATION IN THE INFORMATION DISSEMINATION PROGRAM

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Abstract

This paper focuses on ways to improve NASA's technology transfer system. The analysis in this paper assumes that an improvement of the current status can be achieved if the technology transfer process is better understood. This understanding will only be gained if a detailed knowledge about factors generally influencing technology transfer is developed, and particularly those factors affecting technology transfer from government R&D agencies to industry. Secondary utilization of aerospace technology is made more difficult because it depends on a transfer process which crosses established organizational lines of authority and which is outside well understood patterns of technical applications.

In the absence of a sound theory about technology transfer and because of the limited capability of government agencies to explore industry's needs, a team approach to screening and evaluation of NASA generated technologies is proposed in the analysis which follows. The proposal calls for NASA, and other organizations of the private and public sectors which influence the transfer of NASA generated technology, to participate in a screening and evaluation process to determine the commercial feasibility of a wide range of technical applications.

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Introduction

In providing for the widest practicable and appropriate dissemination of information about its R&D activities, NASA faces a task of vast scope and substantial complexity.

In fulfilling its task NASA must solve two complex problems:

- The Information Problem

The secondary utilization of aerospace technology poses a question that is difficult to answer: "How can an unknown target group in industry be provided with a technology having unknown applications?" In order to respond to this challenge NASA must necessarily initiate "horizontal" technology transfer through a communication process which crosses institutional and organizational boundaries. This process is not well understood.

To transfer the right information to the right target group is a difficult task. But, this is only one part of the technology transfer process. Information dissemination is a necessary but not a sufficient condition for technology transfer (see also: Baer et al., 1976, p. 27).

- The Application Problem

There exists a spectrum of potential reasons why industry does not accept a known technology. Technological feasibility is no guarantee of commercial success. Furthermore, new technologies are very often not only market-creating but also market-destroying.

Studies indicate that NASA performs excellent work in disseminating information. That is not to say that there do not exist ways of improving the NASA information dissemination system. In addition, based on an interpretation of investigations performed by the Denver Research Institute, it appears that opportunities for substantial improvement exist in the application process.

Rather than attempting to improve the technology dissemination system through a new kind of technical report, it may be more beneficial to improve the information itself. More potential value could be added to the information system by detailing competitive technologies, by indicating neighboring technologies which already exist or are developing, by suggesting possibilities for useful applications, and by providing commercial feasibility information. Such activities impact on the application problem in a positive manner (see also: Chakrabarti, 1972, p. 7).

In order to effectively provide this "value added infornation," one must understand the supply characteristics of NASA technologies with regard to potential commercial applications and specific demand characteristics of potential users. In addition, one should be aware of "what is going on" in industry and between industry and government agencies.

How can such a task be accomplished? An important step is to enhance the <u>screening/evaluation process</u> of NASA generated technologies. That is to say, enhancing the ability to anticipate the future value of a NASA technology and thereby choose an effective transfer medium. Since no comprehensive detailed knowledge about the many facets of technology transfer exists, two possibilities seem worth pursuing in the screening/evaluation process.

- Statistical Analysis

Based on existing historical data, one can try to determine the relevant characteristics of technologies which enhance their value for potential users.

Such statistical analysis could provide substantial insights. Industry, however, frequently reorganizes its structure and changes its needs, so statistical analysis is of limited value. But, statistical analysis might be used for preevaluation, thereby filtering out presumably valuable technologies to be evaluated by a team.

- Team Approach

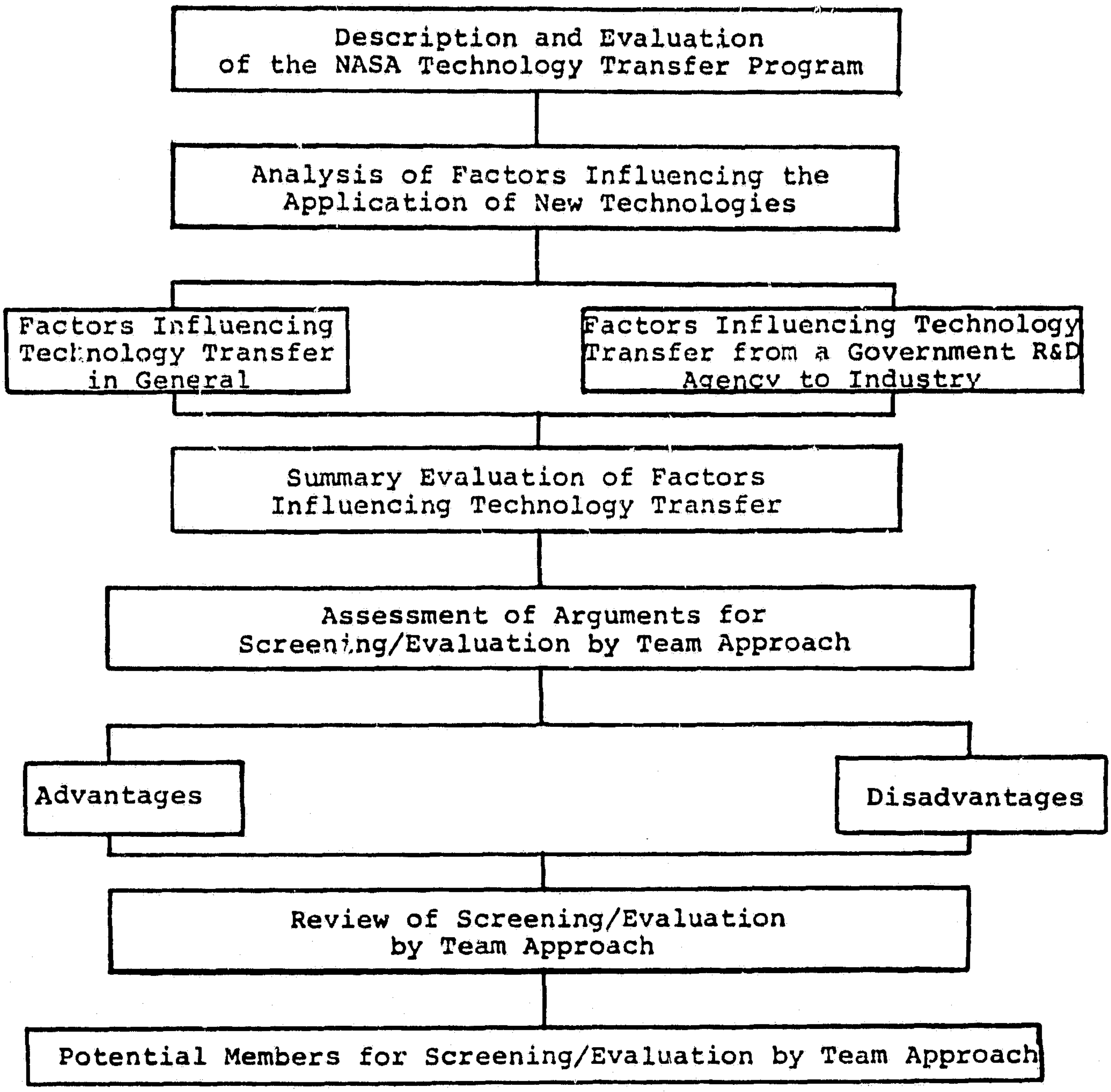
Evaluation using a team approach is suggested here using teams that include members of the user community, such as professional associations, and governmental agencies, which are concerned with regulation and commercial R&D. Such an approach would enhance the technology transfer process.

The purpose of this paper is to explore the potentials of a team approach to the screening/evaluation process. This approach creates two substantial benefits:

(i) Given a lack of knowledge about the complexities of technology transfer, this approach could become a powerful tool in overcoming those complexities.

(ii) Technology transfer is important for all members of a society and should therefore not be the sole concern of an R&D agency like NASA. A team approach would promote acceptance of the view that technology transfer is the common responsibility of all participants in the commercial utilization of advanced technologies.

To outline the characteristics of a team approach to screening/evaluation, this paper is organized as follows:



In the first section below, the NASA information system is described and evaluated. This evaluation suggests that NASA improve the information itself rather than modifying the information dissemination system.

An assessment of factors which are likely to impact on technology transfer is made in the second section. At the end of this section, improvements achievable using a team approach are discussed.

The third section assesses arguments for a team approach to screening/evaluation.

Potential members of a screening/evaluation team are noted and their capabilities explored in the fourth section.

1. Description and evaluation of the NASA Technology Transfer Program

The NASA Technology Transfer (TT) program consists primarily of Information Dissemination, Application Teams, Information Dissemination Centers, and Applications Engineering. For the purpose of this paper, this transfer system is viewed as three phases:

INFORMATION PHASE

- o library service
- o delivery service (technical reporting)

MARKETING PHASE

- o identification of potential users' needs
- o identification of technologies matching users' needs

APPLICATION PHASE

- o demonstration projects
- o reengineering projects
- o production of marketable products

The development of the process can be thought of as an evolution. In its information phase, information is provided for the users. In order for technology transfer to happen, the user must play an active role. NASA's role is more passive, once information has been made available. The library service, for example, consists of a set of interrelated services. In the literature search service ("remote") the user is active; he defines key words which are used for information retrievals performed by Industrial Applications Center's (IAC) personnel. The next extension is an interactive retrieval service (on-site); the user sits beside the "Information Specialist," who now plays an active part due to his knowledge about the NASA data base. He is able to identify keywords the user might never think of. In a current awareness search service (periodical reports which supply the user with up-to-date information in his field of interest, generally delivered on a monthly basis), the user defers to the search service totally. NASA's role is more active in cases where the user requests interpretative services and NASA participates in the exploration of the retrieved information.

Staffed with highly qualified scientists and engineers, Industrial Applications Centers provide not only information but potential applications of information. An IAC's staff personnel may initiate contact between a requester and companies, universities, etc., already working in a certain field.

In the marketing phase, performed by State Application Centers and Technology Application Teams, NASA takes a more active role: exploration of a user's needs, search for a technology which will match those needs and then implementation and commercialization of the technology (see Anyos et al., 1978. p. iii). In the application phase, NASA reengineers technologies in order to bring them closer to commercial feasibility.

Studies investigating the benefit-to-cost ratios concerning the main elements of the NASA Technology Transfer program show a positive relationship. The aggregate benefit-to-cost ratio was estimated to be 6 : 1. The single elements of the program are characterized by ratios lying in a spectrum 3 : 1 to 26 : 1 (Johnson et al., 1977b, p. v, vi). For each dollar NASA invests in its TT Program, benefits equivalent to six dollars are produced.

When interpreting these numbers, one must take several factors into account. First, such benefit-to-cost ratios cannot be directly compared with those of other NASA projects. Of course, the ratios calculated for the NASA TT program do not reflect the investment in developing the technology. Second, each NASA contractor must write a contractor report, which can be thought of as an initial step toward producing an information product, the costs of which are not covered by the TT program.

In assessing possibilities for further improvements of the TT program, an analysis of the NASA Tech Brief Program, undertaken by the Denver Research Institute, is most valuable (Johnson et al., 1977a, p. 36). They classified TT applications in four modes:

- mode 0 no application at all
- mode 1 used for information only
- mode 2 used to improve already existing production technologies, products and services
- mode 3 used to develop new production technologies, products and services

The probability for any of the individual modes occurring were calculated as follows:

mode	probability
0	34%
1	54%
2	11%
3	1%

The 54% for mode 1 indicates that NASA is providing an excellent information service. There is no other information service available which covers the aerospace area and related fields in such a comprehensive way. This is true partly because the NASA data base includes information produced by other organizations. For example, due to a special information exchange agreement between the NASA Scientific and Technical Information Office (STIO) and the European Space Agency (ESA), a user can obtain the latest international developments in this field.

The results of the DRI study show a very different picture concerning the development of new products from NASA technical information: "Successful efforts to develop new products from TSP's have occurred but they are exceptions. More typically, such attempts lead to a new financial loss for the TSP requester. Even for successful Mode 3 application (development of new technologies, products, services), the TSP information is usually a minor technical input (about 5 percent) to the new economic activity" (Johnson et al., 1977a, p. 48).

At the present time, it seems that the most positive outcome of NASA's TT program is that the information about its technologies is available promptly and comprehensively.

The calculated net benefit for the Industrial Application Centers is moderate compared to those of the technical reporting program. One might expect the contrary, due to the comprehensive and thorough services provided by IACs. Moreover, it is important to emphasize that while technical reports are free, users are charged for the services of the IACs. The benefit-to-cost ratios currently available may not describe the true picture. Out of a vast set of new technologies, most will have little or no impact on new products and services. There is a small subset of technologies which are, unexpectedly, so successful that they pay for the whole R&D program of an organization.

To enhance the effectiveness of NASA's TT program, it would be useful to know about the underlying factors which influence technology transfer. For example, it is not particularly useful to calculate time-lags between the technological feasibility and the first commercial application of a technology;

indeed, those calculations show substantial variations (see: Rosenberg, 1976a, pp. 72-74). There are many different factors at work and without a detailed understanding of those factors it is hard to initiate efforts to make technology transfer more effective.

NASA technology has the potential to improve existing technologies and to develop new production technologies, products and services. However, an improvement of the technology information dissemination system by itself is not likely to lead to a substantial change. Producing and reproducing information about a technology where there are barriers in the application of this technology is not likely to lead to better results. In one case hundreds of TSPs were requested regarding a new gas turbine seal, but there were no applications because no firm was willing to take the necessary substantial commercial risk. If a procedure existed, e.g. a team approach to screening/evaluation by which NASA anticipated such a problem, NASA could offer more help. For example, where potential users of a new technology such as governmental organizations are identified, NASA might develop a prototype if the technical risks were so high as to inhibit further development.

The key for solving the applications problem is a mechanism which enables NASA to explore the potential commercial environment for a certain technology which is announced through the TT program. This is the underlying basis for the suggestion of technology screening/evaluation using a team approach.

2. Analysis of factors influencing the application of a new technology

Technology transfer is a complex process which is not well understood (Hoelscher, Hummon, 1977, p. 76), especially horizontal technology transfer or secondary utilization. There may be hundreds of potential secondary applications of aerospace technology, but it is extremely difficult to identify them. Indeed, it might be difficult to think of any useful applications of a new technology at all. Thomas Edison is reported to have thought that a phonograph would be used to record the wishes of dying men (Rosenberg, 1976a, p. 197).

In the secondary utilization of aerospace technology, it is often remarkable how remote the secondary utilization is from the original space application. A joint NASA/military project on helicopter rotors produced a vibration dampening technology, now used in building guitars (Haggerty, 1978, p. 34).

In anticipating secondary utilization one faces an "open-ended" problem. There will never be a method for identifying all the possible or useful non-aerospace applications of a NASA technology. "It is important that one never knows in advance if spinoffs will occur, or what their benefits may (or may not) be. Because of this uncertainty, spinoffs are nothing to bank on." (Thurow, 1978, p. 69.) It might be worthwhile to initiate a potential applications "creativity-session" for selected technologies. Such value added to a purely technical description of a new technology might enable a reader of a TECH BRIEF to envision many possible applications and ultimately to develop a useful application.

Before one explores the potential value of a technology, an idea for the application of that technology is necessary. One can then begin to assess the impacts of factors influencing the technology transfer process. A knowledge of such factors and their impacts on technology transfer is important in estimating the probability of an industrial application of a technology. In the following paragraphs some of those factors are discussed.

2.1 Factors which influence technology transfer.

The following section describes some factors which generally influence technology transfer as well as specific factors which influence transfer from government R&D agencies to industry.

o All technologies have certain characteristics making them advantageous for some applications and useless for others. The application of numerical control in the machine tool industry is not economical for long production runs. Other factors like preparatory and maintenance work have to be taken into account, especially if a skilled work force is scarce. (see also: Ray, 1969, p. 58). One must also check the impacts of a new technology on the organization of the whole production system. This is extremely important in industries like the chemical industry which is characterized by close and interdependent relations between materials, energy and information flows. Often, a new technology - even if only a small piece - can only be used advantageously if the whole production system is reorganized. If the investment expenditures for the reorganization are greater than the anticipated cost reductions caused by the use of the new technology, the latter will be ignored.

It is extremely difficult - if not impossible - to detail the general characteristics of technologies, due to the fact that production systems differ from industry to industry and even within a certain industry. Quite a few mathematical models have been developed to describe the behavior of an industry, e.g. the oil industry. But the value of those models for the explanation of industry's behavior concerning the adoption of new technologies is only moderate (Läpple, 1978, p. 284). Assume that there are two different technologies for the production of a certain product, one of which is relatively more energy consuming than the other one. Without specific knowledge about the production system of a firm, there is no way to anticipate which of the two technologies will be applied. For example, the more-energy-consuming technology might produce valuable by-products which far outweigh the cost advantages achieved by using the less-energy-consuming technology.

In the screening and evaluation of NASA generated technology it is valuable to know about the factors described above. It is extremely difficult to achieve such detailed knowledge on an industry-by-industry basis. In this context, technology screening/evaluation using a team approach would be a valuable asset in gaining knowledge about those characteristics of specific technologies which are relevant to the technology transfer process.

o The degrees of technical and business alignment between industries is an important parameter in the technology transfer process. It is reasonable to assume that the less alignment between industries exists the less likelihood there is of successful technology transfer between industries, and the more important technology transfer programs become in promoting the transfer process (see also: Kottenstette, Rusnak, 1973, p. 106). Therefore, knowledge of the degree of technical and business alignment between industries is essential to planning technology transfer programs.

o Due to the fact that each field in science and technology has developed its own information channels and has created individual problem-solving methodologies, there exist interdisciplinary barriers. Normally, people not trained in a special field are unable to communicate with people who are. The party unable to understand a certain professional language may be unwilling or unable to learn this language. Consequently, there exist barriers between fields in science and technology. The difficulty of overcoming interdisciplinary barriers can be assessed by analyzing an interdisciplinary field. In the American Journal of Operations Research about 10% of published articles are of interest to a special target group but actually only 2% to 4% reach this target group (see: Pierskalla, 1979, p. 8) due to "language" problems.

Of course, to overcome those problems specialized journals can be issued. The Operations Society of America is doing this, for example, by issuing the Journal of Transportation Science. Within this Society there are plans to pursue this approach in other areas by issuing journals on such topics as public systems and marketing (Little, 1979, p. 4). NASA uses a similar technique when it issues bibliographies in areas such as Aerospace Medicine, Biology, Earth Resources, and Energy.

This approach, issuing journals in selected areas, has limited advantages. It is impossible to issue journals in all areas of potential interest and, furthermore, people are often reluctant to use new journals.

A different approach could be adopted. Rather than issue journals, it is possible to develop close relationships with societies already covering a certain field and publish articles in established journals. A team approach to technology screening/evaluation is based upon strong relationships with organizations which cover different areas in science and technology. Doors to these areas would then be opened.

o Estimation of the relative efficiency of a new technology in comparison to already existing ones is an important factor to take into account. Often a new technology offers few or no advantages in terms of technical and cost aspects when compared to those already in use (see also: Cooper, et al., 1973, p. 56). Sometimes engineers need a substantial amount of time to find out efficient ways to operate a new process. This is particularly true for chemical process industries due to the absence of a comprehensive understanding of the production process in many cases.

Often, technologies already in use experience substantial improvements when a new technology is expected to enter the market. For example, the slow diffusion of the steam engine in the United States was caused by improvements in water-wheel technology (Rosenberg, 1972/73, p. 24). Estimation of "switch-over-points," and the efficiency curves of old and new technologies, is a difficult task. In most commercial enterprises, it is rare that a new technology can be used with great success immediately. This situation delays the use of a new technology. The knowledge of this delay is of major interest due to the fact that the new technology might itself become obsolete prior to implementation.

o In some cases one would fail in judging the value of a new technology without analyzing its <u>"neighboring" technologies</u>. To some extent, each technology is dependent on other technologies. For some new technologies, essential neighboring technologies might not be available. Consequently, one must overcome numerous bottlenecks (Rosenberg, 1976, p. 125). Often, efficient technologies cannot be used because "parallel necessary technology did not arise elsewhere." (Locke, 1978, p. 25.) It takes time to make neighboring technologies available due to the fact that 6 to 10 years are often required to develop a process from pilot stage to industrial scale. If such bottlenecks are anticipated, one can initiate appropriate steps to make the new technology more readily available for applications in the commercial area.

o In almost all cases production technology is <u>capital-intensive</u>. If an industry is dominated by a small number of big firms, they might agree to ignore a new technology in case it would cause a major impact on existing production technology. A study of Du Pont rayon plants points out that delays in applying new technology stemmed from the fact that the new technology required new investments (Hollander, 1965, p. 199). If capital goods already in use are relatively new and characterized by long life cycles, the long-run cost advantages of a new technology might be outweighed by short-term financial returns (Ray, 1969, p. 45).

The behavior of the American steel industry in the fifties can be cited in this context. Although the oxygen furnace process had proven superior to the open-hearth process in Europe (Gruber, 1969, p. 43), the U.S. Steel industry switched over to the oxygen furnace process relatively late. The capital intensiveness of the production technology seemed to be a major reason for this delay (see also: Gruber, 1969, p. 49, 50). A spokesman for the U.S. Steel Corporation said that: "Nobody who has efficient open-hearth furnaces is going to throw them out to buy oxygen furnaces. We waited until we needed to replace old capacity." (in: Ray, 1969, p. 45.)

On the other hand, if a new technology is able to overcome bottlenecks in an existing production system and thereby offer incremental change compatible to the existing technology, it is likely that such a technology would be used immediately. An investigation performed by Wright points out that industry's interest regarding those NASA generated technologies offering improvement on existing technologies was nearly eight times greater than industry's interest in technologies not compatible to those already in use (cited in: Chakrabarti, 1972, p. 7).

o An important factor in technology transfer is the comparative advantage a firm gains in using a new technology. In judging contractual arrangements one should take into account that "the smaller the variation in comparative advantages among prospective innovators of the same idea the less will the exclusive right to invent be worth, even if the returns were fully capturable" (Cheung et al., 1976, p. 19).

Regulations requiring mandatory use "of the best available technology" are also an important consideration. In a case where a new technology will turn out to be a "best available technology," an innovator will not enjoy a comparative advantage due to the fact that other firms are forced by law to follow. Furthermore, other firms then have an incentive to hinder potential innovators (Hill, 1975, p. 139).

Another case to consider is a major change of the production technology in an entire industry branch. At present, some 80 percent of products in the chemical industry depend on oil. To switch to coal, major changes must take place. If one firm goes ahead it will face tremendous risk. Other firms, choosing the "second is fastest" strategy, would gain technical knowledge by monitoring the research work of the innovator (Thurow, 1978, p. 70). They will follow only if it is economical to do so. The first firm may not gain substantial comparative advantages. If one is able to anticipate such factors, one can arrange appropriate steps; for example, joint projects between NASA and all major firms within an industry branch, or an industry association.

o New technologies are both market-creating and market-destroying. Market-destroying effects will be greater the more existing technology is integrated into the production system. It is important to realize that it is insufficient to assess those effects only at the firm level. For example, replacement of pesticides might impact the cosmetics industry because both industries use common raw materials. Also, restrictive sulphur emission standards caused oil companies to develop technologies to produce sulphur out of their residuals. Consequently, medium-sized firms which produced sulphur out of elementary sulphur were nearly eliminated. Finally, West Germany experienced labor strikes due to the introduction of text processing technologies. Printers were frightened of losing their jobs overnight.

Attempts of oil companies to achieve control over competitive uranium and coal technologies "may be seen as attempts to assure long-term market control by minimizing the potential threats arising from technological breakthroughs in the provision of substitute products." (Rosenberg, 1976b, p. 533). A recent example is the behavior of the electric utilities towards solar power due to the fact that such a decentralized energy source does not fit the structure of existing centralized power line networks (Commoner, 1979, pp. 69-71).

Those examples clearly show that the market-destroying effects of a technology may lead to the non-application of a new technology or at least a delay in the diffusion process. In assessing the value of a new technology, it is important to keep in mind that it must "become an element of the socio-technological fabric" (Hoelscher, Hummon, 1977, p. 78) and for a firm "of the various kinds of environmental change, few are more pervasive or important than technological change" (Cooper et al., 1973, p. 54).

o <u>Regulation is an important factor to take into account</u>. A major influence is expected from regulations implemented in the form of so-called design characteristics. A firm may feel it is inconvenient to try to change governmental rules for the benefit of a minor improvement and thereby will not use a technology which only leads to moderate benefits.

However, careful analysis can help anticipate industry's behavior. Regulation causes technology arrestment as well as technological advance. One of the industries most affected by environmental regulation is the chemical and allied products industry. This industry claims that this kind of regulation leads to a decline in capital productivity due to the fact that investments for reduction of emissions decrease the amount of capital used for the production line. This argument holds true, but only assuming that no technological advances are made. Indeed, under this assumption a substantial quantity of capital has to be invested for the treatment of residuals without any benefit for the production processes. An investigation performed in West Germany (Meissner, Hoedl, 1978) showed that industry has strong incentives to change this "unpleasant" situation, and one efficient means to do so is to change the production technology. In this case, regulation caused a need for new technologies. In general, only detailed analyses will lead to a well balanced judgement about the impacts of regulation on technology transfer.

o Another extremely important factor is the <u>relation between the development of a technological innovation and the development of the diffusion process</u>. It seems reasonable to assume that industry will slow down the adoption of new technologies if the speed of innovations is high. This assumption is based on the fact that firms face the danger of investing in "soon-to-be-obsolete technology." (Rosenberg, 1976b, p. 534.) While such a pattern might be characteristic of a lot of cases, it does not hold for all. In the computer industry, important innovations are characterized by a diffusion time of 3 to 5 years; innovations of less importance are delivered to the market within 1 year. Firms must be heavily active in R&D in order to achieve a competitive position in the market (Dunn, 1979, pp. 3-4).

Competition is a strong force in promoting the application of new technologies (Gruber, 1969, p. 40). In assessing rates of innovation and diffusion, competition should be taken into account.

o Dependent on its <u>stage of development, a firm shows different responsiveness to different kinds of innovations</u>.

Utterback offers the following model for explaining this phenomena (1976, p. 36):

During the first stage, development is based on product change primarily. Consequently, product innovations have priority over process innovations. Based upon experiences, e.g. in the semi-conductor industry, firms concentrating on process innovations in this early stage face the danger of improving the production-technology of a product which soon becomes obsolete.

The second stage finds established firms in an industry looking for process innovations. These small changes, compatible with the existing production system, reduce costs of existing products.

In the last stage, established firms have an incentive to delay major technical changes because of the inflexibility of capital-intensive production systems. It might be possible to obtain such knowledge by monitoring the development of an industry.

Those factors influencing technological change mentioned above provide a few hints; the list is neither complete nor exhaustive. Yet, the rather brief discussion showed the importance of those factors and the difficulty of exploring their impact on technology transfer. To make technology transfer more effective, however, knowledge about such factors seems to be essential (see also McClain, 1976, p. 116). Therefore, I will now explore the impacts of such factors on the secondary utilization of aerospace technology. Anticipation of those impacts is a necessary condition for choosing appropriate steps in "putting technology to work."

2.2 Factors influencing technology transfer from a government R&D agency to industry.

The factors discussed above are generally important. Those factors analyzed in what follows are of particular interest if the transfer process takes place between a governmental agency to industry. The analysis will focus on such factors important to NASA's TU program.

o For the successful introduction of a new technology the relation between innovation and innovator is most important. Therefore, many firms have adopted a procedure whereby the innovator becomes the product manager for his own product. This reflects the fact that an innovation needs a key individual who pushes it from innovation to commercialization. An empirical investigation of NASA generated technology further points out that the involvement of the innovator in the usage of the innovation is important for success (Chakrabarti, 1972, p. 28). Furthermore, an investigation of federally funded demonstration projects showed that in cases where the project initiative originates from nonfederal sources, the diffusion process is better than projects initiated by a federal agency (Baer et al., 1976, p. 48).

o Psychological barriers to the use of government information and technology and, to some extent, the restricted availability of government information must be taken into account. Up until now industry has hesitated to use governmental information and technology. There is - justified or not - a concern that government might try to influence its activities or at least monitor requests. This problem is reinforced because NASA's data base is not as easily available as other federal data bases. But it seems likely that such barriers can be overcome. A DRI study points out that users, if they have once used NASA services successfully, are likely to do so in the future. A review of the number of users of NASA's data base appears to show an educational process taking place.

Concerning the restricted availability of NASA literature, it is worthwhile to think about improvements. It normally takes a user 1 to 2 weeks to receive the printouts of a literature search service. The information is rarely published in widely available professional journals. Instead it is published in NASA journals which are in most cases only available in NASA Centers and through the National Technical Information Service. Consequently, it takes at least one to two months before a user receives the information.

Further, it might be valuable to improve the "On-Site" literature search service. An intelligent user should be able to screen the information while sitting at the terminal; under current conditions, it is too time consuming to do so. To improve the procedure, "touch-panel" terminals could be installed at the Industrial Application Centers. Those industries remote from the aerospace industry are more likely to be attracted if access to NASA information is made easier.

o <u>The value of NASA generated technology</u> is of critical importance. NASA's philosophy - especially that of the IAC's - that it is wasteful "to reinvent the wheel" - is often not accepted by industry regarding NASA generated technology (see e.g. Olken, 1972, p. 617). It has been argued that NASA technology is the result of reorganizing what was already at hand, that is to say NASA technology lacks novelty. Miniaturization was a new concept in the sixties but is now a well-known design technique. In general, government information is characterized by the label: too much, low value.

To counter such labels, many factors must be explored. At first, it is quite natural that "massive-mobilization R&D projects" (Thurow, 1978, p. 30) like Apollo and the Space-Shuttle can be successfully performed only if the basic knowledge about the technologies employed already exists.

This means that NASA technologies are in a much more advanced application stage. This should not be confused with the value of such technologies. This situation reinforces the need to develop a technological classification scheme which separates basic knowledge, engineering-application knowledge, etc. This classification scheme would enable NASA "to shoot" at appropriate target groups with efficient transfer mechanisms. It is extremely important that a rapid transfer of engineering-applications takes place due to the fact that such knowledge rapidly becomes obsolete. In such cases, it is not a question of technological availability but of whether the technology is known to all potential users. This leads to a second important fact. A certain technology might be well known; a special technique might be general knowledge in one industry, but there is no way to know if this knowledge is available to other industries as well. Vertical technology transfer, a process within one industry, works quite well. In contrast, there are no established mechanisms for horizontal technology transfer, a process which takes place across organizational and industry borders. Kottenstette and Rusnak describe these three caveats (1973, p. 106):

(i) "Firms have varying degrees of technological alignment with aerospace and their relative alignment is of primary importance in effecting secondary utilization."

(ii) "Increased distance from the aerospace sector (less alignment with aerospace) decreases the likelihood of new technology adoption through diffusion."

(iii) "Increased distance from the aerospace sector implies that a planned effort is required to provide access to the aerospace technology."

Communication between firms is important to the transfer of technologies (see Utterback, 1971, p. 82, 83). To estimate the value of aerospace technology for other industries, one might use an "alignment structure" plan: (described below) and organize transfer efforts around such a plan.

Such an alignment structure plan can be illustrated in the form of a graph or a matrix which describes relations between firms. Such an approach was used by Czepiel (1975) to explore the diffusion of the continuous casting process in the steel industry. The arcs in the graph, or the elements in the matrix, represent two kinds of flows--material and information. It is valuable to consider firms and other organizations of the private and governmental sector which influence the technology transfer process. That is to say, the alignment structure plan should represent the entire "technology delivery system." The main components of a technology delivery system are: source of R&D funding, R&D performers, material supplier, manufacturer of the capital goods, producers of the product, distributors, ultimate users (see also: Yin, 1978, p. 13).

In exploring the value of NASA technology for industry one should keep in mind that this technology has been developed for NASA mission-oriented R&D projects. This is to say that the technology is not developed in a commercial environment. There is a trend, as in the military field, to produce such technologies as soon as it is technically feasible. Technical feasibility is no guarantee of commercial success. Of course, there are a lot of fine, commercially successful technologies, like integrated circuits, jet airplanes, etc. But there are other cases, like the nuclear-driven ship.

To sum up, estimating the value of NASA technology is not easy; it requires knowledge or at least three primary components. First, the stage of technological development, from vague ideas to prototypes. Second, the relation of other industries to the industry generating the technology. Third, the commercial "shape" of the technology.

o Aside from the specific value of NASA generated technology the <u>value of externally generated information about technologies in general</u> has to be taken into account. Many firms believe that externally generated knowledge, when compared to its own R&D, is not as unique as is often claimed (VDI, 1979, p. 18). It is important to realize that in any case the firm must check the information. As a result, the value of a Tech Brief is known to a firm only after a check of its content; that is to say, after the firm has invested time and money (Johnson et al., 1977a, p. 11).

Refusing to adopt externally generated technology seems to be typical of U.S. firms, at least when compared to firms in Japan and West Germany. There is some feeling that "an overall increased sensitivity to and utilization of outside technology must be developed..." (Gee, 1978, p. 212). In general, such behavior is caused by factors described in the previous section. For example, in chemical industries there are huge and complex integrated production systems. The change of one element might impact on many other elements. Therefore, incremental improvement is typical; major changes of the production technology tend to be delayed. Major new technologies are often created outside the established firms but are, in many cases, neglected due to the large capital investment in existing technology (see also: Abernathy, Utterback, 1978, p. 41). Firms in the U.S. have also been reluctant to undertake cooperative programs. While these programs are quite common in Europe only a few exist in the United States (U.S. General Accounting Office, 1978, p. 58). In the future this problem might be partly eliminated. The experience of MIT after working with industry under a NSF grant for several years indicates that once firms "enter into cooperative research, they discover that it does not threaten their competitive position" (U.S. General Accounting Office, 1978, p. 60).

The factors discussed above are only a few out of a large set. It is not intended to provide a complete list. An attempt was made to demonstrate that government R&D agencies face specific difficulties in promoting technology transfer, difficulties which add up to those confronting technology transfer in general.

2.3 Summary evaluation of factors influencing technology transfer.

After having discussed factors influencing technology transfer in general and in particular those factors influencing transfer from a government R&D agency to industry, a short summary is provided in the following:

Factors Influencing Technology Transfer in General	Factors Influencing Technology Transfer from Government R&D Agencies to Industry
o relative efficiency of new technologies compared to those already in use	o psychological barriers to use of government generated information and technology
o availability of neighboring technologies	o value of NASA generated technology to industry
o capital intensiveness of new technologies	o relation between innovation and innovator
o value of externally generated information about technologies	

Factors Influencing Technology Transfer in General (Cont'd)

- comparative advantage achieved by the entrepreneur
- market-creating and market-destroying characteristics of new technologies
- interdisciplinary barriers
- technical and business alignment between industries
- major changes of the production technology in a whole industry branch
- regulation

All of these factors may influence technology transfer in a negative manner; at least to delay adoption of a new technology. Therefore, to solve the application problem described in the introduction of this paper, it would be extremely useful to explore NASA technologies with regards to such factors. If the results of such investigations are added to information about a certain technology, benefits might be achieved. In case a new technology is announced by NASA, it might be useful to know to what degree this technology fits current industrial patterns. One can identify material suppliers, producers of equipment, etc. which are able to supply the technology. Such knowledge--gained by exploring factors influencing the transfer process--provides a basis from which to choose the right steps to put a technology to work. To some extent, such value-added functions are performed by staff members of the Industrial Application Centers. Users of the IACs' services can be directed to other organizations working in a certan field. Furthermore, staff members of the IACs provide valuable information concerning market analyses. In order to realize a real breakthrough in technology transfer such services should be provided on a comprehensive basis.

Under current conditions the screening and evaluation process concerning the Tech Brief is performed mainly by the Technology Utilization Officers at the single NASA Research Centers in conjunction with the Illinois Institute for Technology Research Institute. The screening/evaluation process employs the following criteria:

- marketing potential
- novelty
- technology
- nonaerospace potential

If an in-depth analysis of the factors influencing technology transfer is performed, it is likely that procedures can be developed providing for substantial improvement in the screening and evaluation process. Concerning the screening and evaluation criteria of "marketing potential," the following procedure might be developed.

- <u>Marketing Potential</u>

Market Destroying Effects	o Identification of already existing technologies to be replaced in part or in total.
	o Anticipation of improvements of technologies to be replaced.
	o relative efficiency of existing and new technologies over time.

Market Destroying Effects (Cont'd)	o	Estimation of future rate of innovations concerning the new technology.
	o	Necessary reorganizations of existing production systems to integrate the new technology.

As mentioned before, new technologies are both market creating and market destroying. The market-destroying effect is important in the development of market-potential estimates. First, existing technologies which are likely to be replaced in whole or in part should be identified. In many cases those technologies already in use undergo substantial improvements if a new technology is expected. Therefore, such improvements should be anticipated. Such investigations establish a comparison of the relative efficiency of the technologies already in use, and the new technology to be introduced. This relative efficiency is one of the important decision criteria in determining if a new technology will be used. Furthermore, the potential for further technological innovations should be checked due to the fact that industry is reluctant to invest in soon-to-be obsolete technology. Also, necessary reorganizations of existing production systems in order to integrate the new technology should be considered.

The information dissemination process might be made more effective if the dissemination strategy were based upon a structure alignment plan which indicated to what extent organizations influencing technology transfer are linked together.

After discussing a screening and evaluation procedure which takes into account factors influencing technology transfer, I will undertake an analysis of policy options to enhance technology transfer.

Technology transfer has often been described as "technology push" or "demand pull." Most empirical studies point out the superiority of demand pull. However, R&D agencies, like NASA, are likely to push technologies. New technologies need pushing in order to overcome barriers, especially in early transfer phases. Often R&D agencies fail to push a new technology when industry has a need for it. In exploring factors influencing technology transfer, as mentioned before, NASA should incorporate industry's needs in its information dissemination policies. The outcome of this approach would be a mixed policy, linking technology push and demand pull. This approach is in line with recent findings. An investigation performed by Mowery and Rosenberg (1979) provides an in-depth analysis of eight of the best known empirical studies on technological innovation which all support the demand pull policy. The authors of the investigation, in analyzing these empirical studies, claim that "the role of demand has been overextended and misrepresented, with serious consequences for our understanding of the innovative process and of appropriate government policy alternatives to foster innovation" (Mowery, Rosenberg, 1979, p. 3). In the conclusion of their study, the authors point out:

> The existence of an adequate demand for the eventual product is, of course, an essential--a necessary--condition. But, we suggest, the demand pull approach simply ignores, or denies, the operation of a complex and diverse set of supply side mechanisms

> which are continually altering the structure of production costs (as well as introducing entirely new products) and which are therefore fundamental to the explanation of the timing of the innovation process.
>
> At a more general level, the conceptual underpinnings of the "demand-pull" case are perhaps even more fundamentally suspect. Rather than viewing either the existence of a market demand or the existence of a technological opportunity as each representing a sufficient condition for innovation to occur, one should consider them each as necessary, but not sufficient for innovation to result; both must exist simultaneously. (Mowery, Rosenberg, 1979, p. 57.)

In sum, successful technology transfer must be based upon both technology-push and demand-pull (see also: Hoelscher, Hummon, 1977, p. 82; Gilpin, 1976, p. 170).

As such, NASA might consider the "timing of publishing." To push a new technology at a time when industry has an urgent need is likely to produce more success than announcing a new technology at any time. An empirical study of NASA generated technologies published in a TECH BRIEF points out, that "the degree of urgency of the problem to which the technology was related seemed to be an important factor..." (Chakrabarti, 1972, p. 162). At a time of low gasoline prices, where no substantial change is expected, it is not appropriate to push electrical automobile engines. But when gasoline prices are increasing, industry might well be responsive.

Of course, one might argue that it is not NASA's task to explore industry's needs and that NASA should announce new technologies when they are produced, making sure that the information can be retrieved by industry at any time. Nevertheless, hitting the right target group at the right time with the right information might lead to more effective technology transfer and "timing of publishing" might be a method worth considering.

In general, incorporation of users' needs in policies for technology transfer is essential. This kind of approach is now commonly employed by R&D funding organizations (Yin, 1978, p. 12, 13); NASA's TT program is an example. It is not a question of whether or not a government R&D agency (like NASA) should employ such an approach, but rather it is a question of how to implement it.

3. Assessments of Arguments for a Team Approach to Screening/Evaluation

3.1 Advantages of a team approach to screening/evaluation

The objective of this discussion is to describe possible positive effects on the technology transfer process of technology screening/evaluation using a team approach.

- One main advantage of screening and evaluation by a team of industry/government individuals is that this approach may come to grips with everchanging factors which influence technology transfer. The discussion in previous sections has outlined the difficulty of determining which factors influence (positively or negatively) technology transfer. Furthermore, underlying cause-effect relations are not constant but change over time and are difficult to anticipate. The author of this paper assumes that a complete understanding of the factors influencing technology transfer will never exist. This is probably the main reason that the vast number of empirical studies on technology transfer have provided only limited help to policy makers formulating policies to enhance technology transfer.

However, an effective transfer system should allow a rapid check of which factors influencing technology transfer are relevant--even in a time of rapidly changing cause-effect relations--and thereby make possible the choice of an effective transfer mechanism. A team approach might fulfill this task because organizations influencing the technology transfer process would participate in the screening and evaluation process. Thus, the opportunity exists for all relevant information to be promptly available. For NASA this approach would provide a valuable opportunity to ask "what-if" questions of extremely knowledgeable and technically capable partners.

o Assuming that other organizations joined the screening/ evaluation process, it is likely that a balanced assessment of the potential value of NASA generated technology would be possible. Furthermore, because most NASA technology is produced under relaxed commercial restrictions, and because technological feasibility alone is no guarantee that a certain technology will be commericializable, industry hesitates "to pick up" such technologies.

Also, shortcomings in technology transfer occur because potential users lack relevant information concerning commercial feasibility (Udell, Johnson, 1978, p. 177). With the help of other organizations, NASA might be able to provide such valuable additional information and thereby increase the probability of successful transfers.

o An important "by-product" of a team approach to screening/evaluation would be access to other transfer mediums. In case a professional society participates, one might think of announcing NASA generated technology in a variety of ways:

- in a professional society journal
  - under NASA's name
  - anonymously
    - as a standard publication
    - in an "innovation column"
- in a journal issued by both NASA and the professional society, etc.

There are many possibilities. The outcome of such options would be (amongst others):

- a higher reputation for NASA technology because the reader would consider NASA information as competitive with other information announced by a professional society
- better access to NASA information

Concerning access to NASA information, it was mentioned previously that under current conditions NASA information is not that easily available to a potential user. Most information is only published in NASA journals, such as contractor reports, and it often takes a month or more to receive them. That is too long a time lag for serious inquiries. In contrast, professional society journals are available everywhere, and it is likely that a potential user of NASA generated technology would be a regular reader of such journals.

Further, technical information is only one factor in stimulating technological innovation. Education, training and experience also play an important role in that they prepare target groups for new technologies (Utterback, 1971, p. 80). If universities and professional societies joined the screening and evaluation process, it would create an opportunity to disseminate NASA generated technology by means of training and education. In the long run this might lead to a substantial increase in technology transfer. To sum up, NASA technology could be disseminated on a much wider basis using existent and effective non-NASA channels.

o It is possible that the screening and evaluation process itself, through the participation of other organizations, would become a transfer process. This is particularly true when so-called industry "gatekeepers" join the screening and evaluation team (see also: Utterback, 1971, p. 64). This characteristic of the team approach is of substantial importance. Several studies point out that oral communication is an effective means for the transfer of innovations because it provides rapid feedback communication (see: Tushman, 1978, p. 625). However, along with this benefit, there is the possibility that NASA might lose some control of the transfer process.

o Technology transfer is a national goal and is not the exclusive responsibility of any government R&D agency alone. The aim of the transfer process is to improve the nation's economy and is therefore the joint responsibility of all societal groups. Participation of other groups should not be judged as a shortcoming within NASA, but rather as a constructive means to enhance technology transfer.

o Concern about competition between government R&D agencies and industry is frequently mentioned. It is argued that national laboratories engage in "research on technology of commercial significance and thereby directly compete with private industry" (Hollomon, 1979, p. 39). For instance, the McNeil-Schwindler Co. protested NASA's maintenance work on NASTRAN (a NASA computer program), claiming that such work should be performed by private software houses. Evidence is also cited to the effect that commercial R&D performed by a government agency alone might be inefficient (Hollomon, 1979, p. 32; Gilpin, 1976, p. 170). A team approach would establish a forum in which the parties concerned could discuss such problems at an early stage.

o A team approach to screening/evaluation would be effective as well, due to the screening of technologies which have no value for industry. In some recent literature on technology innovation, technology, etc., the need for a team effort to promote technology innovation and technology transfer has been identified and evaluated.

3.2 Disadvantages of a team approach to screening/evaluation.

Since the early sixties, government-industry relations--enforced mainly through regulation--have been of major concern to both parties. All major firms now have at least one full-time Washington, D.C. representative. Industry does not passively accept government procedures. To the contrary, industry plays an active role. Established firms have large, and high-quality staffs dedicated to government relations. One of these tasks is to monitor government agencies' performance and to anticipate their future activities.

Keeping this in mind, it is rather naive to assume that industry would not use the possibility of a team approach to screening/evaluation to try to influence NASA's activities. A possible outcome would be the overidentification of NASA's work with industry's interest. Overidentification of government agencies with industries is a well-known fact. One opinion of the Federal Communications Commission (FCC) states that: "...the root of the FCC's problems is the agency's overidentification with the industries it regulates, its overidentification with the powerful and entrenched elements, in contrast to new and emerging facets or technologies, of the industries regulated" (Geller, 1975, p. 706). In this view, cause and effect are clearly described. Overidentification of a government agency with industry leads to a slowdown of technological advance. This is discussed in greater detail below.

o One of NASA's roles as a governmental R&D agency is to undertake R&D projects with high-risk, long-term pay off, high social rate of return as compared to the private rate of return, etc. Normally, private industry is unlikely to engage in such projects. The lack of private sector initiative in the development of communication satellite technology after 1972, when NASA's efforts were curtailed, is a case in point (see: Office of Science and Technology, 1978, p. 4).

o Some of NASA's projects stem from high priority industry needs. For industry, NASA is a prime source of R&D funding. Potentially a team approach to screening/evaluation could be misused for "doing industry's work."

o Also, the possibility of unfair technology transfer exists. If a team approach to screening/evaluation is established, NASA must offer the body of its knowledge to all participating parties.

o The team approach will only work if an appropriate climate of confidence is created. Members might not express their thoughts if they are likely to read them in the newspapers. Therefore, <u>the team approach might not work under the conditions within which government organizations must operate. Strictly speaking, the "protection of the public interest" is critical</u>. But it is often claimed, for example, that labor unions and "consumer representatives" should join industry committees (see e.g.: Brown, 1970, p. 31). In the past, in connection with follow-up analysis of industry's use of IAC services, NASA has experienced industry's sensitivity to information. The team approach has the potential of indicating to NASA which NASA-generated technologies are of substantial interest to industry; thereby providing a most valuable basis from which NASA can make its information dissemination program more effective. But if the necessary condition of confidence cannot be created, the value of a team approach to screening and evaluation will only be moderate.

o In establishing procedures where other parties join the planning and decision-making of a government organization, one must recognize that the non-governmental members of the team are likely to try to shift the risk of failure to the government agency. On the other hand, NASA cannot delegate its responsibility for secondary utilization of aerospace technology to the team. If the team approach is adopted, NASA must maintain the ultimate responsibility for technology transfer.

A team approach to screening/evaluation then has advantages as well as disadvantages. The disadvantages--at least most of those mentioned above--occur by an overidentification of NASA with industry's interests. Yet, this possibility seems unlikely. Government agencies can be put in two main categories; industry-oriented (e.g. FCC) and functionally-oriented, or crosscutting (e.g. EPA). While industry-oriented agencies may be captured by the interest of the industry they regulate, this may be less likely for functionally-oriented agencies (see also: Weidenbaum, 1978, p. 10). In the secondary utilization of aerospace technology, NASA can be described as a functionally-oriented agency, with the task of transferring technology to all non-aerospace industries. The possibility of being captured by the interests of a single non-aerospace industry exists but does not seem to be a real threat.

3.3 Review of a team approach to screening/evaluation.

Only a comprehensive analysis will indicate the advantages and disadvantages of a team approach to screening/evaluation of NASA generated technology. Critical to the success of such an approach is the organizational structure which provides the basis for cooperation between NASA and the participating parties:

- o Should other participating parties serve as an advisory board to provide suggestions and recommendations, leaving decisions to NASA?
- o Should NASA be only one party among many, that is to say should NASA have no special power concerning decisions?
- o Should NASA and other parties be bound together in an advisory board and the responsibility for decisions be given to another federal organization?

These and other organizational options should be comparatively analyzed.

The advantage of a team approach to screening/evaluation is provided through the direct participation of private and governmental organizations which influence the technology transfer process. It can be assumed that the team approach has particular potential when the operations are based upon people rather than on fixed procedures. Procedures, most valuable for routine tasks, are not appropriate to the exploration of the changing factors which influence technology transfer. But this pattern is twofold, in being dependent on the capability of the individuals joining the team, the performance of team members is a source of potential success and failure. This should be taken into account, especially in the implementation phase. It might be effective for NASA--before announcing the implementation of its team approach to screening/evaluation--to very carefully select individuals who are both capable and willing to perform the task. This selection process might best be achieved through informal contacts, keeping publicity very low. Furthermore, in case this screening/evaluation method is adopted, NASA should resist any moves to demonstrate its potential before the team is stabilized; that is to say, not until all individuals joining the team have accepted their role within the team and a climate of confidence has been created.

4. Potential members for the team.

The intention of this section is to cite and briefly describe organizations which could participate in the team approach to the screening/evaluation. Once again, only a comprehensive analysis can provide in-depth insights.

o One source of participants are industry specific R&D institutes. Besides the R&D effort of specific firms, there are often R&D projects undertaken by all (or the most important) firms within an industry branch. In some industries those R&D activities are institutionalized in the form of R&D institutes, e.g. the Chemical Industry Institute of

Toxicology. This institute is funded by the largest U.S. chemical companies and investigates the toxicology of non-proprietary chemicals (Hiss et al., 1975, p. 97). In West Germany the "Institut der Stahl- und Eisenindustrie," has performed important studies for the steel industry on the development of mathematical process models for control of blast-furnace processes.

Normally, such institutes know the characteristics of technologies already being used and those in research programs. This knowledge would be extremely useful in identifying those NASA technologies having potential value for a certain industry. Furthermore, such institutes might prove useful in aiding NASA's development of prototypes.

o Another valuable organization might be <u>industry associations</u>. Industry associations possess substantial knowledge about the R&D performance of the industry they represent. For example, the association of the chemical industry knows under which circumstances this industry will be willing to switch from coal to oil. Therefore, NASA is able to grasp "what is going on in industry" and to prepare appropriate transfer efforts at the right time. NASA might also gain knowledge about typical industry R&D policies. For example, in areas such as semiconductors, electronic sub-assemblies and scientific instruments, process innovations are not "manufacturer dominated" but "user dominated" (Hippel, 1976; Hippel, 1977, p. 60; Abernathy, Utterback, 1978, p. 42). In other industries, raw material suppliers or the producers of capital goods might dominate innovative behavior. In processing such knowledge, NASA would enhance its ability to address the right target group with information about new technologies.

As mentioned earlier, NASA technology transfer managers may lack "commercial experience." With the help of industry associations NASA might be able to use commercial facts to provide useful value-added technological information.

o The possibility also exists that single firms might join the screening and evaluation process of NASA technology. At first glance, it seems that industry R&D line managers would be highly qualified to perform such work. But difficulties in selecting firms would undoubtedly arise. These difficulties can be avoided through the use of industry associations and professional societies.

o Professional societies might be a valuable organization for screening and evaluating NASA's technologies. In most cases such societies represent a substantial part of professionals working in a certain field, and they generally have good reputations. In some cases those societies already evaluate new technologies and offer education to their members concerning those technologies. Education is important. The mere existence of a technology is not sufficient; a capability to use it must be developed (Gee, 1978, p. 109).

In West Germany, starting in 1978, the Ministry of Science and Technology realized the high potential value of professional societies. The societies perform work similar to that of NASA's Industrial Application Centers.

In an investigation about "diffusion and utilization of scientific and technological knowledge within state and local governments" it is noted that professional engineering societies, e.g. the American Society for Mechanical Engineering, are interested in becoming involved in the area of technology transfer (Feller, Flanary, 1979, p. III-41).

o In some cases it might be worthwhile to think about the possibility of including certain government agencies in the screening and evaluation process, at least on a case-by-case basis. This is due to the fact that while technologies might improve productivity or dampen inflation, they might also have side-effects for health, safety, environment, etc.

The costs of determining if a new technology will obtain regulatory authority approval can be an important factor in the introduction of innovations in technology (Hollomon, 1979, p. 33; see also: Weidenbaum, 1978, p. 17-20). If the concerned government agencies participate in the proposed screening and evaluation process of new technologies, they could facilitate the innovation process. If regulatory information were added to the technical description of a new technology, a potential entrepreneur could more readily assess its commercial prospects.

o Organizations within the <u>university community</u> present another possibility. There are two groups of major importance, scientific and technology utilization personnel. Professors are a very valuable group to have join the screening and evaluation process. Furthermore, in this case it is worthwhile to consider a secondary benefit of using universities. Universities are of substantial importance as a transfer medium and would link NASA directly to the professionals of tomorrow.

One might also think about university technology utilization personnel. In recent years university administrations have explored the revenue generating value of university generated inventions (Udell, Johnson, 1978, p. 175) and by now quite a few universities are active in this area.

Conclusions

Underlying the analysis in this paper is the assumption that the NASA technology transfer could be substantially improved if the application process of technologies were better understood. NASA is successful at information dissemination, but there is a lack of knowledge about why certain technologies are adopted and other technologies are not. A comprehensive understanding about factors influencing technology transfer might indicate ways of developing improvements. By including non-federal organizations, such as professional societies and industry R&D institutes, in the screening and evaluation process of NASA generated technology, opportunities may develop to enhance technology transfer from NASA to industry.

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