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Social Issues and Implications of Remote Sensing Applications: Paradigms of Technology Transfer

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The primary objective of the Social Sciences Group is to improve the state-of-the-art of technology transfer. Main focus is on those manifestations of advanced technology to be found within NASA's Technology Transfer Division. It is apparent, however, that the process of technology transfer transcends organizational demarcations. Much that can be learned about the process and must be fed back so as to implement the policy which gives impetus to NASA's applications programs can be derived from empirical research. Work in the field supplies the real-life dimensions to programs conceived in response to a higher order or level of imperatives. When, for example, we observe the transfer of technology from one federal agency to another, as in the case of the move of Landsat to NOAA, we find an array of unanticipated consequences that will have important impacts on both the process and outcome of the transfer. When the process is studied from the viewpoint of the ultimate recipient, we find a set of expectations and perceptions that will figure more in a final assessment than do the attributes of the technology being transferred. It is clear that, in the process of technology transfer, the technical issues and elements are fairly clearcut and are amenable to customary procedures. Less well known is how to link a technology with a community of potential users. Essentially, this is a question basic to our research activities, report of which follows.

NASA-NOAA Transfer

In a White House Press Release (November 20, 1979), President Carter assigned to NOAA management responsibility for civil operational land remote sensing satellite activities. NOAA's new challanges were manifold. In the first place, the task was technical, command and control of Landsat Multi-Spectral Scanner and Thematic Mapper data. It also involved the dissemination of Landsat data as well as its archiving. In the second place, the task was organizational and conceptual -- a requirement unprecedented in its dimensions. NOAA was to provide the transition between a government-developed technology and some future delivery system; it was to help design the institutional framework for that future delivery system, whatever its sponsorship: private, semi-private, or government. This instance of technology transfer was considered especially significant because it may serve as a model for endeavors of a similar nature.

In essence, NOAA was asked to develop the organizational structure and processes needed to expedite transition between government-sponsored R&D and creation of some "final" delivery system. Because of the precedent-setting propensities of this pioneering effort, we have found it important as a case history, so that its salient factors may be documented for future reference and analysis.

Brief Historical Review of Landsat

In 1972 the United States launched its first experimental remote sensing R&D satellite. Within five years efforts were underway to establish a remote sensing system. In 1977 S.B. 657 was introduced to that end. It was opposed by the Administration, however, as premature. In 1978, President Carter issued two presidential directives. The first, PD 37, dealt with classified and non-classified areas of satellite remote sensing and the second, PD 42, dealt with civilian space policy; it mandated an increase in private sector investment in satellite remote sensing. In conjunction with these directives, the Office of Science and Technology Policy under Dr. Frank Press had two studies carried out. The first, Integration Study, addressed the potential savings from integrating classified and non-classified systems for remote sensing. The second, The Private Sector Involvement Study, explored potential private sector involvement in an operational remote sensing satellite system.

In an attempt to bring pressure on the Administration to take action toward establishing an operational remote sensing system, Senators Stevenson and Schmitt introduced two separate bills which would create an earth resources information service based on an operational remote sensing satellite system. In 1978 Senator Stevenson introduced S. 663, proposing to create the Earth Data Information System as an operational service within NASA for an interim period of 7 years in order to develop institutional, financial, technical and marketing capabilities. This proposal would allow for an evolutionary process in which the technology and institutional arrangements would develop over time. In 1979 Senator Schmitt introduced S. 875 to create the Earth Resrouces Information Corporation by establishing a private corporation which would be regulated by the FCC. Testimony for these bills generally debated the merits of "getting on with it" and letting the market forces create an economically efficient system for delivering remote sensing data. Opposing arguments concerned problems associated with freezing institutional arrangements when the technology was undergoing change and the market not yet identified.

Administration witnesses reiterated the need for future studies and sensitivity to timing while industry witnesses reiterated the need for assurance of continuation and for an operational system with some identifiable institution in charge, whether it be a government agency or a private investment agency. The results of the Private Sector Involvement Study indicated that the private sector, although interested in participating, was not yet prepared to make the level of investment necessary to support a remote sensing system. The study recommended that the Administration not select any option at this time but "make clear its readiness to entertain proposals." In 1979 President Carter directed NASA to transfer Landsat to NOAA and directed NOAA to prepare an Interim Transition Plan.

Background for the Transition

Several considerations motivated the current interest in moving Landsat out of the experimental phase into an operational applications phase.[1] The first two are regulatory in nature: 1) NASA does not have statutory authority to carry out an operational space applications program and can only carry out research and development activities. Because Landsat services appear to have many potential domestic and international benefits which can only be fully realized if Landsat becomes fully operational, there has been increasing Congressional pressure to move Landsat into a fully operational phase. If Landsat is to become operational, either NASA's mandate must be expanded or Landsat must be transferred to a separate organization. 2) International regulations distinguish between experimental and operational frequency bands. If Landsat 1,2, & C become fully operational, they will be functioning on the wrong bands because they were designed to operate on experimental frequency bands. Landsat D, however, has been designed to use the operational frequency band; this implies the need for an institutional framework to support it when it becomes functional.

The third and fourth considerations are institutional in nature: 1) Except for administration assurances, there has been no institutional commitment to an operational program which would take up where the experimental Landsat program leaves off; 2) a transition plan has not yet been successfully implemented. Without assurance of continuation and a viable transition to an operational system, it is hard to judge the potential level of market support and to establish a pricing policy, since neither private investors nor public sector organizations are willing to invest in a system whose future existence is uncertain. Policy makers are faced with a Catch-22 situation: without the existence of ongoing Landsat services, suppliers are unable to judge the potential market; but without a sense of the market, suppliers are not able to determine the level of demand or, in fact, if the service is a worthwhile investment.

Underlying all of these seemingly straightforward practical and technical considerations is a much more complex and intractable issue. There is increasing evidence pointing to declining U.S. productivity, a decreasing rate of technical innovation and a narrowing of our international technological lead in many areas in which we have been unsurpassed. In space, the U.S. is facing competition from France, Japan and the European Space Agency. Awareness of these trends has prompted a poorly articulated Federal policy to promote technological innovation and stimulate productivity. Much of the urgency for getting Landsat services into the private sector is an attempt to transfer a larger share of the costs to the users in order to show a favorable benefit/cost ratio for agency research and development generally and for individual technologies specifically.

The effort to demonstrate productivity can be seen in subtle alterations of space policy. The National Aeronautics and Space Act of 1958 established a three-pronged policy, which called for U.S. space efforts in the service of peace and for the benefit of all mankind; U.S. leadership in space, science and technology; and international cooperation. However, the "purity" of these policy objectives has recently become somewhat muddied. President Carter, in October 1978, issued a statement which introduced some implicit policy modifications to the Space Act by adding emphasis on "uses of space for practical and economic benefit ... (and encouraging) ... the private sector to take an increasing role in remote sensing and its applications."[2] These new themes are a response to the concerns mentioned above and reflect a general agreement on the need to show a higher benefit/cost ratio on government research through careful choice of research areas and through rapid transfer of technology out of government agencies into the private and public sectors. The transfer of Landsat services from NASA to NOAA is, in part, a manifestation of this effort.

If a successful transition is to take place there are some non-technical problems which must be addressed in order to implement a fully operational Landsat system. Several of these were identified in a 1975 report by the National Academy of Science.[3]

- An institutional arrangement is needed for delivering Landsat services for the interim period between the present experimental phase and a fully operational phase.

- The potential market for Landsat data remains largely unidentified and undeveloped. It is disaggregated, scattered, and primarily a market of future users.

- No adequate mechanism exists for communicating the needs of potential users to developers and suppliers.

- There is no assurance of ongoing service delivery because to date there has been no successful implementation of provisions for continuing satellite development after feasibility has been demonstrated.

The NOAA transition plan is an attempt to respond to many of these problems. However, several pivotal assumptions are buried in NOAA's response.[4]

- Remote sensing technology will yield social and economic benefits and should thus be accessible to domestic and foreign users.

- Private sector ownership and operation will lead to increased social welfare to the extent that the private sector is better able to supply services efficiently; is better able to market more aggressively; is better able to stimulate innovation, development and technology transfer; and can be more responsive to user needs.

- There already exists a potential market which is willing to assume some level of risk investment; however continuing government/industry cooperation is necessary.

Several conflicting observations can be noted.[5]

- Motivation for private sector investment tends to be dampened by Federal policy of open access to data.

- There is a conflict between the profit motive which drives private sector investment and public good aspects of remote sensing which cannot be captured by the private investor.

- Private ownership of a U.S. Landsat system would bring private firms into direct competition with foreign governments.

- In the past government agencies have negotiated international involvement in remote sensing and there is no experience which leads us to believe that industry-based negotiations will be possible.

- The private sector generally neglects long range research and development issues. In fact, this has been borne out by experience in commercial communication satellites.

The Transition Plan

The NOAA Transition Plan, entitled "Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options" (June 20, 1980), is a proposal for an interim institutional framework for delivering Landsat services. This is eventually to be replaced by private ownership and operation. The question that might usefully be raised at each step is: will the proposed activity lead to achievement of the underlying policy goals? We might begin by examining the input-output model, which although convenient, is not appropriate.

Throughout the transition plan, policy makers have been guided by an input-output model of the process. They have then taken the next step and assumed that the analytical characteristics of the model can be applied to the real-world process. This is a case of using a model to provide insight into a complex process and then falling into the trap of believing that characteristics of the model *in general* are true of the case *in particular*.

NOAA policy makers, having adopted an input-output model, then identified a list of inputs and outputs which, appropriate to the model, could be manipulated as policy variables. Input-output models have some convenient features. If the process is understood, planners can maximize output. All inputs can be exchanged at the margin until the contribution of all inputs is equal. When this is achieved, resources are allocated in their most efficient distribution and social welfare is improved. The inputs and outputs NOAA chose were a vague set of economic indicators which were supposed to function as surrogates for a complex process. From this flowed a set of assumptions about the way people will behave.

Here, some general observations on the role of indicators in model-making might be apropos. The validity of an indicator is determined by whether it measures what it is supposed to measure. The choice of what to measure is, however, based on a concept of the process one is trying to understand or manipulate. Is it a good concept or model?, i.e., does it simulate the right aspects of the process? Again, what is selected to be in the model reflects the policy-makers' values.[6] As a consequence, although a model can simulate the way the world really works, it usually simulates the way the people think the world <u>should</u> work or the way it would be <u>convenient</u> for it to work. In the present case, the model is an input-output model which through manipulation of the ratio of inputs can be made to be efficient. The underlying beliefs are that improvements in economic efficiency will lead to increases in social welfare and that private sector participation leads to increased efficiency.

NOAA chose several indicators to use in measuring input and output. Willingness-to-pay and to take financial risk are the inputs and various technical capabilities are the outputs. NOAA's emphasis on willingness-to-pay, to assume economic risk, and to identify technically detailed user needs in the operational period implies an understanding of the process of technological innovation and the process for improving productivity. However, for technological innovation and basic research, the results are often not physical output, but rather the conceptual input <u>into some other process</u>. The notions of input and output are not appropriate when applied to research and technological innovation.[7] It is the process and social context which are important.[8] Research reveals that there are no good models for the process of innovation and productivity. There are no objective measures to assess technological innovation.

Not surprisingly, NOAA's policy goals are so vague and value-laden as to elude a workable answer to the question asked earlier: will the proposed activity lead to their achievement? For example, the transition plan states that NOAA should "ensure that the operational system meets (user) needs to the maximum extent possible, given user willingness to reimburse ..." How could NOAA know if it were approaching a maximum or if tomorrow's efforts were better than today's? What measure would NOAA use? The transition plan states that NOAA should operate a system that "responds to programmatically justified user priorities". How would NOAA know if one set of criteria were better than another for ranking needs with respect to the first policy goal of meeting user needs to the maximum extent possible? NOAA is to implement the President's goal by "pursuing appropriate pricing and market expansion efforts." Again, these are vague and evaluative policy objectives that imply that it is possible to tell if you are doing better today than you were yesterday, that the process has identifiable inputs which lead to measurable outputs. These words and the underlying concept indicate that the model of science and technological innovation does not accurately describe the process NOAA is trying to improve.

The Transition Plan states that in addition to managing the technical system NOAA should carry out four activities, each of which we will now examine in detail.[9]

(1) "Evaluate the data requirements of users." In order to evaluate the data requirements of users, the evaluators must know who the future users will be. Additionally, the future users must have clear operative goals and understand their needs with respect to those goals. These assumptions are rarely met in the case of innovative and rapidly changing technologies.

Much of recent organizational theory tells us that an organization's operative goals or its day-to-day procedures for producing its product or service are developed in response to available technology.[10] System goals, however, may remain constant and independent of technology. For example, the system goal of a hospital may be to cure illness. How this is carried out on a daily basis depends on how the hospital staff conceptualizes the nature of disease and the technology available to it. Changing notions of disease have interacted with available technology and resulted in a variety of methods for "curing" illness. Thus, although an organization may have a clear system goal, its operative goals appear to develop in some iterative fashion with the available technology. The formulation of its operative goal -- how to produce its product or service -- largely determines which needs are specified.

An example using Landsat data will demonstrate. Resource managers had an operational goal, which can be stated as "to allocate efficiently available resources toward controlling fire." Once resource managers learned that remote sensing could provide data on vegetation patterns which could be superimposed on slope data, they could use this new combination of information to allocate resources for selectively cutting vegetation in order to control fire. The operational goal did not dictate the need for either information on vegetation or slope. Once the combination of information was available, then managers recognized the new capacity and developed a slightly modified operational goal: efficient allocation of resources toward clearing vegetation as a means for fire control, and as a result, they had a clearly defined need for this new type of data.[11] <u>Needs identification, operational goals and technology appear to be iterative and interdependent. So the requirements of users largely emerge as a result of being a user</u>; future users may not know who they are or what their needs will be.

One of the interesting observations about technical innovation is that the organizations which appear most able to use a new technology are not among the first to recognize the new applications or enter the new markets. A recent example of this phenomenon is the current microprocessor revolution. The small innovative firms developed the new applications of microprocessors, recognized the undeveloped markets, and produced pocket calculators, personal computing systems and digital watches.

This is largely because the organizational structure required for efficient production of standardized products and services is not the arrangement of people needed for taking advantage of new technology and new markets. Relying on current users to develop an understanding of the needs of future users for a technology which will not be fully developed for several years will result in an understanding of needs that reflects past experience and relies on present values. It will probably be the small entrepreneureal firms that will recognize the new uses and markets. They do not exist now because they develop quickly in response to new opportunity.

Relying heavily on the evaluation of users' needs may result in a system which is conservative and backward-looking. The process runs the risk of being inflexible and unresponsive to the innovative behavior that will eventually allow the system to be cost beneficial. The essence of the problem was described by Dr. Frosch in a NASA Management Colloquim at Goddard Space Flight Center in 1978:[12]

> The problem is that we are in the business of producing change; and that leaves us in the paradoxical position that because we are trying to produce change, and looking at the history of change, we rapidly conclude that of course, the really interesting changes are the ones that are not predictable from past experience.
>
> The ones that are predictable from past experience, anyone can predict, with the relatively simple prediction mechanism, either linear extrapolation or fancier forms of Fourier extrapolation, or decision theory, or what-have-you. All of these forms of extrapolation suffer from the difficulty that you can only extrapolate for a time or distance into the future along the curve which is roughly inverse to the bandwidth of the problem, to the amount of information or difficulty or breadth of the problem.

> Since you are usually interested in broader problems, the predictability is rather short in time. Interesting things happen because there are discontinuities; because somebody changes the idea of not only how to solve the problem, but what is the problem to begin with ...
>
> There is a kind of folklore about how one does applications, which is common in Washington. It is the folklore that says "solutions looking for problems are a bad thing; what one ought to do in the applications business is find out what the problems are and figure out how to solve them."
>
> ... I think there is good historical evidence that this sometimes happens but that the solution of existing problems is usually done whether fairly straightforwardly or not at all successfully until something else changes. It is at least as likely that some brand-new idea turns up which has apparently relatively little to do with the stated problem, except that it will frequently change the problem by abolishing it and replacing it by some other problem.

The important point Dr. Frosch is making is that the interesting and important problems will come about because of discontinuities or because of new conceptions of problems. Any simple prediction or extrapolation into the future will identify only the most obvious straightforward solutions to relatively simple problems.

To the extent that the operational Landsat system is designed to respond to the expressed needs of current users or even to the predicted needs of current users, the system will be less able to meet the needs of future users. To the extent that the operational system is inflexible and designed explicitly to address present problems, the system will be less able to supply the information required for addressing the problems which will arise out of discontinuities and the redefinition of problems.

The process NOAA uses now to identify users and user needs will determine who the future users will be. This is the case because the system which will be put in place will be designed to respond to the users which will have been identified. Who the users are now appears to be determining the process by which NOAA is identifying future users. To ascertain user needs and views NOAA sponsored five conferences during March 1980. The conferences generally presented an overview of the present Landsat program and described the future roles of NOAA and NASA with respect to the transition period. User needs were assessed through group sessions and a questionnaire. A report on the conferences and analysis of the questionnaire were prepared by Metrics, Inc.

The number of people who attended the conferences was small and the sample was heavily weighted in favor of government representation. Forty-eight percent of the total number of registered participants attended the Washington conference, and only 38.9% of the participants of all five conferences were from private industry or non-profit organizations. Additionally, companies frequently sent multiple representatives so the total number of participants overstates the extent of industry representation.

The main needs assessment tool was the questionnaire, which asked for technically detailed information, and much of it inquired about user needs after 1988. The questions required the user to understand clearly present and future needs for Landsat data and in several cases to understand the alternatives available. In fact, the questions could only be answered by people who were already active users with well-defined needs. For example, in Part I users were asked for their highest priority programmatic category after 1988; optimum and minimum spatial resolution and spectral bands in the operational period; data acquisition areas and times and operational delivery times; proportion of services which users would have purchased at various prices. The narrative section of Part I asked for changes and/or new products which they now required or would require in the future and a description of their research and development needs not presently being met. Part II referred explicitly to needs in the operational period and asked for performance parameters, relative importance of satellite data to the organization, optimal and minimal values for spatial resolution; estimate of the number of MSS scenes to be acquired annually, and the proportion of scenes which would be acquired on computer compatible tapes and the proportion on film.

The answers to these questions assume a clear idea of how the organization will use Landsat data eight years into the future. Few businesses know what their product mix will be eight years into the future, or what prices they will be willing to pay for the factors of production. Some very innovative and rapidly evolving industries, like the microprocessor industry, cannot even tell what generic products they will be producing in a year or two. No matter what kind of statistical analysis is carried out on the answers to these questions, it can only be based on the information that is there, not on information that is omitted (which is often much more important). Statistical analysis over-emphasizes the value of specifically what is known. Drawing inferences about user needs from such a small sample of specific bits of information is poor statistical practice and misleading as a guide to policy.

The format of the questionnaire forced respondents to appear more certain than they were and to present qualitative information in numerical or quantitative form. In order to respond sensibly to the questionnaire the user had already to be an active consumer of Landsat services. Any inferences made about user needs in general derived from this type of surveying will protect the status quo because it overemphasizes the needs of established users, particularly those who are large and have clearly identified needs. But this outcome is contrary to current Federal policy to encourage innovation and productivity; it responds to and supports what exists now, what is needed now, not what will exist, what will be needed. Dr. Herbert Hollomon, Director of the Center for Policy Alternatives, said in his testimony on S. 1250, "change and response are essential for a dynamic society ... protection of the status quo will only stifle innovation."[13] This may be the ultimate protection of the status quo because it will establish a huge system which has been designed to respond to that small group of potential users who had clearly articulated needs in 1980.

Several follow-on interviews with both large and small users who attended the conferences corroborated the presupposition that the questionnaire asked for information which users could not generally supply. This was true especially with respect to the questions that asked for predictions of technical requirements during the operational phase and for estimated prices users would be willing to pay. One respondent characterized the questionnaire as "vague ... they expected pat answers ... which is not possible with a leading edge technology." When asked about his company's ability to predict future technical needs, he said "We can't make that kind of predictions and cost estimates ... We can't even estimate personnel needs for the next three years." In fact, planning for user needs based on this questionnaire is imposing an artificial certainty onto a highly uncertain response. To the extent that users supplied concrete responses, it was either because the questionnaire forced respondents to "say something" or because a few respondents had some current bona fide needs to set forth.

The report on the conferences, written by Metrics, Inc. and entitled "Overview of Conferences with Non-Federal Users on U.S. Operational Land Remote Sensing Satellite Program", stated, "One of the important results of the series of user conferences ... has been the initiation of a dialogue between NOAA and land satellite data users (p 26)" This is a conclusion not corroborated by personal contact with participants interviewed. They felt that NOAA was not listening. One person said that the questionnaire was an example of a lack of understanding of the problem. "All this future planning is irrelevant because what we need is to get the present system cleaned up and prices must be lower. The field is so new that we are having trouble convincing most people that it is even a viable thing. In industry there are few people that even know about this technology, let alone accept it." Another person felt there was no one at the conferences to whom he could talk, because their areas of expertise were not his.

(2). "... ensure that the operational system meets their needs to the maximum extent possible, given user willingness to reimburse for services and budgetary constraints." There are two aspects to this activity: (1) the notion of maximizing service within identified constraints and (2) basing the level of service in part on the user's willingness to pay. Both flow from the input-output model of the process.

The notion of achieving a maximum within constraints assumes a linear model of the world. Such an approach is only useful for very simple kinds of problems such as determining the cheapest cattle feed given certain nutritional requirements and current market prices. Three assumptions must be met in order for the model to work: the decision-makers must completely understand the process; they must be able to measure all the inputs and exchange them at the margin for all other inputs; and they must be able to calculate and make commensurate the value of all costs and benefits of all inputs. Establishing the "right" level of service based on attempts to do these types of calculations with respect to an innovative and still evolving technology for which there is not clearly identified market would result in an arbitrary outcome. Because the assumptions cannot be met in this case, the process of maximization (even on a rough conceptual level), given identified constraints, can only be performed in cursory and token fashion. The outcome would not reflect the level of service which "meets user needs to the maximum extent possible given willingness to reimburse and budgetary constraints" but rather the process of selecting which information would be included or excluded from the calculations. In this case the process would in all likelihood result in the undersupply of services. Even as an approximation -- or a good guess -- the process is conservative and backward-looking because the criteria for selection are the past experience and current values of the participants. The process, at best, can only be a simple prediction or extrapolation into the future. It says nothing about the future needs of potential users, their experience or values, and it does not recognize the possibility of discontinuities and new problem definitions.

The futility of extrapolating from present trends as a method of identifying future needs has been discussed by many current science writers and philosophers. Prigogine points out "predictable processes are altered by the unpredictable ... in modern science in general, the key discoveries come as a surprise. The impossible becomes possible." Again in different words Eugene Wigner says "Every phenomenon is unexpected ... and most unlikely until it has been discovered. And some of them remain unreasonable for a long time after they have been discovered."[14]

The policy objective underlying the notion of maximization here is the desirability of generating cost-effective data, which in the case of a highly complex and still evolving technology is in direct conflict with the policy objective of promoting innovation as a means to stimulating increased productivity.

The policy objective that a fully operational land remote sensing satellite system "... be designed to generate cost-effective data responsible (and ultimately in a self-financing manner) to a broad range of user requirements"[15] is benefit/cost analysis in a new guise. Such analysis has been detrimental to public program planning in general and is disastrous as a measure of new technologies. It imposes a necessity for premature evaluation which requires quantification of benefits which cannot be identified and dictates that the use of remote sensing data must contribute in an immediately viable cost-effective way.[16] NOAA plans to improve the cost-effectiveness of supplying Landsat services by establishing the level of supply based in part on consumers' willingness to pay. But this assumes that users can calculate the benefits of using remotely sensed data compared to alternative methods, and that the clients or users can also carry out the same types of calculations. Establishing a future level of supply based on willingess to pay today makes some heroic assumptions: that users can calculate the future benefits of using remotely sensed data compared to alternative methods; and that the users know their future needs and the needs of their clients as well as their clients' willingness to pay.

In the case of small firms, the push toward cost-effectiveness and efficiency may have some unintended side effects which will tend to inhibit their growth and success; responsiveness to new needs and technological innovation may also be discouraged. Most of the innovative users of remotely sensed data have been individuals and small firms. The vision has been carried by consultants, university faculty and small intrepreneurial firms. Only recently have large companies established their own laboratories and exploited the techniques. Indeed, it is still the small entrepreneurial firms and individuals who are at the cutting edge of the technology.

Nonetheless, the Transition Plan threatens to put small companies at a competitive disadvantage. Small firms compete by cutting delivery times in order to be responsive to their clients' needs. For example, if a small oil company has an option on a piece of land, it must be able to make a decision in a few weeks. So, a small consulting firm or image-processing firm competes by supplying prompt information, which is specifically tailored to the needs of its customers. They achieve this by utilizing informal personal and direct telephone communication to EROS personnel. If this system becomes formalized and these expedient direct channels are blocked or eliminated, then small firms will be put at a tremendous disadvantage. Even temporary blockage as a result of having to establish new channels of communication in a new organization will work against them.

The push toward cost-effectivness has two additional side effects which work to the disadvantage of small companies and discourage new innovative applications. It increases the capital cost of processing data and reduces flexibility. Small companies purchase film and visually inspect it through optical viewers. The technicians become skilled at visual interpretation and can respond to the particular and specific needs of their clients. Image-enhancing techniques can highlight and bring out some predetermined features in an efficient and standardized fashion, but must be processed by large expensive computors which are usually available only to large companies. So, the per unit price goes down, but the capital overhead is much higher; the process is better suited to a preselected set of qualities, but it less flexible and responsive to a variety of client needs, and the small producer cannot compete.

(3) "Establish and operate a satellite and ground processing tasking system that responds to programmatically justified user priorities." What is a "programatically justified user priority"? What are the criteria for ranking user needs or priorities? Which users are included? How are their needs determined? What time scale is used? What constitutes system responsiveness? Whatever this means, it is certain that what is "programatically justified" with respect to willingness to pay in 1980 will not be programatically justified with respect to willingness to pay in 1990 or 2000 because the alternatives, problems, goals and capacities will be different by orders of magnitude. The rationale for imposing this requirement on a system which is to be operational in eight years and probably will not come into its own for twenty years flows logically from the input-output model. The policy

goals mentioned above would be workable and appropriate if the process really worked like an input-output model and we understood the process, knew what the inputs were and how to measure the outputs.

(4) "Implement the President's goal with respect to the eventual ownership by the private sector of the land remote sensing satellite system by pursuing appropriate pricing and market expansion efforts, and establishment of a satisfactory institutional framework based on the private sector's willingness to invest and share in the risk." This ambitious and vague objective can be separated into three parts: a) the final goal of eventual ownership by the private sector; b) the means of achieving this through appropriate pricing and market expansion activities; and c) establishment of a satisfactory institutional framework based on willingness to invest and to share risk.

In each case we need to ask what model of human behavior, or organizational behavior or economic theory do we have in mind. Are these models based on theoretical assumptions or do they require necessary conditions in order to have descriptive or predictive power? Are the conditions met in this case? And does our common sense understanding of human behavior mesh with these models?

a) The goal of private sector ownership. Should the private sector have access to and control of the production of world wide data and should the government have to purchase it from the private sector? More generally in terms of the overall problem of transition technologies -- of moving technology out of government research and development environments into the public sector -- what characteristics should a technology have in order for it to be a good candidate for private sector control of production and distribution? In the present case, there are some awesome implications for centralization of power in the hands of a small, unelected group of people. Our system of government is not generally responsive to public good issues. It is however extremely sensitive and responsive to the interests of organized groups. Although stated in extreme form, the question we must ask is do we want the private sector to hold the government hostage. To the extent that the private sector is in control of the production of essential data, it has influence on the legislative process. Leaving aside the clearly nefarious possibilities, the drift toward more centralized control of a highly powerful information source should raise serious questions. It is not clear that the advantages of increased economic efficiency which theoretically accompany private ownership outweigh the disadvantages of centralizing power in the private sector.

b) <u>The means of implementing eventual private sector ownership by pursuing appropriate pricing and market expansion efforts</u>. This goal refers to the importance of prices as a practical implement in the search for productive efficiency. However, this assumes both the possibility and desirability of approaching "productive efficiency" as a means to increasing social welfare.

The economic theory that drives this position and the underlying assumptions that must hold if the conditions of efficiency are to be met will be briefly summarized as follows. The logic of the necessary conditions for economic efficiency flows in one direction only: it is true that if A exists then B follows; it is not true that if B exists then A will follow. It is true that when economic efficiency exists then resources should be allocated according to prices; however, it is not true that if resources are allocated according to price an economically efficient situation will be produced.

The main assumption is that the "purpose of economic activity is to provide consumers with the goods and services they want and that the criterion for performance is efficiency".17 Efficiency refers to whether resources are allocated optimally and is based on the Pareto criterion which states that resources are allocated efficiently if no one can be made better off without making someone else worse off. Theoretically, economic efficiency can be broken down into four separate conditions which must all be simultaneously met. The goods produced by the economy must be the ones consumers want; all available resources must be used and there must be efficiency in production and exchange.

Efficiency in production means that given the available resources and technology as much of each commodity should be produced as possible without reducing the output of other commodities. This means that the factors of production should always be used where they are the most productive, where the ratio of benefits to costs is highest. When efficiency exists then the relative price of any pair of commodities indicates the rate at which the production of one commodity can be increased by one unit as a result of using the resources released when the production of another commodity is reduced by one unit.

Efficiency in exchange or in distribution is achieved when goods are distributed to the consumers who want them and all consumers are willing to exchange one unit of a given commodity for a unit of another at the same rate. This automatically happens if all consumers buy commodities at the same price. Then the rate at which they are willing to exchange one commodity for another is equal to the ratio of their prices.

Under conditions of economic efficiency, the rate at which consumers are willing to exchange a unit of one good for a unit of another is the same for all consumers and is equal to the ratio of their prices in the market; the rate at which a unit of one good can be transformed into a unit of another (in the production process) is equal to the ratio of the factor prices in the market; consumer sovereignty exists; and all resources are used to capacity. Economic efficiency exists only when the "tradeoff rates of certain benefits (or costs) are the same for all economic agents"[18].

Given economic efficiency, then the rate at which consumers are willing to exchange a unit of one good for a unit of another and the rate at which a unit of one good can be transformed into a unit of another is equal to the ratio of their prices. And the price a consumer is willing to pay for one good in comparison to other good indicates the level of supply consumers want. When these conditions are met, the right level of production is achieved, i.e. social welfare is maximized; resources are distributed optimally. Therefore, when efficiency exists, the price consumers are willing to pay is a good guide to an allocation of resources; this is consistent with optimal social welfare and the right level of production. However, the reverse is not true. Allocating resources based on the price people are willing to pay does not automatically lead to more efficiency nor to an increase in social welfare. This is because prices are not always available and there are no prices for many types of externalities. Allocating resources based on price in the market place in the absence of overall efficiency will not by itself result in a better distribution of resources with respect to increasing social welfare.

Part of the confusion arises because the policy objectives and the human values supporting them are not clearly identified. The policy goal of creating an "operational system" is to create a stage in a process of technological development -- a particular point in the technological and organizational development of remote sensing technology. The goal in this case is a means not an end and in the present case the ends are as yet unspecified.

c) The establishment of a satisfactory institutional framework based on willingness to invest and share risk. Institutional framework here refers to the collection of organizations which will make up the "operational system". Perhaps the authors of the Transition Plan also meant to include the collection of organizations and policies. However, this discussion will be limited to the structural linkages between people and organizations.

Management responsibility for the operational land remote sensing program will be assigned to the National Earth Satellite Service (NESS), which would be a major line component within NOAA. The Transition Plan states that NESS will be "organized to ensure adequate attention to policy formulation, regulation, relations with users and private industry, and international activities related to land remote sensing." At the same time NESS will continue to manage the Civil Meteorological Satellite System and the National Oceanic Satellite System. Although technology transfer is a relatively new field, an increasing body of evidence suggests that both in the case of policy implementation and technology transfer, the structure of the receiving organization is an important variable bearing on the ease and success of implementation or transfer.

The Transition Plan has not dealt with the actual structure of the new NESS. Important details have yet to be clarified: how will NESS be organized to ensure adequate attention to policy formulation? Will policy formulation with respect to the land remote sensing program create conflict for personnel who are also professionally committed to the meteorological satellite system or to the proposed National Oceanic Satellite System (NOSS)? Will the organizational structure allow the staff to relate to each other in a way which facilitates the transfer or will the structure create interpersonal relationships which hinder the transfer? For example, if the new responsibilities create role conflict or situations where individuals have new or inappropriate discretion, then the structure will have created personnel relationships which may hinder transfer. It is almost a truisim that how people relate to one another within the implementing organization is determined by the organization's structure and is crucial to the success of a program. NESS is being asked to wear many hats, yet attention to how NESS personnel are going to carry out their complex and potentially conflicting tasks is completely lacking. Besides policy formulation, NESS must direct its attention to regulation, relations with users and international activities. Each of these activities is complex and potentially in conflict with the other activities. For example, international cooperation may easily conflict with the profit motive of domestic users.

Interagency coordination will be achieved at the Assistant Secretary level by a Program Board, which will be composed of representatives from eleven different agencies: Defense, Interior, Agriculture, Energy, State and Commerce, NASA, EPA, AID, U.S. Army Corps of Engineers and the CIA. This Board is to provide "continuing Federal coordination and regulation in such areas as:[19]

- Policy issues related to the civil land remote sensing satellite program;
- NOAA's management of the civil land remote sensing satellite program;
- International negotiations;
- Priorities among the data requirements of the Federal and other users;
- A satellite and ground processing tasking system;
- Data and pricing policies;
- Proposals for private sector involvement;
- Private sector regulation;
- Federal budget requests;
- Relationships with other Federal data sources; and
- Necessary research and development.

When NOAA's management decisions are "at variance" with the Program Board's, then any member of the Program Board may refer the issue to the Policy Review Committee on Space. A word on the planned procedures is in order here. Experience with technology transfer indicates that a collection of disparate and conflicting agencies could probably not reach consensus in any one of the eleven policy areas mentioned above. As it stands at present, a structure such as the one proposed by NOAA is designed to encourage continual discussion, conflict, appeal, more discussion and more conflict followed by more appeal.

Although we cannot see into the future and predict the course of the new Administration with respect to science policy, there are some clues in the thoughts of Simon Ramo,[20] who is currently the co-chairman of Reagan's Science and Technology Task Force. Ramo believes that "the climate for innovation can be improved by better decision making and more leadership at the Federal level ... (that) ... innovation is often hamstrung by disagreements over ... pressing issues, typically between corporations on the one hand and politicians and their constituents on the other." One might wonder how well the present Transition Plan can correct these problems. So far, it has created on paper an organizational structure likely to increase advocacy, undermine consensus, and highlight conflict of interest. Our research with the Pacific Northwest Project showed how difficult it was to reach consensus on technological needs even when the participants had common interests and were motivated by an overall common goal. To require consensus from groups with conflicting interests and goals when the technology is immature, the potential market unidentified, and the users' needs undetermined seems impossible. Indeed such a coordinating structure is exactly the arrangement Ramo seems to believe hamstrings innovation.

Even the best programs fail without careful attention to implementation. That this phase of the transition occupies a position of low priority can be seen in the document, "Planning for a Civil Operational Land Remote Sensing Satellite System". This document is in the form of a standard policy analysis and contains history, problem definition, development of a few alternatives which represent various levels of commitment, statement of pros and cons associated with the alternatives, and discussion of the policy trade-offs implied. Out of a total of 119 pages (which were publically released prior to the budget hearings), discussion of the actual implementation of the Interim Operational System is covered in seven brief and somewhat oblique and confusing paragraphs. The "when," "what" and "where" questions are addressed but the controlling "how" question is completely ignored. This observation is particularly noteworthy because the lesson to be learned from NASA's experience with technology transfer is that success depends on careful attention to the detailed aspects of how it is going to be done.

Analysis of the report's seven paragraphs devoted to implementation indicates that the underlying model of the transfer process is incomplete. "Implementation of the Interim Operational System" refers to "transfer of functions." Generally "implementation" refers to how a policy is put into place, or in this case a technology. "Transfer" refers to what has happened. By equating "implementation" with "transfer" the difficult question of how something is going to be accomplished becomes transformed into the simple question of what is to be accomplished. By equating "implementation" with "transfer", the authors beg the question of how the technology (operation of Landsat D) will be transferred from NASA to NOAA. Specifically, the report states

> Implementation of the Iterim Operational System will require transfer of the function of archiving and dissemination of standard data products from the EROS Data Center (EDC) in the Department of the Interior and of hardware and personnel from the National Aeronautics and Space Administration (NASA).

Implementation means how these functions will be transferred not that they will be transferred.

The last two paragraphs of the section on implementing the Interim Operational System begin to address some of the "how" questions.

> NASA will transfer to NOAA available positions from the Goddard Space Flight Center and from its Office of Space and Terrestrial Applications, which provide current civil service support for the management of operational aspects of the Landsat Program, the tasking of Landsat satellites and the interface between operational users and the Landsat program.

But this does not take into account the personal dimensions of the transfer process. Will people carry the information and be the vehicle of technology transfer or will positions be transferred? These dimensions take on particular importance when we look at how users interact with NASA personnel. The users interviewed generally agreed that the system was made workable for them through interaction with specific people in NASA who understood their particular problems. There was the general belief that the delivery system was just beginning to function well, and that much of that success had to do with the individual attention and direct personal communication between NASA personnel and users.

The notion of the transfer process as depicted in the Plan is one of shifting around boxes on an organizational chart, reallocating funding, and declaring that functions have been transferred: the program is implemented! Like most policy analyses, detail is specified where it is easiest and best understood and as a result, the controlling types of interactions are left unidentified.

Conclusion

In summary, NOAA policy makers' expectations and perceptions as to how to link technology with a community of potential users appear to have some unanticipated consequences. These may be detrimental to the broader policy objectives of promoting technological innovation and improving productivity. In the present case the expectations and perceptions on the part of both the supplying and receiving organizations play a far more important role in the transfer process than do the attributes of the technology being transferred. When the process is studied from the point of view of the end user, these expectations and perceptions take on special significance because they control the final outcome.

Through cooperative effort, NASA and NOAA are attempting to make these expectations and their consequences explicit and to use this new understanding in shaping the transfer process. An upcoming regional conference in April on user needs is being sponsored by NASA and will be followed by a day with NOAA personnel. This is an interesting example of the dynamics of the NASA-NOAA transition and may provide an opportunity to observe the technology transfer process at work.

Footnotes - NASA-NOAA Transfer

1. Science Policy Research Division, Congressional Research Service, Library of Congress, World-wide Space Activities, Report prepared for the Subcommittee on Space Science and Applications of the Committee on Science and Technology, U.S. House of Representatives, 95th Congress, 1st Session, September, 1977, pages 11-17.

2. An Interagency Task Force (National Aeronautics and Space Adminsitration, Department of Commerce/National Oceanic and Atmospheric Administration, Department of Interior, Department of Agriculture, Department of Defense, Environmental Protection Agency, U.S. Corps of Engineers, Department of State), Private Sector Involvement Study in Civil Space Remote Sensing, Volume I - Report, June 15, 1979.

3. Practical Applications Board of the Assembly of Engineering, National Research Council, Practical Applications of Space Systems, published by the National Academy of Sciences, Washington, D.C., 1975, pages 33-34.

4. The most obvious assumptions are identified the The Private Sector Involvement Study in Civil Space Remote Sensing (op. cit.), page 3. Although these assumptions were identified with respect to the alternatives described in the study, they are also applicable to the NOAA Transition Plan.

5. An Interagency Task Force, op. cit., page 4.

6. For a discussion of indicators see Comptroller General of the United States, Science Indicators: Improvements Needed in Design, Construction, and Interpretation, U.S. General Accounting Office, #PAD-79-35, September 25, 1979.

7. Ibid., page 22.

8. Allen, Thomas, Managing the Flow of Technology: Technology Transfer and the Dissemination of Technology Information Within the Research and Development Organization, MIT Press Cambridge, Massachusetts and London, England, 1978.

9. U.S. Department of Commerce National Oceanic and Atmospheric Administration, Satellite Task Force, Planning for a Civil Operational Land Remote Sensing Satellite System: A Dicussion of Issues and Options, June 20, 1980.

10. Perrow, Charles, "Hospitals: Technology, Structure and Goals," Handbook of Organizations, James March, Ed., Chicago, Rand McNally Company, 1965, pages 910-971.

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14. Ferguson, Marilyn, Aquarian Conspiracy, J.P. Tarcher, Inc., 1980, page 174.

15. Statement by Dr. David S. Johnson, Director, National Environmental Satellite Service, National Oceanic and Atmospheric Administration, Department of Commerce on Planning for a Civil Operational Land Remote Sensing Satellite System before the Committee on Commerce, Science, Technology and Space, United States Senate, June 26, 1980; taken from a xerox copy of an informal publication.

16. Hoos, Ida R., Conference on Remote Sensing Educators (CORSE-78), A Workshop Held at Stanford University by NASA-Ames Research Center, Moffett Field, California, June 26-30, 1978, NASA Conference Publication 2102, pages 100-101.

17. Dorfman, Robert, Prices and Markets, Prentice-Hall, Inc., 1972.

18. Nicholson, Walter, Microeconomic Theory, Dryden Press, Inc. 1972.

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Information and the Decision-Making Process

The process of assessing the information needs of users of remote sensing is complex, elusive, and difficult. Nonetheless, it is of vital importance, since it lies close to the heart of NASA's concerns. Better understanding of the attributes of data likely to be incorporated into decision-making would help NASA plan for advanced technical systems as well as improve delivery systems. NASA needs to assess users' needs for its own process of validation and evaluation. As a vital step in technical planning, monitoring, and projection, validation is a *sine qua non*. As an essential program component, management tool, and budgetary justification, evaluation is the *ne plus ultra*. They are, in fact, embedded in the policies relating to civil operational remote sensing:

- A national civil operational land remote sensing satellite system should ensure continuity of data and the *appropriate reliability* and timeliness of standard data products;

- *User requirements*, *projected levels of demand* and the cost of meeting these requirements should determine the design of the operational system.

Note the underlined terms above. They reflect the assumptions that someone knows what the proper definition of *reliability* is, how appropriate is *appropriate*, and understands *user requirements* well enough to project *demand*. In point of fact, these matters come under the heading of QED -- they have still to be demonstrated.

How to ascertain and validate user requirements were questions underlying much of the research done in this segment of our work. We were well aware of the view prevailing at NASA headquarters of some of the shortcomings of the current process for assessing user requirements, conventional wisdom being that it was ad hoc, deficient in follow-up, low in credibility, and dependent sometimes on unrepresentative participation. We knew that it was criticized as a process which used varying methodologies. We knew NASA headquarters' version of a desirable user requirements process was one which was "continuing, institutionalized, systematized, representative, visible and directly addresses OSTA objectives for both R&D and user development."

It is useful to have official goals and objectives clearly articulated. However, our work in the field points to the fact that they are at this point so generalized as not to be consistent with the real world of resource management. Because of its diffuse and changing nature and because of the many as yet untried applications of remote sensing, it may be leapfrogging much necessary preliminary spadework and groundbreaking to think seriously at this point of achieving a user requirements assessment process that is methodologically sound and representative for all applications now and future. These are attributes that can be attained only as a result of the activity; they are not a precondition for it. Whether the process will be "continuing, institutionalized, and systematized" depends on NASA's internal organization and management. In their present state, the goals and objectives are not merely of the apple-and-orange variety; they are a bowl of mixed fruit salad. As a matter of ground truth, decision parameters and decision makers' purposes are extremely complicated and imperfectly understood. The use of econometric models, application of decision-making rules, the socio-economic and political environment affecting decisions, management style, organizational arrangements, and personal predilections and prejudices -- all are determinative factors and have bearing on the ultimate value of the information and its characteristics. They form an intrinsic part of the process by which remote-sensing technology will be accepted and utilized and its value assessed.

In our work with the NASA-Ames Applications group and also through our association with the Estes Working Group on Information Utilization and Evaluation, we have concentrated on the user requirements component of the technology transfer process. Even in the early stages, we found user needs assessment to be a highly variable matter. If the users were construed to be the network of technical persons already working with remotely-sensed data, even though they were not the persons responsible for ultimate incorporation into decisions, then a fairly straight-forward "shopping list" could be drawn up. This situation lends itself to the boxes-with-arrows diagram, attractive in its simplicity, deceptive in its concreteness, and amenable to the modeling that so often passes for astute management.

The customary way to ascertain user needs is by means of a workshop. But such events provide a sound track that is already well worn. Presentations show and tell but not much that is not clearly _déjà vu_. There is a good deal of "singing to the choir," and basic issues are lost in the noise of unenlightening discussion, possibly by the wrong "experts", for participants are likely to be the technical middlemen and not "users" of the information. There is a suspicion that they show an inclination, in defining their needs, to put in a blanket order for higher resolution and speedier delivery irrespective of whether and how the data become information and are put to use. When, on occasion, resource managers give their views the picture gets considerably more "complexified". For example, the Chief of Planning, California Department of Resources, when asked* how he would assign priorities to his information needs, in terms of mapping, predicting, and forecasting replied, "At present, the data available are better than the models we have. Our data are pretty accurate; it is the models that are not very good." The circularity here is unmistakable: in considering user needs, we concern ourselves with the decision-making process. This in turn brings us to the role of information in that process. But, as we pointed our earlier, decision parameters and decision makers' purposes are extremely complicated and evaluation can be achieved after analysis on a case-by-case basis. Even then, the assessment seems to have an orientation more backward than forward-looking, in that standard cost/benefit procedures are likely to be applied. While historical perspective is important, cost/benefit analysis may yield false clues and will certainly not answer NASA's need to know how it can best respond through advanced technology to public needs as yet dimly perceived.

In the current models of assessment of user needs there appears to be a set of assumptions not supported by experience. They imply that users are a homogeneous entity that can be tapped. Actually, users must be developed and it is in their diversity

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* Robert Rotter, at the Workshop of Working Group on Information Utilization and Evaluation, Asilomar, California, Sept. 61-17, 1980.

that clues to future generations of technology will be found. There still exists patent predilection for the simple, one-dimensional flow chart notion of a "user requirements mechanism," when what may be called for is a missionary function to establish linkages (1) because the technology is sometimes ahead of the potential users' perception of their needs, and (2) "assessment" of those needs eludes the quantification and calculation which constitutes the uni-methodology nostrum but does not fit the real-world model.

User Needs in Technology Transfer

The process by which NASA fulfills the mandate to transfer its technological expertise to agencies at various levels of government and to private industry is the subject of this research. There are a number of different ways in which this process might be approached. During the summer of 1980, the Social Sciences Group was involved in an effort to analyze several possible models for ascertaining the needs of potential users of Landsat imagery. Working with the Western Regional Applications Division, we investigated in some detail a means for dividing the study of technology transfer into a series of sequential steps. The starting premise was that in order for NASA to transfer its technology effectively it must know something about the technical needs of those who would use the technology. This assessment of users' needs, thought to be necessarily prior to the transfer process, was the principal topic of study.

We were aware, of course, that various methods have been used in the past to ascertain users' needs. The most directly applicable work had been done by Wilson and Westerlund in their studies related to the Pacific Northwest Project. In that project, NASA's Landsat technology was being made available to a number of state and local governmental units. An early phase of that transfer process was an examination of just what those agencies needed in the way of remotely sensed data. Did they need data yearly or monthly or daily? What sorts of resolution and spectral characteristics did they need? The PNP group, having analyzed the answers to these and similar questions, prepared a master profile of data requirements to guide NASA in the development of Landsat data packages.

Given the apparent success of this process, the question arose as to whether there could be some way in which this assessment of users' needs could be routinized for future use in different settings. Several conferences were held at the Space Sciences Laboratory and at NASA's Ames Research Center to discuss how the study of users' needs could be generalized. At first, the idea was put forward that there be a workshop, to be attended by NASA managers and technicians as representatives of the space agency, and similarly situated managers and technicians from the potential group of users.

After some research, it became apparent that the PNP probably did not provide an adequate model for future assessments of users' needs because the PNP study was, in some ways, idiosyncratic. For example, the agencies which were involved in answering the questions about their data needs had already accepted the idea of using remotely-sensed data, -- or had been told by executives of their respective state agencies that they should consider it. Further, the PNP personnel conducting the study were acquainted with staff in the agencies; the agency staff people knew the nature of the technology being transferred; and there was a clear notion on the part of everyone that the assessment of users' needs was an important step in moving this particular process forward. A large element in the PNP was that of acceptance, which had to be developed and nurtured as an instrinsic part of the transfer process. If it had been lacking, even the preliminary step of needs assessment would have been virtually impossible.

Further study suggested that assessment of user needs in isolation from the ongoing process of technology transfer would be devoid of meaning. How, for example, could criteria for evaluation be established in a vacuum? How can we determine bona fide "success"?

It seemed obvious that the only way to evaluate such results as we might obtain would be to see if those needs informed and guided a real effort to transfer the technology involved from NASA to the user. This, clearly, is an interactive process which would require monitoring, documentation, and interpretation. In order to maintain an active and cooperative relationship with potential users, it was necessary to consider the conditions necessary for fostering such a relationship. For example, could the investigators offer the assurance that the givers of technology would or could respond to the needs that had been expressed? Could the technology meet the stated needs? What possible incentive would a user have to delineate his needs if there were no guarantee that the investigators would try to satisfy those needs? It was hard to imagine asking a busy manager in a government agency or private firm to devote several hours or days of valuable time to discussion of needs which he had no reason to think anyone would try to satisfy.

It was apparent that the study of users' needs could be carried out only as part of a larger process of studying technology transfer. That is, the evaluation of the assessment of users' needs could be best accomplished with an empirical base, which might be established through experimentation. An effort of this kind would, in essence, amount to a simulation of the real-life situation and would necessarily include all of the components.

Starting in September, 1980 work began on a small-scale project to study technology transfer intensively: from the assessment of needs to the effort to locate an appropriate

NASA technology for those needs, to the process by which a link is built between the user and the agency so that the technology can be efficently transferred. We have proceeded as follows:

A random selection of four small local firms was made. One firm designs and manufactures stationary solar heating equipment for residential and commercial applications. Another designs and manufactures windmills for the production of electricity. The third potential user is an independent inventor who is currently designing input devices for graphic display computer terminals. And the fourth is a non-profit collective of people who are promoting "soft energy" paths. Each of these potential users was approached and told of our interest in having them be "guinea pigs" - potential users of NASA technology. We offered to sit down with them for an hour or two to explore their technical needs. Then a letter to NASA was to be drafted. This letter, outlining their needs, would stimulate a response from NASA. How and how soon this reponse occurred, the form it took, its relationship to the needs -- all are items for observation and will provide, at the microscopic level, a view of the ways in which the agency and the user interact. The goal is to assess simultaneously our accuracy in defining users' needs and provide the agency with solid information about how to improve its responsiveness to users of its technology.

Fortunately the four users are a diverse group whose interests span many disciplines. Collectively their needs range from heat transfer fluids with certain specific characteristics for viscosity and specific heat to methods for forming fiber optics into bundles, to a need for the use of NASA wind tunnels for testing of their devices. Some requests are highly specific, others very general.

Already the project has an interesting spinoff. None of the four companies knew anything about NASA's program in technology utilization. Even though this is a small sample on which to base any conclusions, the fact that four out of four randomly selected users knew nothing about NASA's efforts at technology transfer has inspired an extension of the research effort. We are now in the process of making a random selection of 50 to 100 manufacturers, selected from the Thomas Register of Industrial Goods. Personalized letters are being sent to the chief executive of each firm with a single question: Are you aware of NASA's technology transfer program? With such a simple questionnaire to be anwered, we hope the respondents will return their answers at a high rate. We can then correlate the answers with some simple characteristics of the respondents, such as geographic location, type of product, size of firm, and so on. While this is not intended to be an exhaustive survey, the findings can help improve one vital link in the chain of actions which add up to successful technology transfer, namely, effective communication.

NASA's Program for the Elderly and the Handicapped

This study was undertaken as the forerunner to forthcoming work on certain aspects of NASA's program for the Elderly and the Handicapped. Its emphasis was, therefore, historical and analytical, and it emphasized salient features of the present program so as to derive guidelines for exploration and development of new avenues of opportunity for service. The year 1981 has been designated by the United Nations as the "International Year of Disabled Persons." This recognition of the special needs of a large and growing sector of the population -- for one may certainly include the process of aging as having disabling effect -- should give impetus to NASA's activities.

By way of structure for the research to be carried out last year, three basic questions were raised:(1) What are the forces which determine the applications to be developed? (2) How do market characteristics affect the choices available to consumers? (3) What are the personal and social impacts of these new technologies?

As is usually the case when research into a complex and relatively uncharted field is undertaken, the six months' effort indicated that in some instances we may have been asking the wrong questions, in others that there were not (and could not be) clear-cut answers. Moreover, our own time constraints and the time factor that must come into play for impacts to become discernible made answers to the third question virtually inaccessible. This is not to say, however, that the research did not yield useful results nor that future efforts need be discouraged. In fact, it is on the basis of these findings that we can proceed with focus sharpened and emphasis more specific.

The first part of the study addressed the question of the way in which potential applications are selected for development. NASA's goal was presented in the Directory of the Technology Transfer Division: "to ensure that the maximum possible benefits are derived from the application of NASA's technology by addressing national priorities." In the arena of technology for handicapped and elderly persons, this task was considerably complicated by the involvement of numerous federal agencies, all with relevant but not necessarily related missions. Primary among them are the Veterans and the Rehabilitation Services Administrations, charged with the responsibility to serve certain sub-groups of the handicapped and elderly, such as veterans or persons who are potentially employable. There are other public agencies whose major concerns are elsewhere but who, like NASA and the Department of Defense, allocated some portion of their resources to this field.

Pinpointing lack of coordination as the cause for both duplication and serious gaps in service, the House Committee on Science and Technology appointed a Panel on Research Programs to Aid the Handicapped. Their two reports (April 1977 and March 1978) proposed establishment of a coordinative body, which, under PL 95-602 (November 6, 1978) emerged as the National Institute of Handicapped Research, adjunct to the U.S. Department of Education. In addition, the law created an Interagency Committee on Handicapped Research; this included representatives from the Veterans Administration, the National Institutes of Health, NASA, the Department of Transportation, and the National Science Foundation. Its duties were "to identify, assess, and seek to coordinate all Federal programs, activities, and projects .... with respect to the conduct of research related to rehabilitation of handicapped individuals." The role of NASA's representative was to consult and cooperate with the Director of NIHR through the committee. Although these organizational arrangements offer a potential for assisting NASA in its determination of priorities, realistic assessment must wait; so far the committee has met only twice.

Up until now NASA has assured itself of the significance of its undertakings through the requirement that mission agencies provide co-funding. The rationale was twofold: (1) the approval of agencies having direct contact with potential users would have potent feedback value; (2) a financial stake in the endeavor would motivate mission agencies to active participation and ultimate adoption of the product being developed.

Internally, NASA carries out its programmatic activities via three Biomedical Application Teams, located at Stanford University, Research Triangle, and University of Wisconsin. Set up to serve as liaison bewteen NASA and the medical community, these teams operate on what appears to be a demand-pull model; i.e., doctors, therapists, and the like come to them with their needs. Conceptually, the Team assists in defining the problem and formulates a problem statement to be circulated throughout NASA to elicit ideas for possible solutions. If the solution meets NASA's criteria -- that the product be new, significant, and utilizing aerospace technology, a formal proposal, Research and Technology Objectives and Plans (RTOP), is submitted to NASA headquarters for approval and funding. Actually, the process is more accurately characterized by the technology-push model, with certain technologies perceived as having promise. Thus, the chain of events is started. One preliminary, partial, and tentative view of the way applications are chosen for development raises some questions as to whether the present mechanism is optimal for engaging the full potential of NASA's technical assistance to the elderly and handicapped. It is interesting to note that the technologies which are finally chosen for development emanate not from some carefully constructed program plan but from a random assortment of chance factors, not least among which are the professional interests of members of the Biomedical Application Teams.

Of no small significance is the matter of magnitude of the effort. There are the usual criticisms on the part of medical researchers that grants are too small to attract first class people and programs or that the Technology Utilization Program does not occupy a position of high prestige on NASA's own roster. There is, however, another, more fundamental area of concern about size. This stems from funding limitations that foster a preference for a variety of short-term projects requiring a low level of support. But this pattern may run counter to what has been recognized as the shape and dimensions of the need. The situation takes on the aspect of a chicken-and-egg dilemma. In a 1973 report, *Study of Aerospace Technology in the Civilian Biomedical Field*, the Committee on the Interplay of Engineering with Biology and Medicine of the National Academy of Engineering stated:

> In the area of health care delivery there are rather significant and somewhat universal problems faced by those providing services and functions. ...if the problem is of sufficient *impact it may well prove worthwhile to expend considerable funds and considerable time to accomplish the transfer of technology*. (Italics added)

While NASA's internal review process serves as the screening mechanism for funding projects, the criteria applied (i.e. that the product be new, significant, and space-derived) do not provide a useful answer to our second question, "How do market characteristics affect the choices available to consumers? In fact, on retrospect, the question as phrased carries several assumptions not supported by subsequent research. "The market" was assumed to be an entity having objective reality and thus identifiable in the process linking technology to user.

There is actually an unmapped middle ground between the providers and the recipients of a given technology; this is buffeted by many forces and peopled by many actors. The gigantic HMO (Health Maintenance Organization) structure must be reckoned with. With the myriad of middle men, brokers, and agents acting for the elderly and handicapped persons, it is virtually impossible to make definitive statements about "the market". What its characteristics are depends in major part on how and by whom it has been delimited. Whether, as currently conceived, it is responsive or even relevant to the needs of the elderly and the handicapped is conjectural. This might be an area for fruitful future research: can a reasonably faithful representation of the user need structure be incorporated in the model? It is important to ask who is the user and how can input from him be elicited and accomodated.

The factor of commercialization in the technology transfer is given more lipservice than serious attention. And this may be not only understandable but commendable, since bio-medical devices are intended for a very limited and specialized market. With the market potential of <u>any</u> innovation the result of a complex and not always predictable interplay of many factors, commercialization in this area is uniquely difficult. Manufacturers must cope with small, specialized, and uncertain markets, often dependent on decisions by third-party payers; they must deal with product safety requirements, arrangements for servicing and repairs, and, perhaps, modifications to suit a particular user's needs. Given the special character of the products and the market, it may well be that issues of subsidy be given serious attention.

The questions raised in the third part of the study as proposed can only be answered in the future. They imply a different model from the one which currently describes the process, in that implicit in them is a stronger role for users, a better understanding of the problems of handicapped and elderly persons, and improved organizational arrangements for accomplishing goals set forward by policy but not implemented practically. How the user requirements can enter into the process and what effect this would have on it are questions of primary importance. It is from them that answers would flow; this suggests that the next step should be in the direction of modifying the model.