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ABSTRACT

Research on the application of remote sensing can be used effectively in solving problems of water quality and land use if researchers and the state agency personnel having responsibilities in this area work together to assure that research projects and agency needs are closely aligned and remain so. However, developing goals and projects that fit the requirements of research units as well as the state agencies, profit by the use of several management tools. This paper describes the characteristics of several processes that transfer research results to the government agencies. Then the management of three projects and the Data Center are delineated to illustrate the application of these tools in the effort to guarantee the applicability of university research to agency needs.

I. INTRODUCTION

Research on the application of remote sensing to the problems of water quality and of land use can be valuable to state and regional governmental agencies that have responsibilities for planning, monitoring, and enforcement in these areas. But in order that the research results mesh with agency needs, conscious efforts must be made to assure that research and needs are closely related and remain parallel or converge.

In the course of research on several remote sensing projects at the University of Wisconsin, observations were made of the use of various management tools in order to assess their effects on the anticipated relevance of the remote sensing research to the needs of these government agencies. Among these tools are different organizational structures and ways of functioning, which are applied to the design and management of projects and to the communication of research results. The observed events on which this paper is based were not controlled experiments but were planned attempts to assess the methods while the remote sensing projects--centered on the scientific understanding of the physical events involved--continued. Members of the research teams chose to try to solve by the use of these different management tools the communication and relationship problems that developed in the natural course of the research. Solving these problems makes available to agency use material and technology previously obscured from their view.

The results of remote sensing projects can be used by a governmental agency in any of several ways.

1. The agency secures data or information it needs :
   e.g., the area within a particular isotherm in a power plant thermal plume.

2. The agency uses technology transferred to it from the research body :
   e.g., a technique for monitoring eutrophic levels of a lake.

3. The agency gains a theoretical understanding of a problem it faces :
   e.g., why thermal plumes behave as they do under certain wind and wave conditions.

This paper treats only the first two of these uses: (1) data and information flow, and (2) technology transfer.

After discussions of the characteristics of these processes, the paper illustrates in the management of three projects and a remote sensing data center the use of some tools for influencing these processes.

II. CHARACTERISTICS OF THE PROCESSES OF DATA AND INFORMATION FLOW AND TECHNOLOGY TRANSFER

A. Data and Information Flow

The elements of the flow of data and information in a remote sensing operation may be viewed as a process of communication across the interfaces between different roles necessary to the process (see Figure 1). An interface in this process is a point at which the output of one part or role of the process becomes the input to another part. A group may perform one role, an individual may, or several roles may be performed by one individual. This description is an adaptation of the standard military diagram for the basic information cycle.[1]

In a simple case, the flow of communication through this process is supposed to begin with the person in Role 1--Decision Making--articulating a problem to someone in Role 2-- Analysis and Interpretation: e.g., How can we more often update land cover information for land use planning? The problem is analyzed in Role 2, resulting in tasks being assigned to persons in Role 3--Data Processing: e.g., Can land cover maps showing urban, forest, agricultural and wetlands areas be produced and updated every six months? This step may involve the communication of tasks in several directions for different areas of investigation which may be alternatives or different phases of the analysis of the problem. Data Processing Role, upon receipt of the tasks, determines how data can be acquired to fulfill the tasks and plans missions for this acquisition: e.g., Get LANDSAT data for April and September 1975. In the Data Acquisition Role, when raw data are secured they are communicated to the Data Processing Role: e.g., LANDSAT tapes April and September 1975. The information is extracted from the data in the Data Processing Role to produce maps that become the input upon which the Analysis and Interpretation Role now studies the problem with which the process was started. Comparison of these maps with other sources of information is made and, on the basis of this, recommendations go to Decision Making: e.g., Compared to maps produced by ground parties, accuracy and cost of remotely sensed maps have these advantages and limitations. On the basis of these recommendations, the decisionmakers now have the possibility of a decision about the problem that was raised in the first place.

The above description is referred to as the simplest case because it is assumed that the roles (1), (2), (3), and (4) are clearly defined and performed by separate persons and that communication at the (1)-(2), (2)-(3), (3)-(4) interfaces is uninhibited. In none of the projects described in this paper were these assumptions true. Lack of clarity in the roles of the decisionmakers and of the analysts and interpreters led to an emphasis on clarifying these roles. The interfaces at which communication was needed in the projects studied here, but at which observation indicated communication was not clear, were those from (1) to (2), (2) to (3) and (2) to (1) (Figure 1).

Some of the complications involving role (1), role (2), and the interface (1)-(2) and (2)-(1) were the result of uncertainty about the boundary between roles. In most cases, decisionmakers were in a state agency, but some of the analysts and interpreters were in the same state agency. Other analysts and interpreters were researchers in the university. The boundary between university personnel and state agency personnel within the Analysis and Interpretation role at times produced groups with two distinct points of view, each doing analysis and interpretation. In these cases the simple diagram should be augmented, as in Figure 2. The interface between (2A) and (2B) is subject to the possibilities of misunderstanding between the research world and the practitioner world discussed in Section II.B.

The interface between (2) Analysis and Interpretation and (3) Data Processing is difficult because the experience of researchers within the university has led them not to be clearly aware of distinctions between roles. In most research projects, analysis of the problem, formulation of tasks, data processing, production of information, and interpretation of information are all combined in the work of one person or one coherent group. Communicating with others in an extended process or confining himself to one distinct role while someone performs another on which he is dependent are unfamiliar skills for many university researchers. This unfamiliarity with these role distinctions may mean that research does

not produce recommendations that would be of use to a decision-making person, but would be useful for making conclusions about hypotheses that were to be tested. A university researcher may believe that he has completed the whole project when, in fact, the information flow sequence has not been carried to the point where a useful product has been produced. There is no reason why one person cannot occupy several roles in this process, but experience indicates that it is important for each individual or agency to recognize as clearly as possible what the different roles are and how they relate to the roles on either side in the flow sequence.

To help the data and information flow process to proceed efficiently, it became an objective of management of the projects involved to improve communications across the interfaces between roles in the process and to clarify the distinct roles. Understanding of a person's role and of other roles in the process seemed to be one of the best tools for improving this communication. Another tool was clarifying the boundaries between agencies, and relating them to distinctions in role. Dialogue, or extended two-way communication with persons on the other side of an interface, was another tool useful for improving communication. Finally, inclusion of persons in all the various roles of the data and information flow in the early planning of projects was an essential tool.

B. Technology Transfer

When an objective of research is to provide a means by which a governmental agency may solve a problem confronting it without continued dependence on the research organization, the transfer of technology becomes crucial. While many of the staff members of state agencies are scholars at work in the application of scholarship, their positions in governmental agencies make it most likely that they operate as practitioners of science rather than as researchers of science. In his article "Relations between Researchers and Practitioners," James P. McNaul[2] lists some areas of difference between researchers and practitioners. The following are adapted from his list with illustrations from Wisconsin projects.

1. The value system of technology, or of the practitioner, is the use of knowledge: "We need a practical way to clean up the lake water." For science, or the researcher, the value system is the increase of knowledge: "We need to understand lake eutrophication."

2. The primary communication pattern for practitioners is through technical agencies or companies: "We'll talk to the Corps of Engineers or consultants from water treatment companies." The primary communication pattern for researchers is through scientific journals: "We'll have to do a literature (journal articles, not brochures from practical companies) search."

3. The time frame required of practitioners is generally short: "We need a plan to show some progress in cleaning up lakes before the end of this year." That for researchers is longer: "This will take about the three years that a graduate student usually requires to complete a research project in collaboration with a professor."

4. Practitioners must be concerned about uniqueness in their products or policies: "Clear Lake is becoming choked with weeds, and swimmers and boaters want to have it cleared up." Research scientists are most interested, on the other hand, in the discovery of patterns that constitute theoretical principles that can be generalized: "We need to understand whether the weed growth is a perfectly normal phase in the lake ontogeny."

5. Practitioners have to assume that the knowledge on which they are going to act has some finality: "If we do this the lake water will be improved." Scientific researchers, on the other hand, think of scientific knowledge as never final: "If we take this action we may discover another whole set of circumstances about the water quality that we don't understand."

6. The conditions under which scientific practitioners operate do not allow manipula-
tion of their environment to allow certainty about the variables involved in
decisions: "We've got to find something to do about Clear Lake with the weeds,
the swimmers, the boaters, and the septic tanks as they are." Research scientists,
on the other hand, try to build experimental designs in which some factors can be
controlled to allow variables to be studied and measured: "If you can just stop
the effluent from all the septic tanks around the lake for three years, we can gain
an understanding of what is happening to the weeds and sediment in the lake, and
then we can understand what might be done about it."

It should be emphasized that while the differences in viewpoint between practitioner
and researcher have been highly instructive in allowing university researchers and state
agency staff members to deal with differences in their viewpoints, neither "practitioner"
nor "researcher" completely applies to any group of individuals. These are models and not
total characterizations.

To aid in the management objective of transfer of technology as a result of these
research projects, attempts were made to help persons on the research side and the agency
side learn the language and customs of the other, expect problems in the transfer, and
expect to be able to solve the problems of transfer through working together. Dialogue was
an important tool in this process. Tools used also included workshops, small group meetings,
collaborative planning, collaborative data acquisition, site visits, temporary switching of
roles, and cooperative work on manuals on the technology. Collaboration in preliminary
planning before a research project commenced was found to be very important to aid transfer
of technology.

III. CASES ILLUSTRATING PROBLEMS OF FLOW AND TRANSFER

A. Remote Sensing Research for Monitoring Eutrophic Level of Lakes

Researchers at the University of Wisconsin had been at work for several years developing
means by which water quality parameters could be determined by remote sensing when the
Department of Natural Resources (DNR) of the State of Wisconsin was faced with a critical
application problem. The department was required to make an assessment of the eutrophic
level of all lakes within the state having an area larger than 100 acres. The assessment of
thousands of lakes by means of ground sampling seemed financially impractical. Suggestions
that LANDSAT-1 or high-altitude aerial data be used for this assessment were met with
reservations by staff of the Department of Natural Resources. Problems of resolution of
LANDSAT-1 data and reliability of analysis seemed to provide good grounds for skepticism.
When trial tests were made, however, a technique appeared possible. Research that was then
designed to include close collaboration between researchers and users produced a useful
technique. The DNR is already knowledgeable about this and is preparing to use its own
interactive terminal for analysis of LANDSAT-1 data. Its own technicians will use the
technology developed to monitor lake eutrophic levels.

1. What was done.- Staff members of the DNR having responsibility for planning and
enforcement of water quality programs had been advisory members of the steering committee
for a project on remote sensing for some time. They brought the problem of monitoring
eutrophic levels of lakes as a possible goal for remote sensing research. In order to be
sure that goals for research would be formulated in such a way that the questions answered
would be clearly related to the questions as they face the DNR, the role of DNR staff members
in the management of the remote sensing project was strengthened. DNR staff members became
principal investigators along with university research personnel. As a result of this, they
participated in deciding specific objectives for research each year, formulating the budget
for the proposed research, deciding research sites and time schedules, supervising laboratory
and field workers, contributing sections to interim and final reports, and discussing or
clarifying final reports wherever they were presented. No attempt was made to have the roles
of the university researchers and DNR researchers interchangeable. Rather, they were com-
plementary to one another.

The specific work of principal investigators from the DNR and the university took place within a general dialogue between DNR staff and university researchers over what is possible in remote sensing. To initiate one phase of the dialogue a one-day workshop on current work on remote sensing was presented for personnel of the DNR. University staff did not know which people in the DNR would be interested. The management of the DNR canvassed their organization: About 30 of their staff members representing a wide variety of interests took part in the workshop.

University researchers led off each session with a brief description of the work in which they were presently engaged, leaving at least 50% of the time for free discussion. Some of those attending felt afterward that a longer time could have been spent on each topic, but experience indicates that the attempt to extend a familiarization session beyond one day produces diminishing returns.

In the course of the workshop, participants were urged to make arrangements to pursue specific questions by individual or small group arrangements on a more limited topic. One example of this occurred several months after the workshop when a small group met to discuss specifically what could be done through digital analysis of LANDSAT imagery of lakes to monitor eutrophic level. One university researcher had prepared a program for image analysis by means of an interactive computer terminal and arranged to explain the possibilities and limitations of this process to operating personnel of the DNR. This small-group, one-half day discussion, including demonstration, was focused clearly on further development of this particular piece of technology. Progress toward fulfilling the need of the DNR and areas in which greater development was needed became clear in the interaction within the small group. As a result of this meeting arrangements were made for refining the technique and for establishing a means by which employees of the DNR would develop proficiency in the use of this program. Although hired by the DNR they would work at the university under the supervision of a university researcher.

Finally, on the basis of experience of the DNR personnel who are developing competency in the use of this interactive program for assessing lake eutrophic level, instructions will be prepared by researchers bringing together theory and technique in a manner that will allow the DNR to use its own employees and its own interactive computer terminal to carry on a program of continued operation without reliance on university personnel. The manual will not only give instructions but will explain theory and limitations of the techniques in order that the DNR can be clearly aware of areas in which the application of the technique will be dependable.

2. Data and information flow.- While research on monitoring the eutrophic level of lakes has developed into a transfer of technology to the DNR, it has also involved data and information flow. Decisionmakers in the DNR needed to know the eutrophic level of each lake in the state as soon as possible. This problem was communicated across the (1)-(2) interface (see Figure 1) to university researchers in the course of general meetings of the Steering Committee of the research project and the workshop described in III.A. University researchers collaborating with DNR personnel analyzed the problem and defined the tasks of identifying lakes, analyzing density on LANDSAT-1 and RB-57 imagery, relating this to ground truth, and establishing a classification system. Data requests in this case went from university researchers to NASA for LANDSAT-1 and RB-57 imagery. The data were received for processing by the university and by DNR personnel. In this particular case, the data processing and the analysis and interpretation become intermingled since interface (3)-(2) involves an interactive computer program. After the lake to be studied has been identified on the digitized computer-compatible tape made from LANDSAT-1 or RB-57 imagery, the researcher viewing the image on a television screen is able to choose areas of the lake from which data samples will be taken to establish characteristic readings for the whole lake. This allows him to avoid idiosyncrasies in determining density readings from the area of the lake that might be caused by the large pixel size of LANDSAT-1 imagery or other conditions he can identify by viewing. In this process, he can also choose between different scanner bands of one image and images from different dates. By a series of questions and answers and of images, the data are refined and interpreted. The data and information flow sequence is finally completed when the eutrophic level is reported to the decision-making agency.

At two points the communication at an interface was more complicated than the simple diagram (Figure 1) indicates. Figure 3 illustrates the nature of the communication at the (1)-(2) interface in the formulation of this problem. The communication across interface 1-2A-2B has been stylized but it can be seen from the scheme depicted in Figure 3 that numerous elements of interactive communication back and forth across these interfaces are necessary before a problem is formulated clearly. At each point the university researchers or DNR staff members felt they were asking a clear question or making a clear statement. The need for elucidation each time they communicated across the interface made the attempts to communicate burdensome and made disengagement seem attractive. But with continuation of the communication, productive work was done. If communication difficulties at an interface appear to disable the data and information flow, greater concentration on dialogue--message and response or question and answer--may free communications and the data and information flow.

A diagram similar to Figure 3 could be drawn for the interface between (3) and (2) in the return of information for analysis and interpretation by means of the interactive computer program. A diagram of this communication would appear as a series of questions and answers, questions and clarifications across the interface (3)-(2) until the operator received the data that would be best used to characterize the eutrophic level of the lake. The operator would relate data received from imagery to data received from other sources during his interaction with the digitized data displayed by the computer terminal, before final interpretation was made. In research projects in which no computer interactive program is involved, this kind of interchange back and forth between data processors and analysts and interpreters may be necessary in order to clearly define the data.

3. Transfer of technology.- In this project, a technique was being developed that ultimately was transferred for use to the DNR. It can be assumed that all of the differences of viewpoint referred to in the previous section could potentially inhibit transfer of this technology. Here are some ways used to get around differences in viewpoint in several areas.

(a) Value systems: The primary emphasis to be expected of research personnel in this project would be an understanding of why differences in reflectance of water bodies would be related to the eutrophic level of the lake. The emphasis of DNR staff members would be to assure the development of a useful tool for establishing the eutrophic level. Because the agency staff members and researchers sit together in planning research and have equal voices on the steering committee for the project they are able to work out the implications of their different points of view about what is the most important product of the research. They have been able to maintain two emphases: (1) the development of a satisfactory technology within a reasonable time and (2) the understanding as fully as possible of the reflectance phenomena connected with eutrophication of lakes. These two emphases broaden the perspective of each group in work on the research.

(b) Uniqueness or generality of the result of research: University research personnel would like to develop a generalized theory of lake water quality while DNR personnel need to have specific categories of eutrophication established for each lake. It has generally been agreed in planning sessions and exchanges between principal investigators that the work to determine specific classifications of the lakes must go first, but at the same time generalized work on the dynamics of lake eutrophication need to be going on. Were it not for the emphasis given by DNR personnel in planning this research, it is possible that the result would have been a highly theoretical treatment of lake eutrophication that would never have been usable by the DNR.

(c) Time frame: Differences in time frame have been worked out by interaction between the principal investigators during the design and execution of the project. University researchers feel rushed and have to do things more quickly than they otherwise would. Were it not for the emphasis on getting a product fairly soon from the research it is possible that a technology developed might have come along too late to be useful in this specific problem.

(d) Manipulation of the environment: The extent to which the environment should be manipulated in order to isolate particular variables in the research has been resolved by

collaboration by the principal investigators planning and executing the research. It is probable that university researchers on their own would have relied more on work in test tanks where conditions can be arranged and manipulated to suit the needs of measurement. Application to specific bodies of water might have been left to personnel of the using agency. As a result of collaboration between the using agency and the university researchers, however, the researchers have gone as far as they are able in making measurements on existing water bodies as they occurred in the environment. It is expected that there will be a movement back and forth between actual field conditions and laboratory conditions as steps are made in the progress of the research. The technology that is being developed, however, is useful in lakes as they actually exist.

(e) Communication patterns: Differences in communication patterns between the researchers and science practitioners have influenced the form in which final results of the development of this technology will be published. Research results still will be submitted to journals for journal articles; in addition, in order to facilitate the transfer of technology, a user's manual is being prepared to explain the use of the technique, the training of personnel to use it, and limitations to be observed in its use. These matters ordinarily would not be covered in journal articles produced by university researchers. The production of a user's manual grew out of collaboration between DNR personnel and university personnel.

(f) The finality of knowledge: Differences in viewpoints over the finality of knowledge contained in the technology largely remain. University research personnel as a result of their collaboration with DNR personnel probably understand better the need of an operating agency for a technique that represents a solid answer to the problem. Yet university research personnel cannot abandon their dedication to the pursuit of knowledge and the understanding that tomorrow we will learn more and what we know now will possibly be obsolete. The continued skepticism of research personnel about how final their answers are will probably continue to bother the users of the technique, but greater understanding and appreciation of these two different viewpoints will probably reduce misunderstandings that might slow the transfer of technology.

B. Importance of Including Decisionmakers in Preproposal
Planning of Research on the Regional Land Use Process

Strong negative attitudes toward the use of data from LANDSAT-1 for regional land use planning and toward the research process seeking to evaluate the potential use of the data were experienced in one project. This appeared to be attributable to the lack of opportunity for input from decisionmakers in the preproposal planning for the research.

As part of the research entitled "Evaluation of the Application of ERTS-1 Data to the Regional Land Use Planning Process", an advisory council was formed. The function of the advisory council, including county planners, regional planners, state planners, private planners, and other members of the planning community, was to interact with the project investigators to attempt to involve the land use data users in the evaluation of the application of the data generated from satellite and high-altitude aircraft for regional and state land use planning.

The advisory council met three times: the first for familiarization with the characteristics, capabilities, limitations of the LANDSAT system; the second and third for full-day workshops directed toward the evaluation in user terms of the research investigation. Some of the advisory council found in the investigation new potential uses of the LANDSAT-1 data, and approved the conclusions of the research. A few, however, felt that the investigation itself was not necessary, since it would have been clear from the beginning of the preproposal planning, had regional planners been involved at that point, that satellite data could not meet the needs of regional planners. The Assistant Director of a Wisconsin Regional Planning Commission wrote that since "in Wisconsin regional planning is local planning," the detail for local planning could not be secured from satellite imagery.[3] While there was not agreement to this idea, a generally agreed understanding of what was meant by "regional planning" was so basic to the research, that such a question should have been anticipated in the design of the research. Since there was not opportunity to include very much preproposal input from decisionmakers in the design of the research, a potential

problem in the project was not discovered until late in the work.

The Advisory Council member who took exception to the view of regional planning in this project suggested that "actual users of data to be derived from research programs at the University or operational programs at the state level be included in the structure preceding the actual operations of programs and specific studies in order that these users may provide input regarding specific needs."[4]

In this case the debate stimulated by this incident may have served to bring out more in the responses of potential users of remote sensing data than would have been seen if the opportunity for more preproposal planning had been present. Certainly NASA had gone far to try to include the planning community as users in the preparations for the LANDSAT research, but not all possible users could be involved.

For a university, approaching the planning of research related to the needs of governmental agencies, preproposal planning must include adequate input from the expected user agencies. Yet money is not readily available for this very important preproposal planning. Some mechanism must be found to support research planning in this phase if user-related research is to continue.

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C. Meeting of the Minds in Preparation
of Land Cover Maps

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In a small research project in which difficulty had been experienced in the data and information flow process, a contract was used to clarify communication at the interface.

1. What was done.- When results of a research project on the use of LANDSAT-1 data for statewide land-use planning functions were presented to the decision-making organization, the results did not seem to answer the questions that had been proposed. Discussion of the problem afterward indicated that while there had been communication between the research staff and the decision-making agency, the two groups had not developed compatible understandings about the work involved. When a new project was being considered, the decision-makers and the researchers used a technique from the business world to clarify the understanding between them. A contract was drawn up clearly specifying the expected product from the research.

In this case, the decisionmakers were identical with the interpretation and analysis personnel. Their need was for land cover maps made from LANDSAT-1 imagery. Researchers were in the role of data processers. While it seems rather simple to write a contract clearly specifying that maps of a certain type will be delivered, the comparison of ideas and perceptions that went into the discussion of terms for a contract helped parties on each side of the interface to communicate and agree and to spot potential misunderstandings. If the preparation of a contract, however, is a perfunctory matter,it may not serve much useful purpose in clarifying the flow of data and information across the interface.

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D. A Data Center in the Data and Information Flow Process

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A Data Center, maintained to serve as a library for data acquired by several remote sensing projects and to make remote sensing data available to users, occupies a unique place in the data and information flow sequence.[5] In operation for several years, the Center makes available low altitude color and color infrared photography, thermal imagery, high-altitude RB-57 imagery, LANDSAT-1 70mm and 9" transparencies, and a 16mm Browse file of LANDSAT-1. Publications to support the imagery are also available. Announcements of the imagery available are mailed to potential users, and a catalog of imagery available is distributed.

If the Data Center is considered in relation to the diagram of data and information flow, Figure 1, several characteristics are suggested. User input into the data and information flow process is limited to "after the fact" input--the data have already been acquired and are waiting there. They cannot be changed to respond to the potential user's needs. This may be expected to produce lower credibility than would data from a process

into which the user had input. But this may be balanced by another factor: the data can be compared with other data from different sources. This gives a degree of discretion to the user, and may help credibility.

In the case of the Data Center, the question of communication among the roles represented in the data and information flow may be different from the diagram in Figure 1, depending on the role of the potential user. Figure 4 is a revision of the diagram in Figure 1, to indicate two special cases of communication. The person looking at data in the Data Center is looking across the interface toward the (4) Data Acquisition role. But this person may be (1) a Decisionmaker, (2) an Analyst or Interpreter, or (3) a Data Processor. If he is a Data Processor, the flow of data should be the same as in the simple case shown in Figure 1. If he is in the role of an Analyst or Interpreter he may not directly make sense out of data. Processing probably is needed. In the operation of the Data Center, users who need help in understanding the imagery are sometimes given help by researchers in remote sensing. This is a way of filling the need for a Data Processor in the data and information flow. The path of communication is on the curved line by-passing the Data Processing role with the assistance of a person brought in to help the user.

A practice adopted by the Data Center to represent the data in lay rather than technical terms, indicates another special communication problem. To help lay persons, site names were assigned and an "industry category" created to permit access to the collections by the type of problem being studied. (For example, in a cross-reference section of the card catalog, film of power plant effluents are grouped together, algae blooms are grouped together, and paper mill effluents are grouped together.) This is an attempt, from the point of view of the data and information flow, to aid a (1) decisionmaker in communicating across the (2) Analysis and Interpretation and (3) Data Processing roles, shown by a curved line on Figure 4. It would seem to be important that in this case, adequate supplementary help be available to allow the decisionmaker to be able to encompass the whole data and information flow process in one move, while several distinct moves are ordinarily needed.

A final question about the place of the Data Center in the process is related to the proposal that a survey be made to seek from users an indication of their needs. In this case, is the Data Center in the role of Data Acquisition (4), asking users as though they were (3) Data Processors, and (2) Analysts and Interpreters, and (1) Decisionmakers? These roles probably must be kept separate in the survey questions--with the normal role of the potential user identified--in order that the questions may presuppose the right context. But in asking the questions the Data Center may be functioning as a combination of (4) Data Acquisition and (3) Data Processor, seeking information from primarily (2) Analysis and Interpretion, but needing another step, interpretation, to allow open communication with (1) Decisionmakers. This illustrates the special problem of the Data Center Survey: It represents a particular case in which the distinctions in role in the data and information flow must be clearly understood, since the meaning of questions and answers will depend upon which interface the communication is assumed to involve.

IV.   CONCLUSION

If a necessary result of research is useful technology or useful information available to decisionmakers in governmental agencies, this result will be most likely to develop if objectives of the research from the beginning of the planning include the flow of information or the transfer of technology. This adds a dimension to what scientists would call "pure" research, requiring of the researchers and the potential users not only scientific clarity, but skill in "extra-ordinary" communication. Such ability is distributed no more equally among individuals than is scientific skill.

Some tools of communication, such as meetings or reports, may not be valued by scientists because these tools are common to nonscientific, everyday enterprises where their functions are blurred and their execution often is inept. This negative appraisal may lead to reluctance to use such tools, even when they are necessary.

To include in a research project the dimension of relevance to decisionmaking, objectives and specific tasks should be designed to call attention to the need for communication as part of the process of research. Aids should be available to supplement the communication skills of researchers and decisionmakers. Time schedules should allow participants in the research to withhold their judgements of what is being communicated, or whether communication is successful, long enough for the dialogue necessary at crucial points to mature (See Figure 3). Finally, participants in the research and decision-making aspects of this enterprise must be helped to expect success in finding the relationships between research and use wherever there are possibilities for such a connection.

NOTES

1. Adapted from Arnold Lanckton, "Remote Sensing:International Market and Market Trends," presented at Conference of Institute for Graphic Communications, Ipswich, Mass., October 1973.

2. James P. McNaul, "Relations Between Researchers and Practitioners," in The Social Contexts of Research, eds., S. Nagi and R. Corwin (New York: Wiley-Interscience, 1972).

3. James L. Clapp, "Evaluation of the Application of ERTS-1 Data to the Regional Land Use Planning Process," Final Report, prepared for the National Aeronautics and Space Administration, 23 October 1974, pp. 269-279. Contract number NAS5-21754.

4. Ibid.

5. The basic material on the Institute for Environmental Studies Data Center upon which this interpretation of processes in the Data Center was based, was furnished by Barbara Kenny, Data Coordinator.
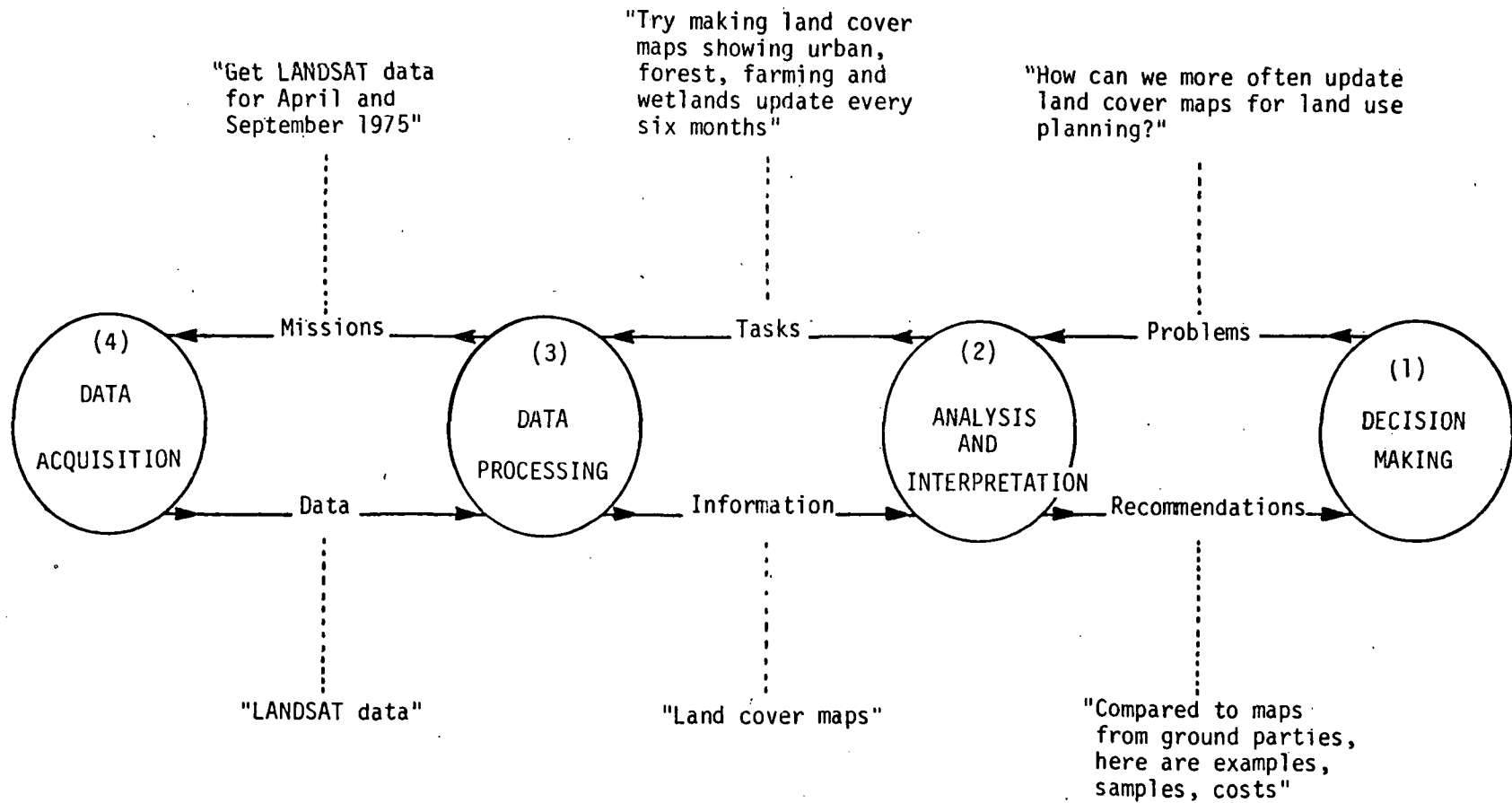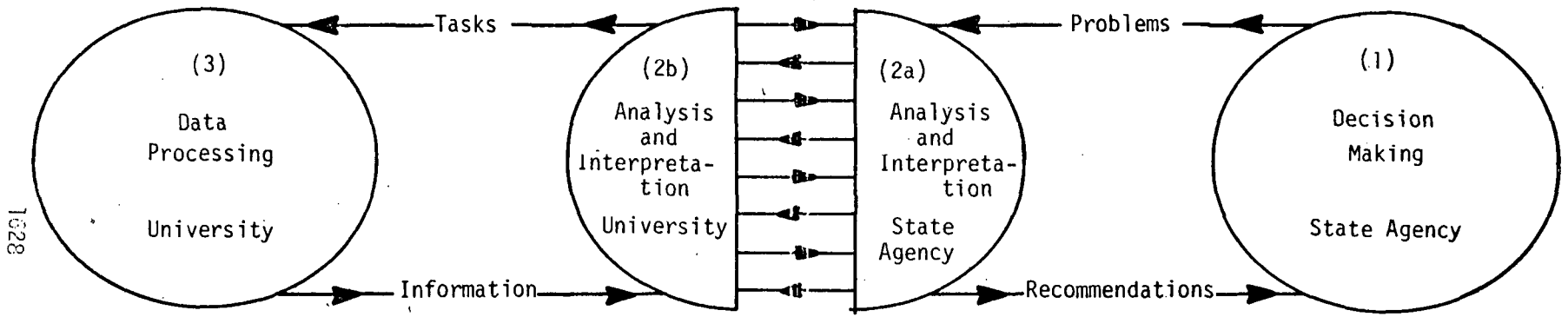
Figure 1. Diagram of data and information flow showing four distinct roles and communication across the interfaces between them. Adapted from Arnold H. Lanckton, "Remote Sensing: International Market and Market Trends," presented at Conference of Remote Sensing, Institute for Graphic Communications, Ipswich, Mass., October 1973.

Figure 2.   Detailed section of diagram of flow of data and information showing relation between state agency staff members and university research personnel when both are involved in the role of analysis and interpretation.

General meeting - "What state agency problems might require research in remote sensing?"

"Water quality of lakes and rivers"

"What do you need to know about water?"

"Clarity, nutrients, plants, sediment, algae and more. What can you measure?"

"Turbidity, algae, macrophyte density"

"Needed very soon: eutrophic level of all state lakes."

"How soon can we assess eutrophic level?"

"How precisely?"

"Three levels"

(2b)

Analysis and Interpretation

University

(2a)

Analysis and Interpretation
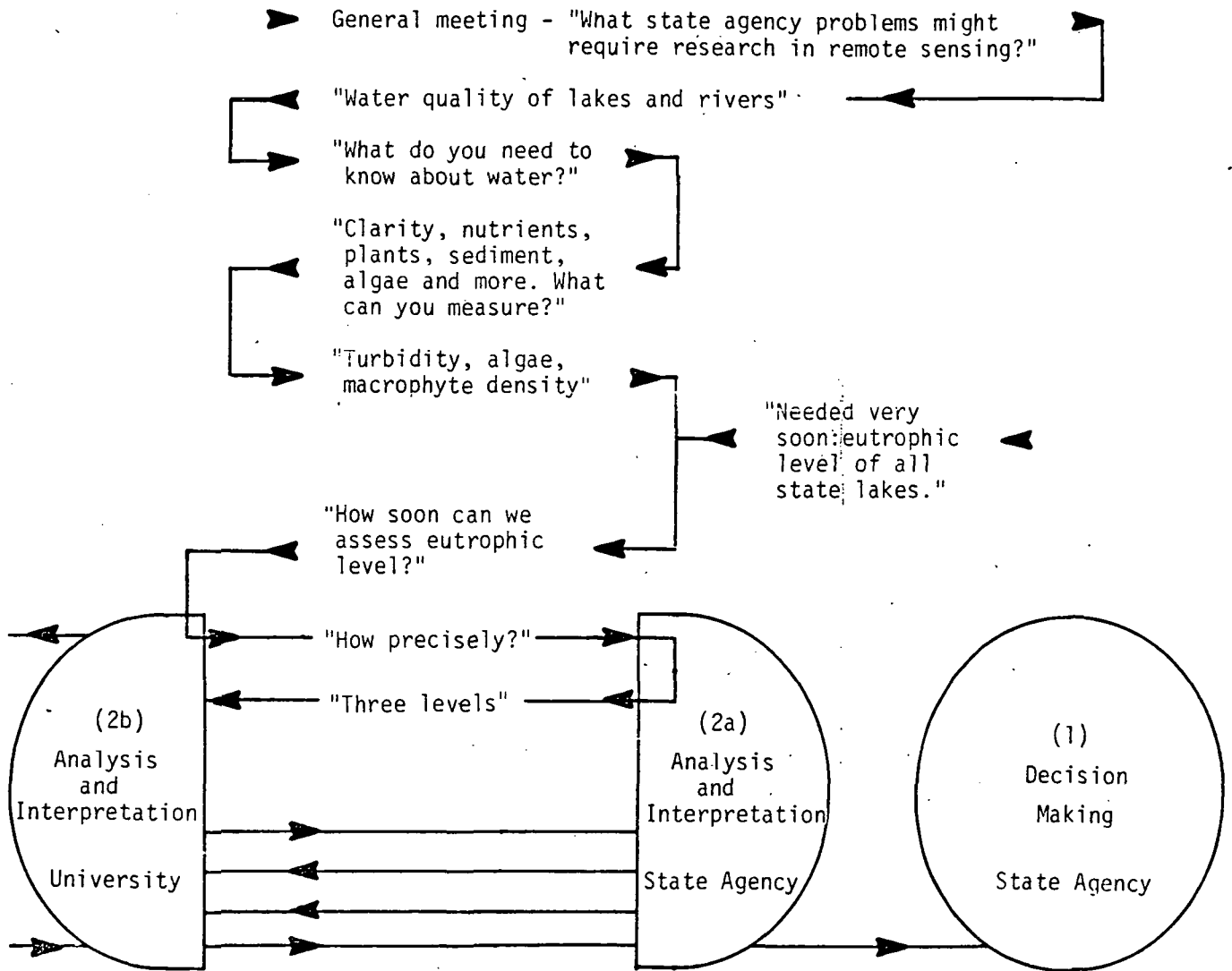
State Agency

(1)

Decision Making

State Agency

Figure 3. Detail of section of Figure 2, diagram of data and information flow, showing typical steps in the communication across the (1 - 2a) and (2a - 2b) interfaces.

Researchers helping users with data

Missions   Tasks   Problems

(4)
Data
Acquisition

(3)
Data
Processing

(2)
Analysis
and
Interpretation

(1)
Decision
Making

Data   Information   Recommendations

1630

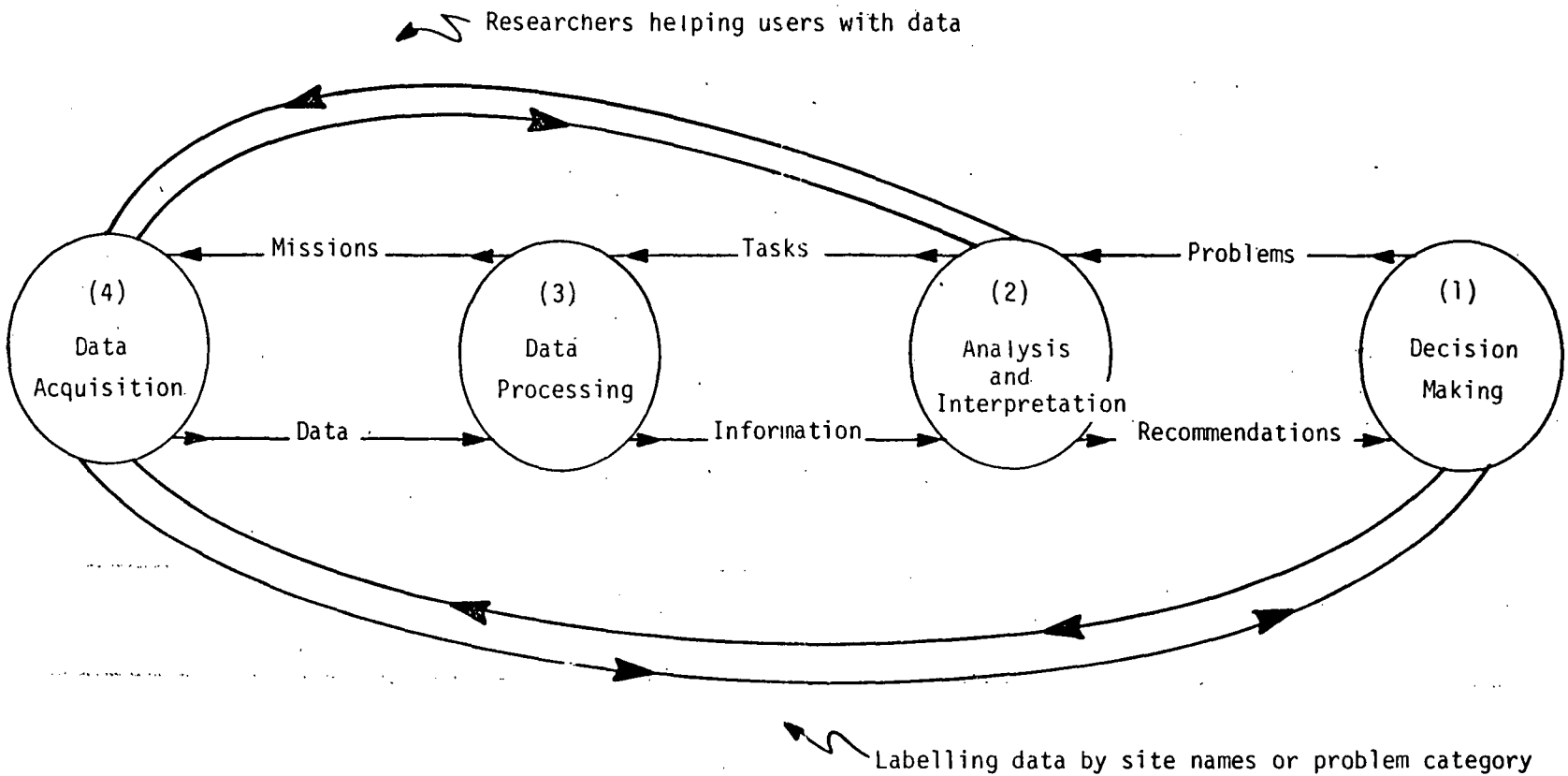Labelling data by site names or problem category

Figure 4.   Diagram of data and information flow revised from Figure 1, illustrating the addition of research
personnel and the use of lay-oriented labelling to complete process of information flow in a Data
Center.