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IMPROVED INFORMATION SYSTEMS: A CRITICAL NEED

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ABSTRACT

The theme of this conference places special emphasis on Thematic Mapper (TM) Data and Geographic Information Systems (GIS). It is significant that the remote sensing community has recognized the importance of GIS technology. Effective and efficient access to remotely sensed and other data for scientific investigations is a major problem today. These problems and a number of broader trends in remote sensing makes it imperative that we broaden our focus and examine a wider variety of information science issues than just TM and GIS. In the years to come work on improved information systems will become increasingly important as we seek to improve our understanding of Global Processes. Improved information systems are a critical need.

The theme of this conference places special emphasis on Thematic Mapper Data and Geographic Information Systems. As a Geographer who has been working in the field of remote sensing for some twenty years, this realization of the potential of geographic information systems (GIS) in the processing and analysis of remotely sensed data is significant. As stated in Estes (1982), both GIS and remote sensing have moved beyond the novelty stage. The papers presented here and at other recent conferences clearly demonstrate this. These two powerful technologies are merging. Researchers in many fields have realized that the synergism created by this merging can result in significant overall increase in information extraction potential for both basic and applied research.

Yet, if this improved information extraction potential is to become a reality, if we are to use these tools to move to higher levels of understanding local, regional, national and global processes, there are still a great many steps which must be taken. We have laid a foundation in remote sensing and GIS demonstrating the power of these technologies. We now need to build on this foundation and to broaden our persepctive to include some of the larger issues involved in integrating remote sensing into an overall information system. An information system as I am using the term, goes all the way from user-perceived models of information requirements through acquisition, transmission, processing, analysis, evaluation and utilization of the information (see Figure 1). An integral component of such a system is a geographic information system, i.e. a system which has as its primary source of input a base of data referenced by spatial or geographic coordinates. Important as geographic information systems are, is the research on the use of remote sensing; Figure 1 clearly indicates that there are broader information science concepts involved as well.

Naisbitt (1984) in his work Megatrends, talks about new directions which are transforming our lives. A number of comments concerning Naisbitt's work are, in my opinion, quite relevant in recognizing the critical need for improved information systems.

Relevant megatrends, Naisbitt discusses, include the move from: an industrial society towards an information society; from force technology to high technology with high touch, i.e. counterbalancing human response; short term to long term; centralized to decentralized, hierarchies to networking; either/or to multiple options; and, finally, with apologies to Mr. Naisbitt for not using "national economy to world economy", we are moving from addressing local and regional science issues to topics of global concern.

The first megatrend discussed by

Naisbitt (1984) is our move from an industrial to an information society. In Naisbitt's own words, "None (of these megatrends) is more subtle, yet more explosive than...the megashift from an industrial to an information society." This information society, says Naisbitt, had its beginnings in 1956 and 1957. It is interesting to note here that this is the time frame for the launch of Sputnik and about the time we began to move from using the term aerial photographic interpretation to the term remote sensing. The term remote sensing is used to describe the field remote sensing which, as I have said many times in my lectures to both colleagues and students, is an information generating technology. One only has to examine the Applications volume of the recent Manual of Remote Sensing (Estes and Thorley, 1983) to find eleven chapters and one thousand, one hundred and eighty-two pages written by over one hundred and fifty authors to see the tremendous variety of information which has been, can be, and is being generated from this technology. Yet, many of us deeply involved in this field still feel frustrated. Our frustration reflects the theme of this conference and has been discussed above. We feel that if we could only find our data more efficiently, manage it better, and use it in a better fashion, we could do so much more. The frustration of scientists who see the tremendous information potential inherent in remotely sensed data feel this way due to the lack of ability to exercise this full potential. This is why the theme of this conference is so important. Most important is that we relaize the significance of geographic information systems for facilitating the analysis of remotely sensed data. But, as I stated before, we must go further. We must examine the full range of information sicence needs inherent in the flow of information from experiment or application design to the user decision process. This requires that we examine questions of improved access, timeliness, standards, protocals, and so on to make the finding of, transfer to, and use of these data as easy for the ultimate user as possible. Improved total information systems are the key.

In remote sensing we are also moving, albeit in this area most slowly, from forced technology to high tech/high touch. To see that remote sensing is high tech you need only look again to the Manual of Remote Sensing. This time to Volume I (Simonett and Ulaby (eds) 1983). Yet, how often in our early years in remote sensing while working with NASA have we, as scientists and data users, been presented with systems and asked the question, what can you do with this? While this has changed in recent years with at least ultimate science data (if not always ultimate applications data) users are being brought into the picture at an earlier phase in the planning process. There is still a nagging suspicion that our voices are not always heard. It is obvious that we, as scientists interested in our own data needs, may ask for too much. Still, I believe NASA and a number of other agencies could listen somewhat better to a community which has recognized the information potential of remote sensing yet is leery of the impacts of commercialization on our long term access to satellite data - a community fearful that space stations will further erode what is currently a bare minimum and patently inadequate funding for basic and applied remote sensing oriented research. We have the high tech but what is needed in my estimation is, as Naisbitt says, more high touch, a counter-balancing human response that recognizes the needs and concerns of the scientists and applications of remotely sensed data. The concern that we have to do the best science possible and the concern to use these data too, as Estep (1968) said in his paper at the Fifth Michigan Symposium on Remote Sensing of Environment back in 1968, employ the fruits of our marvelous technology to provide an adequate standard of living for mankind.

In a more subtle way within this high tech/high touch trend, I also see an increase in the use of techniques from artificial intelligence as a trend towards high touch. Particularly, work in the area of expert systems and natural languages is showing potential for making complex processing of remotely sensed data easier and more understandable for science and application users with less training in image processing. The high touch can, in effect, let scientists function more as scientists and not as image processors. In addition, the use of techniques adapted from the field of artificial intelligence can also aid in the total information flow illustrated in Figure 1. These techniques, if properly applied, show potential for allowing the less-trained individual to take full advantage of the range of services offered by a system. Research and development in this whole area is, and should be, directed at letting scientists and users act more like scientists and users than librarians, communications specialists, computer scientists, and so on. This AI high touch move is an important sub-trend which I feel should continue and indeed be pushed strongly.

Analogous to Naisbitt's short term long term are the trends we have seen in the shifts from applied to basic research within NASA since the launch of Landsat 1. Prior to 1972 while a great deal of applied work was being accomplished with manual analysis of photographic data, many of us in the field were doing very fundamental work on the digital processing of aircraft multispectral scanner data. Then Landsat, our first Earth Resources Satellite, was launched. Overnight this (Earth Resources) satellite provided a large volume of data in digital format which was not a research, but an operational satellite. Instead of building a solid research foundation, we moved directly towards application with a sensor which had an inadequate information system to support a large number of applications to which it was being directed.

In recent years (1979-1980), we have seen a shift within NASA to a basic research emphasis looking at the use of remote sensing to provide data/information concerning problems requiring long range research. The recent Global Biology and Global Habitability documents produced by NASA make this trend clear. This should also be true but just slightly less, in the area of NASA's dealings with information sciences. The current data pilots funded by NASA code EI are aimed at employing existing technologies to improve access to processing of, and interaction with, remote sensing data and scientists using that data. I believe that this is proper in this case. There is a very large and compelling need here to do this. Yet, NASA should not lose sight, and I believe they have not, of the need for basic research in the information sciences as well. If we are to employ effectively the data from systems such as the Advanced Imaging Spectrometer, let alone combine data from the system with Thematic Mapper and Synthetic Aperature Radar data and other ancillary data types in an effective and efficient fashion, a great deal of fundamental thought and work is needed.

Dealing briefly with the next two trends, centralized to decentralized, hierarchies to networking corresponds to the trend in remote sensing from centralized image processing facilities to distributed image processing systems. This trend also points out a change from single-investigation research to multi-disciplinary, multi-insitutional research. In the past, only a few research centers had the computing capability to deal effectively with satellite data. In the Earth Resources area these centers included: NASA Johnson Spacecraft Center, Goddard Spaceflight Center; Ames Research Center and the National Science Testing Laboratory, NASA/California Institute of Technology/Jet Propulsion Laboratory. In addition, universities such as Purdue, Michigan, Berkeley, Kansas and Penn State had such systems. Now many institutions in all parts of the country have processing capabilities. This presents a challenge, a challenge associated with the idea of hierarchies as opposed to networking. If we take hierarchies in Naisbitt's sense to be individual organizations geared toward working independently and compare this to networking which attempts to facilitate the interaction of these organizations, my point is clear. What we have in remote sensing today are hierarchies, yet there is at least some movement towards networking. How often have any of us seen NASA centers work together in a truly cooperative fashion? For that matter, how often have we seen universities in different states, as within states, work cooperatively? While there are exceptions which prove the rule, these exceptions are, I believe, few indeed. In an era of more abundant resources, such independence and parallel development should be supported, encouraged and in some cases, deemed quite healthy. Certainly we need independent lines of research; yet we can no longer afford the largely unnecessary duplication which has occurred in the past. Duplication hinders the networking of scientists needed to fully address the multi-disciplinary science and applications issue in remote sensing. The Data Pilots in the NASA Code E Office of Information Science are addressing the issues involved in networking scientists conducting NASA and NASA-related research at insititutions across the country. I believe these efforts should be encouraged and expanded. The megashift from "either/or" to "multiple options" bears special relevance to the theme of this conference. It is the use of geographic information systems which facilitates the multi-options, we have in remote sensing today. Early on in machine assisted processing, there was a push in remote sensing to obtain all information on a given problem from remotely sensed data alone. When researchers began to realize that the information needed for their particular problem might not reside in the spatial and spectral domains represented by a single image, we began to explore the multi-temporal aspects of the data. Once we exhausted this possibility, we began to explore the potential of incorporating digital terrain data. Later we digitized soils, landuse maps and crop phenologies. We now employ a wide variety of spatially-referenced data in our research. The synergism between geographic information system technology and remote sensing truly enhances the potential of each. For remote sensing data to be most useful they must typically be combined with other data types. In contrast, the quality of geographic information systems depends on the currency of the data they contain. Remote sensing can update GIS data planes while GIS can provide for the efficient use of the ancillary data required by remote sensing.

Finally, in the use of remote sensing, we are moving toward addressing issues which are truly global in nature. Indeed, remote sensing offers humanity, essentially for the first time, a tool with which we can obtain significant global information. That is, we now have the potential to collect consistent global-scale data sets from which information may be derived and whose accuracy is verifiable. Past estimates of important global characteristics such as areas with a particular kind of surface cover or total global biomass on rates of deforestation, have typically been based on estimates which have been difficult if not impossible to verify. We now have the tools to begin to overcome this situation. Remote sensing is a key - a key to unlocking global science, a science of the biosphere (Botkin, 1984, in press). Yet, to carry the metaphor further, it will be information systems which will allow us to turn this key in the lock. Improved information systems will facilitate our ability to conduct our research in an effective manner. Such systems will:

- provide reliable linkage to scientists at locations geographically distributed throughout the country and around the globe;
- permit scientists to function as scientists by enabling effective use with minimal formal systems training;
- allow researchers to rapidly review and select needed data sets;
- provide systematic archiving and maintenance of relevant primary and derived data sets;
- facilitate simple, rapid access to archived data sets and bibliographic information;
- contain as far as practical a history of the data contained; e.g., origin, calibration, quality assessment, etc.
- encourage easy communication among scientists and users;
- provide science access to processing power from level I to level VI systems;
- facilitate data registration and calibration;
- improve the ability to modify, correct, integrate and/or otherwise change data sets; and
- facilitate access to software from a variety of nodes.

Such a system supported by a user-friendly data management philosophy will go a long way towards improving the research potential of the total U.S. research community as a whole, and remote sensing researchers in particular. Some institutions are working on these problems. We at UCSB, among other institutions funded by the NASA University Applications Program and the National Academy's Committee in Data Management and Computation, are looking at this problem as well as are NASA centers. Yet, more needs to be done.

In conclusion, as Naisbitt (1984) says "Fads are top down. Trends are bottom up." The realization of the importance of information systems as shown by this conference, is a trend. Let me return to the first megatrend discussed. I believe we are moving from an industrial to an information society. As seen in Figure 2, the scientific and applied user is faced with an amazing variety of data sources today. What is needed is an answer. The answer may include the generation of a seemingly simple statistic such as the total acreage of the Boreal Forest in North America, yet involve extremely complex data acquistion, transmission, processing, analysis, verification, and display steps. This would require the use of geographic information systems. But even more, such questions demand that we pay attention to the overall information system as well. In the coming years, improved information systems linking multidisciplinary teams of scientists at institutions throughout the world can, and will, facilitate improved understanding of significant science issues facing mankind. Improved information systems are a critical need.

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BIOGRAPHICAL DATA

Dr. John E. Estes is a Professor of Geography, University of California, Santa Barbara. Dr. Estes has published widely in the remote sensing literature and is the Volume Editor of the Applications Volume (II) of the Second Edition of the Manual of Remote Sensing. Dr. Estes has also authored a number of articles on remote sensing and geographic information systems and headed a recent NASA science working group conducting a study of the need for a pilot land data system. Dr. Estes is a member of the National Academy of Sciences (NAS) Committee on Planetary Biology and that committee's representative on NAS's Committee on Data Management and Computation.

IDEALIZED REMOTE SENSING DATA / INFORMATION FLOWS

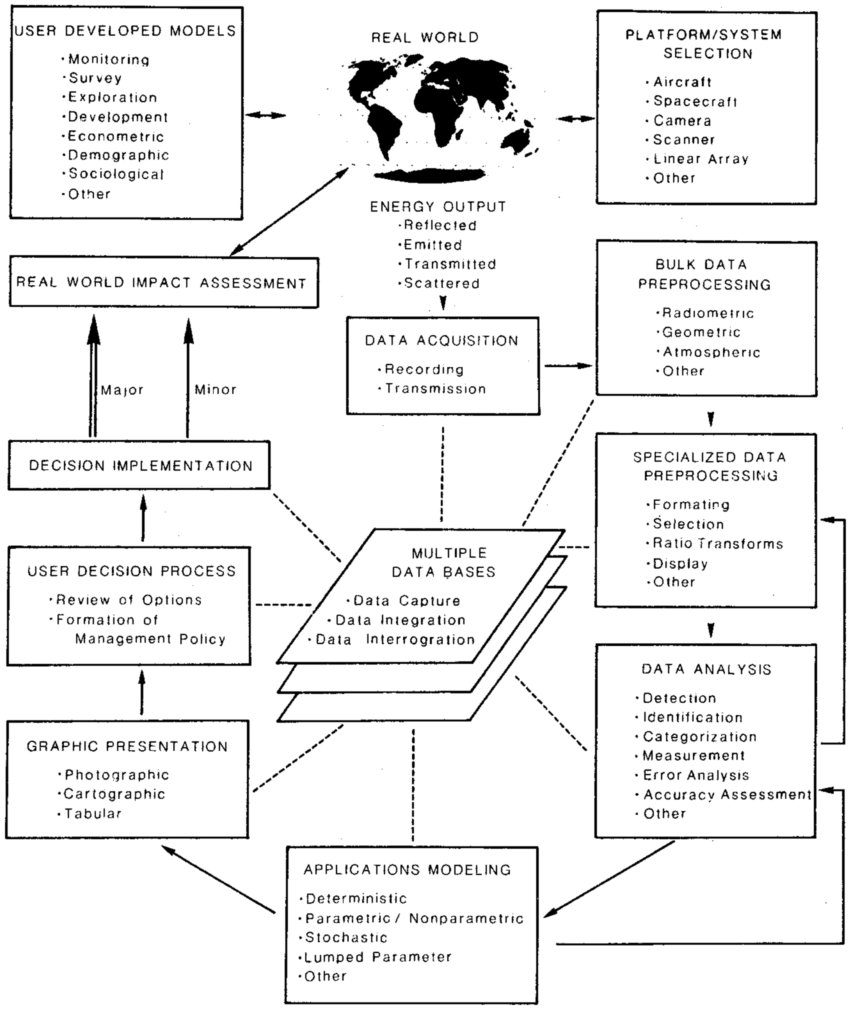

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Figure 1. This figure illustrates the complex data information flow within a remote sensing information system.

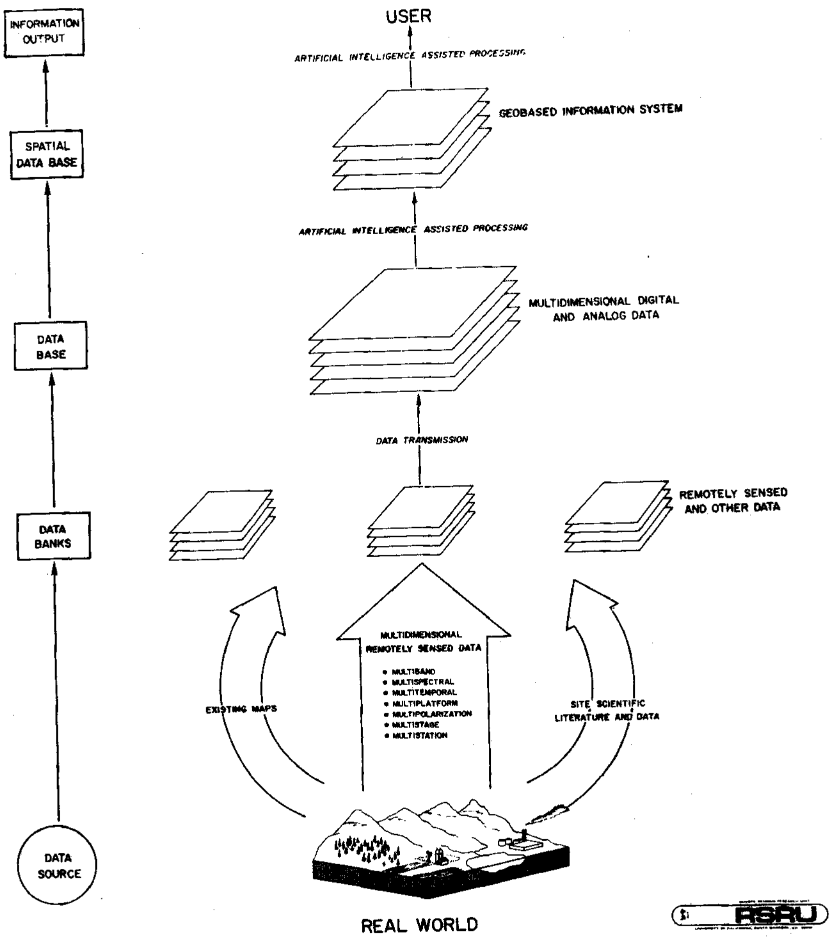

Figure 2. This figure depicts the variety of data types and the flow from acquisition to user.