BENEFITS TO BE DERIVED FROM METEOROLOGICAL SATELLITE TECHNOLOGY

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Introduction

The ultimate user of satellite technology had been relegated to a position of relative insignificance in early developmental programs, because of great pressures at a domestic and international level for successful technical results. Even where the user was considered, it was primarily concerning benefits derived from technological spillover. Now this situation has changed, and an attempt is being made to insure that the full benefits of satellite technology reach the general population. But this is not an easy task. In a sense, it becomes an exercise in the "linking" function, attempting to determine and correlate users' needs with the technology required to fulfill these needs, and then to shape the development of future technology.

At the Space Science and Engineering Center of the University of Wisconsin the above approach has been undertaken in two areas: communication and meteorological satellite development. It is the purpose to briefly set forth the efforts that have been undertaken in these two fields.

Educational Satellite Development: An Approach

While advances in satellite telecommunication technology promise to revolutionize global communication, it is not certain that educational uses of such satellite systems will develop concomitantly. Educational uses may be relegated to obscurity while our society utilizes the more spectacular and commercially viable facets of the medium.

A relevant question for satellite development becomes: What if the medium really is the message? What if the communication satellite, which is a tremendous new medium, becomes the ultimate message? To avoid this outcome I suggest that there is an ethical responsibility which must be assumed by those charged with the development and utilization of communication satellites and also, by those in our universities who must apply the knowledge obtained from their respective disciplines for optimal use of communication satellite technology. It is necessary to examine the various ramifications of the technology, while resisting developmental programs, which do not deal with the software problems and possibilities that should, in fact, establish prerequisites for hardware design.

While commercial satellite development, and particularly, the signing of the definitive International Telecommunications Satellite Consortium (INTELSAT) Agreements, revolutionizes worldwide telecommunications, there are also educational needs and related specialized needs in areas, such as law, medicine, and government services that must be explored. There is a presumption in favor of the desirability of widespread utilization of satellite telecommunication in conjunction with commercial radio, telephone, television, and data transmission, but there is no such presumption regarding an educational satellite system, whether global, regional, or domestic.

In the U.S., the Federal Communications Commission (FCC) is considering proposals which would allow private corporations to develop domestic satellite systems in conjunction with existing ground communications facilities. Within these proposals there is little said regarding educational usage of the system. This is an area where detailed arrangements and plans should be formulated if educational users are to be accommodated.

Some of the less-industrialized countries of the world are considering the possibility of national and regional communication satellite systems, which may prove to be the best means of expanding presently inadequate terrestrial communications facilities; but they, too, lack a full understanding of such a system pertaining to education and the need for in-depth feasibility research.

At the World Administrative Radio Conference (WARC), which this writer attended this past summer in Geneva, frequency allocations were considered for a wide variety of space activities. Of particular interest was the worldwide allocation at

2.5 GHz for educational purposes. The implication of this allocation is that there will be significant domestic and regional educational uses of communication satellites. Thus, it is necessary for educators and government officials responsible for educational planning to develop educationally viable satellite experiments, which contain evaluation components. The Rock Mountain satellite experiment and the possible Appalachia experiment are pointed in the right direction, but much more needs to be done if the potential of the satellite is to be realized as a medium for education at a distance.

If satellite technology is to fulfill its promise, its development must be guided by carefully defined humanistic purposes and priorities. There must be an objective assessment of the limitations and capabilities of the new communication satellite technology in meeting our expectations. Often we proceed under the illusion that, merely because it is technically feasible to develop a given satellite system, it is reasonable to expect that the system will function successfully in pursuing the goals we have set for ourselves or for our national development. There are many components of any major technological system, and usually the least complex of these is the technical one. Perhaps most often overlooked is the question of social feasibility, and particularly, of users' needs. Assuming that a satellite system can be built, is there reason to believe that it will be accepted and used as anticipated by the people for whom it is intended?

Another vital problem relates to the effectiveness of the system once it has been accepted and is being used. If you wish to design a satellite system to serve the teleconference needs of legal educators, for example, to what extent will this means of communication effectively replace, supplement, or improve the conventional techniques of the face-to-face conference? The question of effectiveness applies to most educational and social communications processes, which have been suggested as communication satellite activities, and can be determined only by conducting in-depth feasibility studies in particular discipline areas. We need to learn more about the consequences of utilizing communication satellites. To do otherwise would be, at best, irresponsible and, at worst, disastrous.

The Educational Satellite (EDSAT) Center

At the University of Wisconsin, the EDSAT Center has undertaken the study of the educational and social applications of satellite telecommunications, coupled with the development of the necessary hardware systems. The Center is a multidisciplinary facility with a satellite transmitting capability, which focuses on problems relating to satellites and their educational and social applications. The main objectives of the Center are:

1. To provide a focus for multidisciplinary research and training in the educational and social applications and impact of satellite telecommunication

2. To develop working models for the application of satellite telecommunication systems to educational and social problems

3. To develop and maintain a satellite transmission and reception capability which will allow for an integration of hardware and software research

4. To serve as an information clearinghouse for the collection, annotation, and dissemination of information relative to the educational and social applications of space telecommunication.

The location of the Center within the Space Science and Engineering Center of the University provides immediate access to scientists, technicians and engineers so that our software research does not lose touch with reality and we are able to maintain an effective multidisciplinary approach to our work. In addition, representatives from the fields of international development, anthropology, law, education and mass communication help to maintain a significant humanities input.

Research and Training

Center research interests focus on the inter-institutional, problem-oriented applications of satellite telecommunication and the potential of satellites in education. Research areas of special interest include:

1. Satellite teleconferencing: information exchange and data transmission with links between institutions, administrators, and scholars in multidisciplinary, national, international, monocultural, and cross-cultural settings

2. Satellite telecommunications in teaching-learning activities: the uses of satellite telecommunication in the context of other educational media and their broader educational and social implications

3. Telecommunication law: the stimulation and development of studies with special emphasis on international telecommunication control and the need for relevant international treaties and agreements

4. Evaluation and assessment: the design and testing of means for the evaluation and assessment of the social and educational impact of satellite telecommunications.

The Center provides research facilities to established scholars concerned with problems relating to the educational and social applications of satellites, and involves foreign scholars in research and training operations.

Development of Models

A user-oriented approach is applied at the EDSAT Center which utilizes feasibility studies and other means in determining the most beneficial satellite system configurations. Based on the results of research generated at the Center and in the field, working models are developed which can then be adapted by others, in cooperation with EDSAT, to suit their particular needs and circumstances.

It is important that hardware and software be regarded as integral parts of the same total system, neither of which can be applied in an unrelated fashion. To the extent that software development precedes and shapes hardware development and uses, it becomes possible to develop a hardware technology which is user-oriented and which consists of equipment of a specialized nature developed in response to users' needs.

Further, the Center is attempting to determine, by hypothesis, demonstration, testing and evaluation, models for teaching and learning that will be effective in expanding the scope of multicultural adult education. These models will examine the use of satellites as a component of a broad-based system of information diffusion.

Telecommunication Law

In addition to models for the development of hardware and software, the Center also conducts studies to establish legal and organizational models to serve as the basis for eventual national, regional, and global communication satellite systems. The complexities of such systems may in some cases require the creation of new institutional bodies or special national and international legislation to deal with the problems involved.

Further legal research has been undertaken pertaining to the need for changes in the International Telecommunications Union (ITU) to enable it to deal more effectively with problems arising in the satellite broadcasting area, and concerning the need for revision in international copyright law. Many of the problems that will arise at the 1973 ITU Plenipotentiary Conference are also under study.

The legal implications of the Definitive INTELSAT Agreements have been analyzed at the Center and an analysis of the domestic satellite offerings is currently being made with emphasis being given to the provisions being made for educational access.

The educational and legal implications of Cable Television (CATV) development are also being studied, and the roles of the Office of Telecommunication Policy and the FCC are being considered. This research is considered necessary inasmuch as CATV promises to provide a means of local distribution for satellite signals.

Experimental-Demonstration Laboratory

The Center's experimental-demonstration laboratory operates under an experimental radio license with FCC call letters KB2-XML. Equipped with two Motorola base station transceiver units (110 watt and 400 watt) and a Cushcraft Model A144-20T antenna, the Center has full voice and data transmission and reception capabilities. The base station is designed for remote-control operation permitting transmission, reception, monitoring, and control from various locations. EDSAT Center transmissions are made at 149.22 and 149.25 Hz and receptions at 135.6 and 135.62 Hz. All activities thus far have been conducted via Applications Technology Satellites (ATS) I and III which are used by permission of NASA. Future transmissions will be at 2.5 GHz and participation in ATSF-G experiments is anticipated.

Information Clearinghouse

The EDSAT information clearinghouse provides for the collection, annotation, and selective dissemination of information. After initial selection, the information is made available through the publication of special bibliographies. The clearinghouse has developed a continuing in-house bibliographic service to meet the information needs of the Center-connected research personnel in the U.S. and abroad.

In May 1970, the first EDSAT bibliography was published, titled, "The Educational and Social Use of Communications Satellites." A second entitled "Teleconferencing" has been published and our first annotated bibliography entitled "The Legal and Political Aspects of Satellite Telecommunication" has recently been made available. An annotated bibliography on conferencing and teleconferencing as related to future telecommunications trends, and a bibliography on the adult learner are in the printing process.

Further, the Center is developing an information network in cooperation with United Nations Educational, Scientific, and Cultural Organization (UNESCO) which can utilize the resources of other institutions, domestically and internationally, in pursuit of common educational goals. There is a need for a consortium of universities and research institutions to become involved in research and the exchange of information in the area of educational satellite usage.

We are also aware of the technological changes that have brought about new concepts pertaining to information exchange. The areas of information transfer utilizing existing technology for services, such as medical diagnosis, high-speed transfer of data, teleconferencing and data retrieval, are all being given research consideration. Again our research in these areas is user-oriented, attempting to ascertain both the perceived needs and the future demand for a specific service, within the context of the necessary legal regulations. It is hoped that this research and experimentation will have a positive effect on governmental decisionmakers in coming years.

The Communication of Meteorological Satellite Data to User Groups: The Need for a Multidisciplinary Approach

While the applications of educational satellite broadcasting activities present a wide variety of problems covering areas of educational policy and related areas, the utilization of meteorological satellite data presents a more precise parameter. The spin-scan camera in the meteorological satellite produces a photograph which is enhanced and interpreted with the result being information that a person can use to determine his activities for the day. The more accurate the information is, and the less the amount of time elapsed between the taking of the picture and the dissemination of the information, the more desirable the system. In order to determine the optimum dissemination system and the sensor configuration for future meteorological satellites, NASA-sponsored research has been undertaken by the Space Science and Engineering Center to determine users' needs.

The Research Design

The approach of the multidisciplinary team, in this area, was to begin with the user and to work back to the meteorological data, in order to be able to make suggestions as to the design and development of future satellite systems. It was considered important that meteorological satellite system development be responsive to users' needs, since, ultimately, it is the satisfaction of these needs that justifies the system. Such a system should possess the ability to respond to a wide variety of users, who will be increasing in number, and it should also be able to serve a wide variety of users who have both general and specific needs. In addition, there should be an ease of access to the data and sufficient flexibility in the system to enable it to change to meet new needs.

One difficulty in trying to develop an optimum system is that the users who might benefit from an improved forecasting service are not ordinarily self-motivated to seek the data. The mass media have been used to some extent to increase the availability of the data, but no attempt has been made to ascertain from the media viewer whether this is what he really wants and needs.

Data that originate with the satellite is altered in form as it proceeds from its source to the general public. One of the first users of satellite data is government and other scientists, who have the greatest effect on the alterations to be made in the satellite data acquisition systems. Since the data are altered and processed before reaching the general public, it becomes difficult for the average person to suggest changes in the quality, or quantity, of information that he is receiving. Specifically, users of weather data are not aware of any possibility for improving their weather information and thus they do not attempt to initiate any changes. In fact, there could even be some user resistance to change, which has to be overcome by making the user aware of opportunities that could be made available through the new satellite technology.

What we are determining is not only user needs but also user behavior. By utilizing the expertise available in various disciplines, we were able to analyze this behavior and thus come to a truer picture of actual needs. By including agricultural specialists in user-oriented research, not only were we able to ascertain users' needs but also to determine unarticulated needs which the satellite can fulfill. The use of field studies to determine users' needs and, specifically, the analysis of the behavior patterns of users when interrogating a weather distribution system for information were the best techniques for this purpose. By using the additional techniques of oral interviews, questionnaires, and meetings, we were able to optimize our research findings.

Therefore, it was one of our research parameters that not only should the user be made aware of the best way to use satellite data, but also, there should be a user input which would contribute to the best development of the system; in this case, the meteorological satellite.

The values to be gained through user-oriented research include an improved use of our natural resources, a reduction of damage to people and buildings from natural disasters, economic gain in agricultural and other sectors, a reduction in uncertainty, and a greater ease of planning for various sectors of our society.

There is also a time factor involved in any user-oriented study. When we first made contact with various user groups, we received an initial response. To a large extent, this response was based on a complete lack of knowledge or understanding concerning the satellite. As we proceeded with our interviews and other forms of user contact, an education process was taking place. Users' needs were actually being created. The awareness of the possibilities of the satellite created needs in areas that had not been given any prior consideration. In this sense the researchers acted as "linkers" between the user and the originator of the data.

The concept of a linking function, which has been utilized in the communications theory for some time, provided for us a focus for the collection of data relative to users' needs. Our subject matter experts served an educational function as they translated the technical terms associated with satellite weather data to the various user communities. In the course of our research we reaffirmed our feeling that the existence of the data does not insure its utilization, and that a comprehensive linking function must be present.

The major divisions within our case studies were (1) natural resources utilization and impact, (2) agricultural impact, and (3) commercial activities impact. Experts in these areas undertook individual case studies to determine the nature of the impact of weather-predicting capabilities, provided by the meteorological satellite program, upon their area of special concern. They detailed, where possible, the annual cycle of human activity in their area and identified those times when weather affected their operations. The characteristic effects wrought by weather variations, the type and cost (if any) of preventive measures which might be taken as a protection against adverse weather phenomena, and the benefits derived from this protection were estimated.

Each case-study investigator described how the weather and the availability of precise weather prediction information affected the activity he was studying.

Generally, each case study was undertaken according to the following outline:

1. The activity to be studied was described.

2. The weather-sensitive features of the activity were identified.

3. The functional relationships between weather phenomena and weather-sensitive features were described.

4. The economic implications of this relationship were ascertained.

5. The potential economic benefit of weather information, available from currently used weather-gathering methods, were compared with the potential economic benefit to be gained from fuller utilization of the meteorological satellite program.

<u>The Legal Study</u>

Various independent studies were undertaken in conjunction with the case studies in this multidisciplinary project. An independent legal study has examined the national and international effects and ramifications of the U.S. meteorological satellite program. The focus has been upon the impact of this program on political and international affairs, and the nature of the international cooperation, which has stemmed from the development of the U.S. weather satellite program. Emphasis has been placed on the implications of the use of satellites in conjunction with sensors, such as constant altitude superpressure balloons and ocean data acquisition systems. The fact that the existing international law in this area is minimal has given increased significance to this work which considers both the state of the current law and the alternatives available for a future legal regime. The interactions between the law and technology have been presented, and consideration has been given to an analysis of the relevant international legislation, the applicable safety regulations, the question of liability, and the need for possible international agreements. The legal problems relating to the multiplicity of uses of satellites have been considered, as have been mechanisms for the dissemination of information from meteorological satellites.

Further research in this area will stress both the need for international legal rules in the area of satellite meteorology and the need for the development of domestic law to deal with the interpretation and utilization of satellite meteorological data. An analysis of the question of legal liability for the use and applications of satellite meteorological data will be of particular concern. Also included will be a section on the law of evidence relating to the use of meteorological photographs in courtroom proceedings.

Preliminary Findings

Weather sensitive parameters. While there was found to be a significant information gap, we also found that there were inarticulated needs that satellite meteorology could fulfill. Even though some users were completely unaware that meteorological satellites were even existent, it was apparent that the two-culture separation that existed could be bridged by undertaking detailed analysis of users' needs. From these case studies we found that there are weather-sensitive parameters for about 80 percent of the users studied, and there are substantial economic benefits to be obtained from increased weather information in the majority, that is, 70 percent of the cases studied. The existence of these weather-sensitive parameters provided a first cut for our research and indicated that further work would prove valuable. Thus, in order to evaluate user requirements in detail and to assess the impact of improved weather information, whether from the present origination and distribution system or directly from a meteorological satellite without any system in between, it was necessary to look into each case study area in some detail in order to extract the relevant information.

The case studies clearly showed that different weather parameters can be critical along the path from beginning to completion of the activity and, also, that the time scale required for the user to react in a useful way, also varied over wide limits. It appears, thus, that the best way to meet user needs would not be to produce highly detailed data far in advance. To do so would simply transfer the data storage and retrieval task to the user. Users' needs are specific, both in time and data content. Predictions of those weather parameters which affect long leadtime items are needed well in advance of the weather, but when short reaction time is possible, the user actually would prefer being advised at a later date. In general, large-scale weather phenomena can be predicted further in advance than can smaller scale phenomena. There is a tendency for users' needs to correspond with forecast capability, but, unfortunately, this is not always true. If the occurrence of smaller scale phenomena, such as hail, could be predicted sufficiently in advance, crops could be selected at planting time to avoid loss. Put another way, it may be argued that users' needs adapt to forecast capabilities only because other forecast options have not been offered. A specific finding of our work shows that even very short-range information of severe weather (hours rather than days) has significant economic value. One need not provide any predictive information at all in this situation, since merely communicating the present weather in some detail would be sufficient if it were received in a timely manner.

Key information flow. Still another finding of our work thus far emphasizes the need for a "linker" in the overall weather information gathering, dissemination and utilization process. This individual must know enough about meteorology and about satellite observing systems, as well as the needs of the user, to be able to enhance the key information flow. We emphasize the words "key information," which refer to data which are necessary in the operation of a weather information service and is also critical in the design of a meteorological system.

The dual need for key weather information can be illustrated with two examples, one requiring medium-range and the other short-range information:

1. The case study concerning the hay crop showed a very large potential economic benefit ($ 88 million for one crop, in one state, in 1 year) if a 3-day spell of no rain could be predicted near the hay crop flowering date, in early June. This crop needs a 3-day, no-rain period to dry after it is cut. The protein content of the crop is sharply reduced if the crop becomes wet after cutting. In looking at this statement in detail, we learn that what is really needed is the specification of an effective drying index. Three days with no rain but extensive cloud cover may not be as effective as 2 days with no rain and bright sunshine. Since in the summertime the satellite can easily indicate extensive clear, sunny areas, it becomes apparent that satellite meteorology could have a significant impact in this sector of our agricultural economy.

2. With vegetable crops there is a need to predict calm wind conditions for spraying operations. Except for very flat pressure gradients usually found near the center of a high-pressure area near calm winds, it is almost impossible to predict calm wind conditions from gross weather features alone. In the Midwest a calm or light wind condition can exist in early evening, even with fresh winds a few hundred feet above the surface, provided the sky is clear. Surface cooling by strong back radiation stabilizes the atmosphere and decouples the surface layer from the windy layers above. Satellite cloud images, particularly IR images, provide the key information needed here, and, thus, could improve the economic situation for another agricultural area.

It would be unrealistic to expect every agriculturalist to become an expert in quantitative boundary-layer physics and be able to derive the key information needed himself, although he is an adequate amateur micrometeorologist from experience. Thus, a linker is needed to interpret what could be available and match this to the expressed needs in order that the agriculturalist be able to reduce his costs and maximize the benefits.

Most of the cast studies show several similar specific short-term information needs, and this area of weather data dissemination is clearly identified as needing additional study, both to establish the impact of the requirements on the design of meteorological satellite systems, and also to project the greatest benefit to the user. In this continuing multidisciplinary study, we are building on our current findings to proceed back along the chain from the user to the satellite in order to be able to suggest the optimum design of the meteorological satellite system.

Conclusion

In both educational satellite communication and meteorological satellite data dissemination there is a need to more fully develop an appreciation of users' needs and requirements. In the former, the educational process must be explored and related to the technology. In the latter the weather-sensitive parameters and key information flow must be isolated and this information used in turn to help increase the use of the system. In each case the information obtained will help to determine the configuration of future satellite systems, the interface between the hardware and the software in the system, and the optimum application of the data from the system, whether it be educational programming or meteorological information. The result will be a more responsive and user-sensitive satellite technology.