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THE EMERGENCE OF AIRBORNE VIDEO TECHNIQUES AS AN ALTERNATIVE FOR ACCESSING TROPICAL ENVIRONMENTS (A HISTORICAL PERSPECTIVE)

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ABSTRACT. The development and introduction of remote sensing systems was a rather slow process until the advent of Landsat. Since that time governmental agencies have become strong advocates for the use of satellite systems. Videography, a logical extension of video technology, appears to have substantial promise for the acquisition of airborne remote sensing imagery and data. Because of the relatively low cost of investment required, videography appears to be a good alternative for use by developing countries located in tropical regions of the world.

I. INTRODUCTION

Descriptions of airborne videographic systems and applications that involve this rather unusual technology are quite rare in contemporary remote sensing literature. Therefore, this paper is intended to serve as a brief introduction to airborne video systems and to remote sensing applications that involve video imagery and image data. The approach taken is historic in the sense that it reviews the development and evolution of some older remote sensing systems. In addition, it recognizes some of the factors that have encouraged the use of particular techniques in some developing regions of the world. This paper suggests that rather than looking for a panacea to solve all remote sensing problems, careful consideration should be given to defining each problem, and then selecting an appropriate technology to solve it. This is especially true for developing countries which coincidently are often found in tropical regions.

II. EVOLUTION IN REMOTE SENSING

Long before the term "remote sensing" was coined, data acquisition techniques involving remote sensors such as aerial cameras were developed and employed to locate, measure, evaluate, and monitor natural and cultural phenomena throughout many parts of the world. Lee's (1922) seminal study on the application of "airplane photography" to landforms and settlement patterns is an excellent example. In 1936, aerial photos were first used as the basis for large-scale regional mapping by the Tennessee Valley Authority (James, 1972). Since that time, technology supporting the acquisition and use of aerial photographs has undergone tremendous change. Indeed, a new industry has evolved to provide aerial photographic equipment, products and services to private businesses and governmental agencies throughout much of the developed world.

In much the same way, non-photographic remote sensing systems have undergone a long period of development and use. For example, nearly two decades ago the utility of side-looking airborne radar (SLAR) imagery and thermal infrared imagery were described by Simpson (1966) and Estes (1966), respectively. Somewhat later, with the advent of Landsat, Rudd (1974) described the potential use of satellite acquired imagery as an important geographic tool. More recent technological advances have provided a variety of complex acquisition systems that are capable of sensing in the infrared and microwave portions of the electromagnetic spectrum as well as in the visible. Data acquired by these new systems, whether they are visible images, or data in digital or analog format, are generally processed, interpreted and analyzed with the aid of sophisticated digital computers. Of course the use of these new systems, whether for data acquisition or analysis, necessitates the availability of highly trained operators and skilled technicians as well as experienced application scientists and engineers.

With increased performance of modern remote sensing data acquisition and analysis systems has come increased costs. This is not to suggest that sophisticated aircraft and satellite sensor systems and interactive, computer-based analytical systems are more costly because they are less efficient. On the contrary, they are highly competitive when their initial high costs can be amortized over a long period of time and when their costs for highly trained support personnel can be shared by many projects and programs. Unfortunately, few organizations in the world can justify the purchase of large expensive systems for occasional projects. This is especially true for developing countries where the investment of monetary resources must be wisely done.

III. NATIONAL EMPHASIS ON SATELLITE REMOTE SENSING SYSTEMS

The space age began in 1957 when Sputnick was launched by the USSR. After the United States began to launch its own satellites, the importance of space platforms for remote sensing purposes was soon recognized. In 1966, the National Aeronautic and Space Administration (NASA) asked the National Academy of Science (NAS) to conduct a study of the probable future usefulness of satellites for practical earth-oriented applications. In their reply to NASA, the NAS (1969) made two recommendations regarding the direction of future international joint efforts in satellite applications. First, NASA was cautioned that "while refraining from overselling, the United States should use opportunities to educate foreign data users in the value and use of remote-sensing imagery." Secondly, NAS pointed out that cost-sharing may be desirable "to insure a sense of participation by other nations." In summary, NASA was to promote joint international efforts in satellite remote sensing applications.

Our national emphasis on remote sensing from space that began in the 1960's has continued to excite laymen, scientists, engineers, and national leaders since that time. Our desire to foster world-wide acceptance of remote sensing from space was clearly evident during the 1970's. The successful launch and deployment of ERTS 1 (later renamed Landsat 1) in 1972, and the high quality of images received from that system gave great impetus to the use of satellite acquired earth resource data by many nations throughout the world. In order that all countries share in benefits of space technology, the Board on Science and Technology for International Development (BOSTID) advocated:

> That the United States, through AID and through multilateral bodies where possible, engage itself in a sustained, long-term and systematic effort over the next decade to transfer to interested developing countries the capability to utilize the technology of remote sensing from space (NAS 1977).

USAID has functioned as a strong advocate for the development of regional Landsat remote sensing capabilities to serve developing countries throughout the world. In a paper presented at the Second Conference on the Economics of Remote Sensing, Charles K. Paul (1978), who was then Manager of Remote Sensing Programs, USAID's Office of Science and Technology, expressed some frustration regarding the acceptance of Landsat technology by some developing countries when he said, "...now after five years, if any country hasn't gotten on the band-wagon, they're simply out of luck." Paul suggested that an "appropriate technology" was needed in developing areas; Landsat imagery, in his view, was suitable for that purpose. Regarding the future, Paul reported that next year (1979) he was going to develop a tropical agricultural program, "and carry the crop inventory all the way to its conclusion." He then added, "We'll...try to convince them that they need to do something with this information to benefit the poor." Unstated in Paul's report was the implication that we, the United States, must somehow convince developing countries to commit themselves to satellite remote sensing systems and programs.

For their own reasons many developing countries have not opted to support the development of national or regional centers dedicated to the use of Landsat images or data. Their lack of interest may have been due in part to the lagging commitment on the part of the United States for a long-term Landsat program, or they may have been awaiting the French SPOT satellite system which they expected to represent a new generation of technology. In many other cases the problem may have been the lack of resources to invest in facilities dedicated to Landsat, or the fear that if the Landsat programs in the United States were commercialized, costs would escalate to the point that they would no longer be affordable (Office of Technology Assessment 1984). In any event, Landsat has not proven to be a panacea for the remote sensing needs of the world.

The point here is not to lament the failure of Landsat to meet all of our expectations, nor is it to question the good intent of United States governmental agencies, or to impugn their ability to conduct successful technology transfer programs. In the same sense, my point is not to criticize the huge investment required of the United States and other countries to support Landsat programs. Rather, some very simple questions need to be addressed regarding whether or not Landsat is the "appropriate technology" for all countries of the world, and if not, which remote sensing technologies would be useful given the rather unique needs and circumstances of some countries.

IV. VIDEO TECHNOLOGY

Television technology has been available for the entertainment of home audiences since the mid-1940's; since its inception the fabulous "tube" has captivated the imaginations of millions of people throughout this country and others. More importantly, during the same time frame, video technology has been developed to the point that it can be used to accomplish many difficult, demanding tasks for science and industry. The ability of video cameras to view a scene or process from a vantage point safely removed from the point of action has been a boon for many research activities and industrial processes. Likewise, video sensors mounted on various aircraft and satellites have been extremely useful to those involved in the collection of military reconnaissance and meteorological data. In the latter examples, however, the video remote sensing systems used were either "classified" or they were part of very sophisticated satellite sensor systems. Certainly, they were not designed to be used by developing nations for environmental monitoring or resource management.

On April 1, 1960, the first of ten Television and Infra-Red Observation Satellites was launched. A video camera system (VCS) was the principal sensor for each of the TIROS meteorological satellites (Barrett, 1974). Likewise, more recent meteorological satellites have often included a VCS as part of their sensor package (Eagleman, 1985). When the Landsat series of earth resource satellites was initiated in 1972, a return beam vidicon (RBV) system was included as the principal sensor for that mission. The point to be made is that video cameras have been employed as the principal sensor component of many sophisticated satellite remote sensing systems. Equally important, however, is the fact that data from these complex satellite systems have not been generally available to users in an inexpensive format that could have been easily analyzed and applied to environmental and resource problems.

V. AIRBORNE VIDEO DATA ACQUISITION SYSTEMS

In recent years, several relatively inexpensive video camera systems have been adapted for airborne data acquisition purposes. Many of these systems have been developed from off-the-shelf components. An airborne video system generally consists of at least five basic components: a video camera, video cassette recorder (VCR), video display, power supply, and video camera mount. In addition, other components can be very beneficial depending upon a particular mission's objectives. For example, a microphone system that permits an operator to make voice annotations on the video tape as data for a scene is being recorded is extremely useful.

The most common airborne video systems in operational use today generally utilize a vidicon tube and produce black and white images. Video cameras employed with these systems are essentially the same as those used for surveillance purposes in banks and other closed-circuit television (CCTV) applications; they are sturdy, relatively inexpensive, and produce a video signal suitable for the purpose intended. The feasibility of using color video systems for airborne data acquisition is being carefully investigated by members of several organizations. For example, research by Meisner (1985) at the University of Minnesota - St. Paul involves the use of a newly developed color infrared video camera. Results of his research suggests that color video systems may be suitable for remote sensing purposes in the not-too-distant future. A somewhat different approach is being taken at USDA-ARS in Weslaco, Texas, where researchers have developed a multispectral technique that employs three or four black and white video cameras mounted to view the same scene simultaneously. At ARS each camera is fitted with a different narrowband filter, and acquired data are stored on separate video cassette recorders. For processing, three data sets are digitized and then combined to form color composite images (Nixon, 1985). This multispectral video technique appears to have considerable promise for future applications.

Xybion Electronics Systems Corporation has recently introduced a solid-state multispectral vidicon camera that is capable of sensing in six selected spectral bands. Video data acquired by the camera are recorded on a portable video tape recorder (VTR) for subsequent analysis using an IBM PC computer. The Xybion Multispectral Video Imaging and Analysis System (MSVIAS) appears to represent a new generation of video technology that could significantly enhance videography as a viable airborne data acquisition system in the near future (Nixon, 1985).

VI. ANALYSIS OF AIRBORNE VIDEO DATA

A great range of techniques are available for the analysis of airborne video data. Visual interpretation is the least sophisticated option available in terms of special equipment requirements; however, the quality of the analysis is directly dependent upon the qualifications of the image interpreter. Video images can be viewed in the aircraft as they are acquired, or later in the laboratory, assuming that a video display device and VCR are available. The quality of visual interpretation often can be improved if selected features in a scene can be enhanced. Currently, several electronic devices are available from commercial sources that include an enhancement capability.

Airborne video data can be analyzed using digital computer techniques; indeed, several manufacturers now market analytical systems that include a video data analysis capability. In some cases, unique hardware components have been designed to perform selected analytical functions; then they are interfaced with micro-computers which perform additional functions. In other cases, special software programs have been developed to permit off-the-shelf micro-computer systems to accomplish desired analyses.

VII. AIRBORNE VIDEO REMOTE SENSING PROJECTS

Compared to other forms of remote sensing, airborne video applications are relatively unknown; however, in the past five years several noteworthy research groups and individuals have begun to devote more time and resources toward understanding the potential value of videography. For example, Edwards (1982) and Escobar et al (1983) conducted experimental programs to evaluate the use of near-infrared aerial video for accessing freeze damage to citrus leaves. Results of their research were encouraging. Mower (1983a) used video imagery to determine the susceptibility of top soil to erosion by winter winds. Experiments by Vlcek (1983) in Canada demonstrated the utility of airborne video for the delineation of drainage patterns and forest types. Scientists at Rocky Mountain Mapping (1983) successfully used video imagery to inventory vegetation types at a proposed mining site in North Dakota, and Mower (1983b) was able to detect and map African oil palm plantations in Colombia's tropical Rio Magdalena Valley using video techniques.

More recently, reports by Nixon (1985, 1984) regarding video research and applications throughout the world, have been encouraging. This has been particularly true of research activities at USDA ARS in Weslaco, Texas. Likewise, the ambitious program being developed at the University of Arizona for the application of video technology to agricultural problems is also encouraging. Furthermore, Nixon's newsletters have reported on successful video research applications in Africa, New Zealand, and Canada. These and other possible examples serve to demonstrate that the interest in, and use of airborne video remote sensing techniques both domestically and abroad are rapidly increasing.

VIII. VIDEO APPLICATIONS IN THE TROPICS

From the economic point of view, nations found in tropical regions of the world are generally classified as developing, emerging, or as third world countries. The need for such countries to invest their meager resources wisely is obvious. In many cases, airborne video remote sensing systems are an attractive alternative for data acquisition and analysis. Airborne video techniques enjoy several advantages when compared to either satellite systems or conventional aerial photography. Video provides imagery on a real-time basis. Video screens in the aircraft can display the scene as it is being acquired. This allows the system operator to monitor both the extent of coverage and the quality of the imagery. As a result, navigational and system errors can be corrected while still in flight. Image interpretation or data analysis can begin immediately following the flight. All video data are recorded on magnetic tape--tape that does not have to be processed before analysis can begin. Video tape is very inexpensive and can represent a considerable savings when compared to other alternatives.

From a technical point of view, airborne video is an attractive alternative for many applications, but one must also recognize its disadvantages. Low resolution and geometric distortion are problems that must be considered. Likewise, the relatively narrow field of view of some video optics, and possible image smear at lower altitudes are constraints to be recognized. However, even with these limitations, airborne video imagery and data have proven to be very useful in many regions of the world. As we extend our remote sensing research to include problems found in tropical environments, airborne video techniques will undoubtedly contribute more and more to the answers we seek.

IX. AIRBORNE VIDEO ACTIVITIES IN COLOMBIA INVOLVING UNDIRS

Members of the University of North Dakota Institute for Remote Sensing (UNDIRS) have been involved in several airborne video programs in Colombia during the past three years. In October 1982, an airborne video camera system was taken to Bogota where it was used to acquire airborne video imagery and data for a series of sites selected by the Instituto Geografico "Agustin Codazzi" (IGAC). All video imagery and data acquired were for the exclusive use of IGAC; the results of their analyses have not been published. Among the sites flown and problems addressed were the following:

- Guatavita--severe soil erosion
- Fusagasuga--changing land use along transportation route
- Sasaima--monitoring agriculture in the coffee area
- Barrancabermeja--monitoring oil field and refinery
- Middle Magdalena River -- tropical agriculture and forests

During the summer of 1983, a complete Measuronics LMS II system was taken by UNDIRS to Bogota where it was made available to all groups that expressed an interest in the use of video remote sensing techniques. Faculties from the Centro Interamericano de Fotointer-pretacion (CIAF), Universidad Nacional, and Universidad Distrital were permitted to use the Measuronics system for small demonstration projects. Likewise, application scientists from several private firms and governmental agencies had the same opportunity to test the LMS system using their own data.

During the same time frame, Interconexion Electrica (ISA) S.A., a large national power company in Colombia, sponsored a series of flights along the Rio Cauca for the purpose of collecting video data. ISA's primary interest was the ecology of the wetlands associated with the river; however, they also collected video data for a series of fresh water lakes near Medellin and for a rural land use project north of Sincelejo. In addition to standard black and white video imagery, ISA acquired color video using their own camera system. All airborne video data acquired for ISA are considered privileged, and the results of their analyses are not available except through their company offices in Bogota.

Many Colombians are extremely proficient in the acquisition and analysis of aerial photographs, and in recent years their facilities and expertise for the analysis of satellite data has rapidly improved. Based upon the response of Colombians who were exposed to airborne video remote sensing techniques, it is clearly evident that they want and need the capability to select the appropriate technique for a particular task at hand. They view video remote sensing technology as an important alternative that appears to have considerable promise for use in Colombia.

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REFERENCES

Barrett, E. C. 1974. Climatology from Satellite. London: Methuen & Co.

Eagleman, J. R. 1985. Meteorology: the Atmosphere in Action. Belmont: Wadsworth Publishing Company.

Estes, J. E. 1966. "Some Applications of Aerial Infrared Imagery," Annals AAG, 56: 673-682.

James, P. E. 1972. All Possible Worlds. New York: The Bobbs-Merrill Company, Inc.

Lee, W. T. 1922. The Face of the Earth as Seen from the Air: A Study in the Application of Airplane Photography to Geography. New York: American Geographical Society.

Meisner, D. E. 1985. "Fundamentals of Airborne Video Technology," Technical Papers, 51st Annual Meeting of the American Society of Photogrammetry, Vol. 2, pp. 828-843.

Mower, R. D. 1983. Remote Sensing Techniques Applied to Wind Soil Erosion: Identification of Soil Cover Characteristics. Grand Forks: University of North Dakota Institute for Remote Sensing.

Mower, R. D. 1984. "Monitoring Agricultural Production in Tropical Environments: A Colombian Example," North Dakota Academy of Science, Vol. 38, p. 44.

National Academy of Science. 1969. Useful Applications of Earth-Oriented Satellites. Report of the Central Review Committee, Washington, D.C.: National Academy of Sciences.

Nixon, P. R. 1984. Video Technology Newsletter, USDA ARS, Weslaco, Texas, No. 3, August.

Nixon, P. R. 1985. Video Technology Newsletter, USDA ARS, Weslaco, Texas, No. 4, February.

Office of Technical Assessment, Congress of the United States. 1984. Remote Sensing and the Private Sector: Issues for Discussion, A Technical Memorandum, March, pp. 103-113.

Paul, C. K. 1978. "The USAID Program in Remote Sensing," Proceedings of the Second Conference on the Economics of Remote Sensing, January 15-18, Department of Economics, San Jose State University, San Jose, California.

Rudd, R. D. 1974. Remote Sensing: A Better View. North Scituate: Duxbury Press.

Simpson, R. B. 1966. "Radar, Geographic Tool," Annals AAG, Vol. 56: 80-96.

Vlcek, J. 1983. "Videography: Some Remote Sensing Applications," Technical Papers, Vol. 49, pp. 63-69.