# Congressional Testimony

## Testimony of Dr. Thomas M. Lillesand
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## on behalf of the
## American Society of Photogrammetry
## before the
## Subcommittee on Space Science and Applications
## and the
## Subcommittee on Natural Resources, Agricultural Research and Environment
## House Committee on Science and Technology
## 21 July 1983

MR. CHAIRMEN, members of the subcommittees, thank you for the opportunity to testify today concerning the proposed commercialization of the civil space remote sensing systems. I come before your subcommittees in the combined capacity of a remote sensing educator and researcher, and as a formal representative of the American Society of Photogrammetry (ASP). To elaborate briefly upon the personal and organizational perspectives which I am here to present, let me say that my personal perspectives derive from involvement in university remote sensing teaching and research for the past 13 years in the states of Minnesota, New York, and Wisconsin. My expertise resides primarily in land applications of remote sensing, having conducted formalized remote sensing research programs in agriculture, forestry, land-use analysis, and water resources. I currently direct the operations of an interdisciplinary remote sensing research center at the University of Wisconsin-Madison. I also hold academic appointments in our university's Institute for Environmental Studies, College of Agricultural and Life Sciences, and College of Engineering.

The organization I am here to represent, ASP, was established in 1934 and is the world's largest professional/scientific society devoted to the exchange of ideas and the dissemination of knowledge and new information about the application of the combined fields of photogrammetry and remote sensing. The society's 8,000 members come from across the spectrum of education, all levels of government, industry, and private practice. Hence, the membership of the society includes technical researchers, practitioners, and end-users alike. One of this organization's principal activities is the publication of scientific literature on the subject of remote sensing such as the *Manual of Remote Sensing* and the monthly journal, *Photogrammetric Engineering and Remote Sensing*. These publications are recognized internationally as authoritative sources on the state-of-the-art of remote sensing.

In addition, ASP is affiliated with the American Congress on Surveying and Mapping (ACSM), a national professional society with 20,000 national and state members in the fields of surveying, mapping, and geodesy.

Before I begin to treat the substance of my testimony, let me underscore the difficulty of one's trying to present the view of an 8,000 person organization as diverse in its membership as ASP. The best I can hope to accomplish is to present to you some of the salient issues which a broad segment of the remote sensing R&D and user community deem significant in the ongoing debate on the feasibility and appropriateness of transferring all, or portions, of the civil space systems to the private sector.

I have structured this testimony in direct response to the committee's specific request for information on (1) Characterization of the Remote Sensing User Community; (2) Need for Additional Research to Develop Applications of Satellite Data; (3) Public Benefits of a Government Remote Sensing Program; and (4) Other Concerns. Again, let me emphasize that my remarks relate primarily to the land observing

Note: On Thursday, 21 July 1983, Dr. Thomas M. Lillesand became the first member of the American Society of Photogrammetry to testify before a committee of the Congress of the United States as an official representative of the Society. The subject of the Congressional hearing was commercialization of remote sensing satellites. Dr. Lillesand's oral testimony was condensed from the above written statement, which was submitted for the official committee hearing record. (John M. Palatiello, ASP-ACSM Government Affairs Director.)

PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING,
Vol. 49, No. 10, October 1983, pp. 1461-1467.
0099-1112/4910/1461$02.25/0

program (Landsat), though many of the same issues relate to the existing meteorological satellite program and the prospective ocean program(s).

## Characterization of the User Community

Anyone who has followed the development of remote sensing policy over the years is aware of the scores of hearings and studies that have dealt with characterizing the Landsat user community. Rather than attempting to reiterate the genesis and results of these various activities, suffice it to say that the Landsat user community is indeed broad. Landsat data are used to varying degrees by our federal, state, and local governments as well as by the private sector and the foreign counterparts to each of these groups. Landsat data have been used for everything from predicting snowmelt runoff, to aiding in petroleum and mineral exploration, to assisting in the estimation of wheat production on a global basis.

I am most personally familiar with the uses of Landsat data at the level of state government. For example, in our state Landsat data have been used for such applications as

- quantification of the water quality (trophic status) of all public waters in the state to assist in lake preservation and restoration management;
- assemblage of statewide land-use inventories to facilitate generalized land-use planning efforts;
- analysis of vegetation associations to support generalized wildlife habitat assessment;
- completion of county inventories of agricultural crops to assist such programs as farmland preservation, irrigation management, soil erosion control, and flood/drought damage assessment;
- assistance in the mapping of the surficial glacial geology of the state;
- detection and quantification of large area, commercially significant insect problems (e.g., spruce budworm defoliation) in the forested areas of the state;
- study of coastal processes operative along Lake Michigan and Superior; and
- analysis of watershed land-cover patterns to aid in streamflow estimation and assessment of non-point pollution impacts on receiving waters.

While the above list illustrates the broad applicability of Landsat data to a range of resource management tasks at a statewide level, it should be pointed out that the above efforts have been conducted under essentially *research* conditions. That is, these programs have by and large been cooperative university, state, and federal activities conducted on a pilot project basis. Frankly, some of these exercises have produced some rather discouraging results. Most, however, have underscored the tremendous potential Landsat data hold for assisting a number of *operational* resource management activities in the state.

I would like to emphasize the concept of the *potential*, rather than the *reality*, of the user community's employment of Landsat data on a day-to-day basis. While I am not familiar with all segments of the user community, those with which I am familiar currently represent a rather fragile market for Landsat data. The reasons for this are many and varied but they revolve principally around the following:

- *The continued uncertainty about the status of the Landsat program.* Current and potential users are reluctant to make large investments in equipment and training, and to modify existing methods of data acquisition in the absence of an assurance of long-term data availability.
- *The conduct of the Landsat program fundamentally as an experimental, rather than operational, activity.* Throughout the program users have been frustrated by such factors as the inability to obtain data in a timely fashion; the lack of standardization of the data products made available (e.g., changing formats of computer compatible tapes, changing geometric and radiometric processing of the data); the various technical failures of the system (e.g., the failure of the thermal channel and the presence of the line start anomaly on Landsat-3, and the transmission and power problems on Landsat-4); the program's inability to tailor products to specific user needs; and the sometimes poor communication between the data providers and data users.

The kind of problem I'm referring to in this latter area is typified by a situation we encountered some time ago in Wisconsin. Our Department of Natural Resources deployed substantial resources to collect field water quality data on a number of lakes in the state coincident with the overpass of Landsat-3. Without advance notice to users (but for sound technical reasons), a switch was made from Landsat-3 back to Landsat-2 as the primary sensing system. That meant that the very costly field observations made in support of a Landsat-3 overpass were nine days out of sync with the schedule of the primary satellite. Accordingly, these field measurements were virtually worthless for calibrating the available satellite data. This kind of experience can influence greatly the user's overall confidence in system operation. Ironically, the whole circumstance could have been avoided by a user-supplier communication mechanism as simple as a daily recorded tape enabling a telephone check on system status and data collection progress.

A final point to be made about the experimental flavor of the Landsat program, particularly early on, was the tendency for some to present or perceive Landsat data as an information panacea. This problem stemmed primarily from early over-enthusiasm and lack of experience with the data. Nonetheless, some users have been hesitant to take a second look at the potential utility of Landsat data because of early overselling or overbuying of the technology.

- *The fundamental shift in the philosophy determining the price structure for Landsat data.* At the beginning of the Landsat program prices for the data reflected only the actual cost of reproduction and dissemination. That is, data prices were set using the same philosophy governing the costs charged users for such items as government maps and aerial photographs. Currently, prices are not set by the cost of data reproduction and dissemination, but rather by the principle of using data sales to recover a greater share of the costs of the entire Landsat system. This shift in philosophy has been a deep concern to ASP for some time and on 18 March 1982 the society's Board of Directors passed and forwarded to this Committee and to the President, the following resolution:

  "WHEREAS the American Society of Photogrammetry, which represents the collective disciplines of photogrammetry and remote sensing, is aware that the prices for copies of Landsat data were increased in October 1981, and are scheduled to be raised again (more than doubled) in October 1982;

  WHEREAS the current prices have already resulted in a significant decrease in the volume of Landsat product sales;

  WHEREAS the full value of Landsat data for current and future government and private applications (including data from the new Landsat-D) can only be realized if the data continue to be available at reasonable prices; and

  WHEREAS the October 1982 prices will inhibit all but the most affluent users from purchasing Landsat products, and it will be difficult for the average user to realize the benefits of a promising program for which taxpayers have already contributed about 1 billion dollars.

  NOW, THEREFORE, BE IT RESOLVED that the Society recommends that the U.S. Government maintain prices for Landsat data which reflect actual cost of reproduction and dissemination."

Recently announced prices for Landsat Multispectral Scanner (MSS) data in computer tape form indicate that an image costing $200 in 1980, costs $650 today, and will cost $730 in 1985. A tape for one scene of data from Landsat-4's Thematic Mapper (TM) costs $2,800 today, will cost 3,400 this October, and $4,400 in 1985. It is our feeling that this price structure does not serve the general public well and that data sales will likely decline in response to these increased costs.

Another question raised by certain members of ASP about the current pricing structure is its potential violation of the spirit, if not the letter, of the Freedom of Information Act. This law seems to establish the policy that all government documents (unless restricted for reasons of security or privacy) should be made available to the public according to a uniform schedule of fees "limited to reasonable standard charges for document search and duplication."

- *The lack of aggregation of Landsat users.* The Landsat user community is still very immature, technically and institutionally, in its ability to employ Landsat data to their fullest extent. While results to date have been most promising, the land remote sensing market is not yet analogous to that typifying the communications satellite industry. This latter industry enjoyed the benefit of having large ground systems for utilizing the satellite data already in place when the satellite systems were originally developed. Landsat represents an entirely new source of information that we are just beginning to learn how to use. This fact, ironically coupled with the very multiplicity of potential uses of the data, has limited the development of a concerted voice on behalf of the program. In my estimation, no single dominant civil application group (governmental or commercial) has emerged to lead the demand, or guide the philosophy, for a transfer to a fully operational program status. However, given the aforementioned factors, this situation should come as no surprise. The "loud silence" you may be currently hearing from the Landsat user community does not mean one does not exist. With the exception of the geologic elements of the community (represented by the Geosat Committee, Inc.), it is simply too new and diverse to have an articulate voice expressing its needs and concerns.

### Need for Additional Research to Develop Applications of Satellite Data

There is little doubt in my mind that further research is needed to fully develop the applications of satellite data. Again, it has only been some 11 years that the research community has had access to repetitive, global, multispectral, Earth resource data in a computer compatible format. Since then we've made tremendous strides in acquiring and processing these data, but we still have substantial amounts of both basic and applied research to do to be able to fully transform satellite *data* into useful *information* for decisionmaking. Our baseline information on the spectral properties of the atmosphere, biosphere, lithosphere, and hydrosphere is simply insufficient to fully exploit satellite remote sensing data at this time. While this new measurement tool is enabling us to develop a whole new array of parameters expressing the quantity and condition of Earth resources, developing these procedures takes a great deal of time, thought, and experimentation. On this basis, I question one of the fundamental premises that has led to the whole subject of this hearing. That is the judgement that the investment in Landsat to date has been sufficient to permit the evaluation of the operational uses of the data and, if these are cost effective, to attract a private sector owner/operator. In my opinion, more research is needed to continue the development of operational applications of the data. Further, I don't believe cost effectiveness is the basic issue at this point in time.

As a scientist, I tend to shy away from soapboxes and overstatements of the gloom and doom variety. But let me tell you that my colleagues in the scientific community tell me that the future quality of life on Earth is premised on a much more thorough understanding of the physical and biological processes currently operative on this planet. I frankly am in no position to judge the long-term consequences of such complex phenomena as global soil erosion, atmospheric and climatic variation, ocean degradation, tropical deforestation, desertification, acid rain, decreased genetic diversity, energy demand, food and fiber supply, and global population distribution. What I do know is that satellite remote sensing can play a central role in a better understanding of all these phenomena if we have the systems and the research capacity to tackle the problem. It is very hard for me to attempt to assign a dollar value to what we might learn in the process.

I find it interesting that, at least historically, government has had little difficulty deciding—on faith and belief in the ultimate value of science—to make substantial investments in looking at planets other than the Earth, but finds it very difficult to bring itself to make even relatively modest investments in looking at the Earth. Again, we must consider the scientific value of Landsat data, along with their market value, in implementing our present decisionmaking process.

Departing from the philosophical premise for the need for additional research with Landsat, I'd like to also point out that by current technological standards our "operational" system is already archaic in many respects. Though data from the Landsat MSS system has had a range of application throughout the world, from a technical standpoint the system corresponds to using coke bottles for binoculars. Many potential users who have had high hopes for employing Landsat MSS data in their work have concluded that the 80-m resolution data available for the past 11 years are simply inadequate for their needs. However, when Thematic Mapper (TM) data become more generally available, we will see a quantum jump in the applications of satellite remote sensing if there is sufficient research to develop same. TM data are in new spectral bands and in a more finely tuned format both spectrally and spatially. The resolution of TM is 30 m in all of its visible and reflected infrared channels—a substantial improvement over the 80-m resolution of the MSS. The price paid for this increase in detail is an increase in data rate and volume. This translates into a range of research tasks aimed at improving the capacity and efficiency of computer processing the data in a form broadening its application. We are just beginning to learn how to *handle* the TM data stream. Much research remains in the area of *understanding what the information content* of the data stream is.

Along with the research to be done in support of the use of TM data is research on the application of other important systems such as the Large Format Camera and the Shuttle Imaging Radar systems. These systems are part of what has to be a much larger and longer-term commitment to fundamental R&D in sensor system development to guide the design of our "operational" systems of the future. In short, whether we "hand over" all or parts of our operational systems to industry, government must continue and enhance its program for fundamental, high-risk R&D. Private sector companies, with limited capital, simply will not invest in such high-risk ventures where the payoff is a long time off and where they have no assurance that the benefits of their investment will accrue principally to them. Continued government support of short-term research to nurture the application of TM data and long-term research and development for the definition of future systems is imperative if the U.S. is to continue its leadership role in remote sensing.

## Public Benefits of a Government Remote Sensing Program

I and the organization I represent believe commercialization is an inherently *desirable* objective for our civil remote sensing programs, *if implemented at the proper time, at a reasonable rate, and in a fashion insuring the greatest service to the national interest.* There is little doubt that the private sector can play a strong role in *marketing* remote sensing data and tailoring the data to more specifically meet various user's needs. Thus, the potential benefits from nurturing multiple value added service companies in a highly competitive environment are indeed great. Likewise, as remote sensing technology matures, a range of industries will likely develop to provide launch, reception, and dissemination services aimed at meeting the needs of particular high value portions of the market. However, it does not follow that government should simply get out of the remote sensing business. Strong government involvement will continue to be a necessity from a number of standpoints.

First, a fundamental paradox confounds the issue of running our operational remote sensing program as a totally business venture. Often the economic value of the basic product involved, Earth resource data, increases inversely with its distribution. For example, the value of data to support such market activities as petroleum/mineral exploration or knowledge of Russian wheat yields increases as the distribution of and access to these data becomes more restrictive and limited. In contrast, the scientific impact of data on such phenomena as tropical deforestation increases dramatically as its distribution broadens.

This leads to the question of the extent to which our program should be driven by a return on investment strategy or by a philosophy of enhancing the public good derived from the data. Again, I'm personally incapable of putting a dollar amount on the importance of our monitoring the resources of this planet. All I can say is that it is in the national—actually the global—interest that we continue to do so.

In a related vein, as remote sensing technology matures in this country and elsewhere, it will contribute substantially to the overall collection of economic and environmental intelligence. The related security and foreign policy issues will accordingly multiply over time, and these concerns will have to be dealt with by government directly—irrespective of industry's role in an operational system. Just as government is an inappropriate entity for marketing remote sensing, industry should not be expected to guide remote sensing's role in international trade, global environmental protection, and foreign relations.

On this latter point I'd like to emphasize the goodwill our land and weather observing programs have established. The U.S. is recognized for leading the way—both in technology and policy—toward the establishment of cooperative global satellite information collection and dissemination. Our numerous cooperative agreements in the foreign sector have served as well, and we must continue to remember the value of this cooperation as we define industry's role in our operational program.

## Other Concerns

- Interwoven with the potentials of remote sensing are those of other related technologies impacting how we will monitor and map the Earth in the future. Among these related technologies are precise global positioning systems, inertial surveying devices, and computer-based land information systems. With these systems, the potential for closing the gap between our ability to *acquire* Earth resource data and to store and *interrelate* these data with other land-related information is in view. The technological capacity will soon exist to integrate the vast array of legal, fiscal, and environmental records we collect about our land on an accurate geodetic base. In light of these evolving technologies, we could soon have an integrated network of federal, state, and local multipurpose land information systems which would greatly facilitate how we convey property, administer land taxation programs, and manage our land resources and environment. These technical developments afford a tremendous opportunity to reflect upon where we've been and think about where we should head in the collection and integration of land related information in this country.

It is with this issue in mind, Mr. Chairman, that ASP and ACSM commend your colleague, Mr. Lujan, for his foresight and confidence in the scientific community, in his introduction of legislation to study the feasibility of establishing a multipurpose cadastre. The Federal Land Survey Act, H.R. 4399 in the last Congress and H.R. 2279 in the current session, is an important step toward coordinating our nation's fragmented and duplicative land information systems.

As the National Research Council of the National Academy of Sciences has pointed out on several occasions, it makes little sense to continue our country's current multiplicity of disjoint, limited-focus land data collection programs (e.g., property mapping, topographic mapping, tax mapping, soils mapping, land-use mapping, wetlands mapping, mined land reclamation mapping, etc.). We must evolve toward the implementation of multipurpose land information systems (cadastres) at all levels of land management in a coordinated fashion. Accomplishing this evolution technologically and institutionally will take some creative planning. The manner in which remote sensing data can and should be integrated into such systems must be considered carefully as we define the future form of our programs. ACSM-ASP commend Mr. Lujan's bill to your attention.

- To say that this is a critical time for our country's remote sensing program is a severe understatement. In theory, Landsat-D' is scheduled to operate until 1988. With the early technical problems being realized by the Thematic Mapper onboard Landsat-4, Landsat-D' could have to be launched early and data continuity could be interrupted before 1988. It should be noted that nothing is currently planned beyond Landsat-D'. With the lead time needed for system development, a decision to pursue some form of program must be made *now* for data acquisition to continue without interruption. In the absence of such a decision, not only may opportunities for effective commercialization be lost, but also the U.S. leadership role relative to the foreign sector will be at stake.

The French SPOT satellite is scheduled for launch in January, 1985 and strong French government/industry presence in the market is already being felt with an aggressive nationwide SPOT simulation campaign. In this campaign, prospective SPOT data users are being afforded a preview of the form and quality of the future satellite data through the supply of essentially equivalent customer-tailored airborne coverage. As users are obtaining their preview of the data to become available from SPOT 1 and 2, France is simultaneously announcing their plans for the design of SPOT 3 and 4.

It should be noted that the French are writing off the costs of operation of the space segment of their remote sensing system in the hope that the activities of their ground segment will lead to new information technologies that will rapidly enhance growth and development of their economy. For this reason it is doubtful that a United States commercial venture which attempts to recover the costs for operation of the space segment will be able to compete on an international basis without government support.

In addition to supporting the space segment of their programs, competitors such as France and Japan also "write off" aggressive research and development efforts within their government as investments in their economic future. Of concern here is the fact that industry respondents to NOAA's recent Request for Information (RFI) on the conduct of the civil program proposed very conservative, proven technologies for new systems to be utilized in the next decade. Accordingly, I wish to reemphasize that any plan for commercialization must be paralleled with an accelerated program for remote sensing research of a fundamental, high-risk, and long-term nature. The responses to the RFI underscore the fact that such research and development of advanced technology will not be done by industry. Industry will focus on applied, low-risk, and short-term research to improve profitability using current, proven technology. Our government must commit now to the aggressive R&D necessary to keep our industries competitive.

Before departing from the theme of the international arena, I would also like to point out that, while funds to support graduate instruction and research in remote sensing are currently few and far between in the U.S., numerous foreign students and scholars are being supported by their governments to study this subject—both here and abroad. We must be concerned about improving the educational opportunities in remote sensing for our future resource managers. One indication of this is the fact that the Society of American Foresters recently reported that fewer than 60 percent of accredited forestry programs nationwide provide adequate instruction in remote sensing. Equally disturbing is the fact that the Mapping Science Education Data Base indicates that fewer than ten remote sensing courses are taught in the entire country in the context of an agricultural discipline. Not only to remain competitive, but also to invest in our future, we must enhance the educational development of this field hand-in-hand with our R&D efforts.

- The complexity and importance of designing, implementing, and maintaining an operational system—technically and institutionally—suggest the need for a new approach to conducting our civil remote sensing program. In this regard we note the recent report of the Land Remote Sensing Satellite Advisory Committee emphasizing that "One of the most significant problems in remote sensing has been the lack of direction for the program." The report suggested a Board of Directors for Civil Remote Sensing to evaluate Governmental programs of research, industry proposals for commercial activities, etc. The primary purpose of such a group would be to maximize commercial opportunities while insuring that the public interest is being best served. Such a board could be appointed by, and report to, the President. It could have representation from government, industry, academia, and relevant professional societies. This would provide a mechanism for broadly-based remote sensing policy development at the level where it is needed. We submit that some such model is needed in order for government, industry, and the scientific community to develop a good working relationship in the whole area of satellite remote sensing.

## General Recommendations

Just as Congress has in the past considered legislation to establish national space policy, perhaps it would be prudent to draft and enact a National Remote Sensing Policy Act. We can't estimate the impact of the commercialization process until its form and limits are defined. While the government might "turn over" portions of the operation, it simply can't turn over its *responsibility* for the operation of the land, weather, and ocean satellite programs. Again, neither I, nor the society I am here to represent, oppose the concept of commercialization if its implementation recognizes the various issues I have attempted to summarize. We must give the ongoing decisionmaking process an objective chance and participate with a perspective of creativity rather than criticism—for commercialization in some form and extent will likely impact the use of remotely sensed data in many favorable ways. We reserve final judgement on the specific form commercialization might take pending the specific responses from industry to the RFP currently under development. In the interim, *it appears that a staged approach to any transfer of the land observing system to the private sector, commencing with the ground segment and based upon a strong value-added industry, is the most practical approach. This ground segment should include adequate acquisition, archiving, and data distribution capability for all users under the open skies policy, at equitable prices.* This approach would allow for the continued development of an effective user base and would provide simultaneously for an effective vehicle for the input of user requirements into the system.

## Conclusion

The question of what form our civil remote sensing program should take over the long-term simply has no clear-cut answers. However, what is clear is that it is time we make a substantive investment of thought and dollars in crystallizing such a program and recognizing its importance to the national and global interest. Aggressive R&D is needed; funds to provide for program continuity are essential immediately (i.e., satellites beyond Landsat D'); and aggressive marketing, a reasonable pricing structure, and an institutional structure for clear policy development are critical.

In light of foreign competition, the worst thing we can do is further delay our action. This has the long-term impact of effectively precluding the domestic commercial opportunities we are trying to nurture.

While our civil remote sensing program has some shortcomings, much has been accomplished in the last decade. The exciting fact is that we've only begun to scratch the scientific surface of remote sensing's role in improving our understanding and management of the atmosphere, lithosphere, hydrosphere, and biosphere. This will become increasingly apparent as experience with Landsat-4 TM data is acquired. We have the opportunity to employ this technology to aid in the revitalization of our economy, to enhance our international prestige, to revolutionize our methods of scientific inquiry, and to improve international communication and cooperation. *The real challenge before us is to recognize our remote sensing program as a public good and to formulate a policy for the program which will insure future scientific advances, assist in the proper stewardship of our natural resources, provide creative commercial opportunities, and bring remote sensing to a much higher position on our national agenda.*

With the Age of Information upon us, remote sensing holds the potential to play an increasingly important role in providing for the improved peaceful and bountiful habitability of Earth. The long-term global implications of the choices made on the form and conduct of our civil remote sensing programs are indeed profound. The World has patiently awaited our decision on this issue over the last several years, but this patience is wearing thin.

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## Forthcoming Articles

*A. K. Bagchi*, Generation of the Snowline.

*A. J. Brandenberger*, *S. K. Ghosh*, and *Mohamed Bougouss*, Deformation Measurements of Power Dams with Aerial Photogrammetry.

*Russell G. Congalton*, *Richard G. Oderwald*, and *Roy A. Mead*, Assessing Landsat Classification Accuracy Using Discrete Multivariate Analysis Statistical Techniques.

*Paul J. Curran*, Estimating Green LAI from Multispectral Aerial Photography.

*Charles W. Dull* and *William H. Clerke*, Loran-C Navigation as an Aid to Aerial Photographic Operations.

*Bruce Forster*, Some Urban Measurements from Landsat Data.

*C. S. Fraser*, Photogrammetric Monitoring of Turtle Mountain: A Feasibility Study.

*Daniel E. Friedmann*, *James P. Friedel*, *Kjell L. Magnussen*, *Ron Kwok*, and *Stephen Richardson*, Multiple Scene Precision Rectification of Spaceborne Imagery with Very Few Ground Control Points.

*Floyd M. Henderson*, A Comparison of SAR Brightness Levels and Urban Land-Cover Classes.

*K. Jeyapalan*, A Layman's Analytical Plotter: The SDP System.

*D. S. Kamat*, *G. S. Chaturvedi*, *A. K. Singh*, and *S. K. Sinha*, Spectral Assessment of Leaf Area Index, Chlorophyl Content, and Biomass of Chickpea.

*B. J. Myers*, *M. L. Benson*, *E. E. Craig*, *J. F. Wear*, and *P. W. West*, Shadowless or Sunlit Photos for Forest Disease Detection?

*Melvin Satterwhite*, *William Rice*, and *Jerome Shipman*, Using Landform and Vegetative Factors to Improve the Interpretation of Landsat Imagery.

*J. Vlcek* and *D. King*, Detection of Subsurface Soil Moisture by Thermal Sensing: Results of Laboratory, Close-Range, and Aerial Studies.