

NASA Conference Publication 2195

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**Western Regional Remote Sensing
Conference Proceedings - 1981**

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Proceedings of a conference held
at the Holiday Inn
Monterey, California
March 30 - April 2, 1981



NASA

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by NASA Ames Research Center and held
at the Holiday Inn
Monterey, California
March 30 - April 2, 1981**

FOREWORD

From 30 March - 2 April 1981, the Second Western Regional Remote Sensing Conference was held at the Monterey Holiday Inn in Monterey, California. The first three days were sponsored by NASA Ames Research Center. The fourth day was sponsored by the National Oceanic & Atmospheric Administration National Earth Satellite Service. Nearly 300 participants attended the conference, which featured more than 60 speakers. During four days of talks and panel discussions, remote sensing users from 14 Western states explained their diverse applications of Landsat data, exchanged problem solutions and discussed operational goals.

Attendees also focused their attention on proposed FY 82 federal budget reductions for technology transfer activities, as well as the planned transition of the operational remote sensing system to NOAA's supervision. Several speakers stressed the need to continue the remote sensing applications programs, and for the United States to maintain its leadership in the development of operational systems.

This publication contains the proceedings of the NASA sponsored first three days of the conference. The text of the proceedings was produced by Bendix Field Engineering Corporation from summaries supplied by the speakers and, in several instances, edited versions of recorded transcriptions.

Alfred C. Masey
Conference Chairman

TABLE OF CONTENT

	<u>PAGE</u>
<u>SESSION I 30 MARCH 1981 MONDAY (AM)</u>	
A INTRODUCTION - Alfred C. Masey	1-1
B OVERVIEW - WESTERN REGIONAL APPLICATIONS PROGRAM (WRAP) STATUS - Susan M. Norman	1-2
C PERSPECTIVE - TECHNOLOGY TRANSFER PROGRAM - Alexander J. Tuyahov	1-8
D OVERVIEW - NASA REMOTE SENSING PROGRAMS - Dr. William P. Raney	1-13
E STATE RESOURCE MANAGEMENT & ROLE OF REMOTE SENSING - Huey D. Johnson	1-20
F OPERATIONAL LANDSAT REMOTE SENSING SYSTEM DEVELOPMENT - Daniel J. Cotter	1-26
G USDA/FEDERAL USER OF LANDSAT REMOTE SENSING - Richard Allen	1-30
 <u>SESSION II 30 MARCH 1981 MONDAY (PM)</u>	
A WELCOME ADDRESS - C. A. Syvertson	1-37
B REMOTE SENSING IN ALASKA - OPPORTUNITIES & POLICY IMPLICATIONS - Dr. Jay H. Moor	1-43
C OVERVIEW - INTERGOVERNMENTAL SCIENCE/ENGR/TECH ADVISORY PANEL (ISETAP) - Leonard Slosky	1-49
D OVERVIEW - MONTANA STATE'S LANDSAT PROJECTS - Thomas R. Dundas	1-52
E IMPLEMENTING AUTOMATIC GEOGRAPHIC REFERENCING IN UTAH - Bruce L. Plott	1-53
F STATE/FEDERAL INTERACTION OF LANDSAT SYSTEM & RELATED TECHNICAL ASSISTANCE - Paul A. Tessar	1-56
G MULTIRESOURCE ANALYSIS & INFORMATION SYSTEM CONCEPTS FOR INCORPORATING LANDSAT & GIS TECHNOLOGY INTO LARGE AREA FOREST SURVEYS - Dr. Philip G. Langley	1-64

TABLE OF CONTENT

	<u>PAGE</u>
H	SOME PRACTICAL APPLICATIONS OF LANDSAT IMAGERY IN CHEVRON OVERSEAS PETROLEUM INCORPORATED EXPLORATION PROGRAMS - J. Vandemakker 1-66
I	JOINT GEOSAT NASA/JPL TEST CASE PROGRAM - Dr. Frederick B. Henderson III 1-67
 <u>SESSION III 31 MARCH 1981 TUESDAY (AM)</u>	
A	STATUS REPORT FOR LANDSAT 2, 3 & D - Vincent V. Salomonson 1-68
B	UNCERTAIN FUTURE OF LANDSAT DATA UTILIZATION AT SUBSTATE LEVEL - Lawrence Shadbolt 1-77
C	OVERVIEW - REGIONAL & STATE LEVEL REMOTE SENSING APPLICATIONS - Paul M. Wilson 1-78
D	THE ROLE OF THE UNIVERSITY IN APPLICATIONS DEVELOPMENT - Dr. Barry Schrupf 1-79
E	AgRISTARS - REMOTE SENSING APPLICATIONS AT A NATIONAL LEVEL - R. Bryan Erb 1-80
 <u>SESSION IV 31 MARCH 1981 TUESDAY (PM)</u>	
<u>FORESTRY APPLICATIONS (PARALLEL SESSION)</u>	
A	COOPERATIVE FORESTRY INVENTORY PROJECT FOR NEVADA - Ronan Thornhill 1-82
B	PRESENT/FUTURE CALIFORNIA DEPT OF FORESTRY REMOTE SENSING ACTIVITIES - Nancy Tosta-Miller 1-85
C	REMOTE SENSING/VEGETATION CLASSIFICATION - Ivan E. Parker 1-87
D	FIRST DOWN & GOAL TO GO - Gene Little 1-93
 <u>AGRICULTURAL APPLICATIONS (PARALLEL SESSION)</u>	
A	APPLICATION OF REMOTE SENSING TECHNIQUES FOR IDENTIFICATION OF IRRIGATED CROP LANDS IN ARIZONA - Howard A. Billings 1-98

TABLE OF CONTENT

	<u>PAGE</u>
B AN INVENTORY OF CALIFORNIA'S IRRIGATED LAND - Glenn B. Sawyer	1-100
C APPLICATIONS OF DIGITAL IMAGE ANALYSIS CAPABILITY IN IDAHO - Kim A. Johnson	1-102
<u>URBAN & LAND USE APPLICATIONS (PARALLEL SESSION)</u>	
A LAND COVER CLASSIFICATION FOR PUGET SOUND 1974 - 1979 - James R. Eby	1-106
B UPDATING CENSUS URBAN AREA MAPS WITH LANDSAT DATA - Steven Z. Friedman	1-110
C VERIFICATION OF LAND COVER MAPS FROM LANDSAT DATA - David S. Linden & John Szajgin	1-119
<u>RANGE & WILDLIFE HABITAT APPLICATIONS (PARALLEL SESSION)</u>	
A REMOTE SENSING APPLICATIONS FOR RANGE MANAGEMENT - Dr. Robert H. Haas	1-126
B COMBINING LANDSAT MSS, AERIAL PHOTOGRAPHS & GROUND MEASUREMENTS TO ESTIMATE RANGELAND PRODUCTIVITY - Michael J. Gialdini	1-130
C REINDEER RANGES INVENTORY IN WESTERN ALASKA - Thomas H. George	1-133
D APPLICATION OF LANDSAT MSS TO ELK HABITAT MANAGEMENT - Dr. Barry J. Schrupf	1-138
A THE PACIFIC NORTHWEST STORY - Wally Hedrick, Kim A. Johnson, Dr. Barry Schrupf, Luke (Ted) Krebs	1-140
A GEOGRAPHIC INFORMATION SYSTEMS - ESRI APPLICATIONS OF GIS TECHNOLOGY - MINERAL RESOURCE DEVELOPMENT - William Derrenbacher	1-144
B LANDSAT DEMONSTRATION/APPLICATION & GIS INTEGRATION IN SOUTH CENTRAL ALASKA - Anthony W. Burns, William Derrenbacher	1-146

TABLE OF CONTENT

	<u>PAGE</u>
C	IMPLEMENTATION & APPLICATION OF A MULTISCALE/MULTIFACETED STATEWIDE GIS - James R. Anderson 1-152
D	DESIGN & IMPLEMENTATION OF COUNTYWIDE GIS FOR ORANGE COUNTY, CALIFORNIA - Thomas Tousignant 1-153
 <u>SESSION V 1 APRIL 1981 WEDNESDAY (AM)</u>	
<u>SOFTWARE IMPLEMENTATION</u>	
A	IMAGE DISPLAY SYSTEM 511 - Mark Gross 1-155
B	INTERACTIVE DIGITAL IMAGE MANIPULATION SYSTEM (IDIMS) - Michael D. Fleming 1-160
C	VIDEO INFORMATION COMMUNICATION & RETRIEVAL/IMAGE BASED INFORMATION SYSTEM (VICAR/IBIS) - David B. Wherry 1-163
D	EARTH RESOURCES LABORATORY APPLICATIONS SOFTWARE (ELAS) - Dr. Thomas W. Balcerek 1-172
 <u>HARDWARE IMPLEMENTATIONS (PARALLEL SESSION)</u>	
A	THE STATE AGENCY EXPERIENCE (EVALUATION/SELECTION OF HARDWARE FOR AUTOMATED - GEO-BASED INFORMATION SYSTEMS) - Dr. Louis F. Campbell, Jr. 1-175
B	THE ALASKA EXPERIENCE - Douglas L. Mutter 1-179
C	THE MONTANA EXPERIENCE - Thomas R. Dundas 1-186
D	THE COLORADO EXPERIENCE (EVALUATION & SELECTION OF HARDWARE FOR AUTOMATED, GEO-BASED INFORMATION SYSTEMS) - David Sonnen 1-189
E	THE WASHINGTON EXPERIENCE (EVALUATION AND SELECTION OF HARDWARE FOR AUTOMATED, GEO-BASED INFORMATION SYSTEMS) - Roger A. Harding 1-195
 <u>ENERGY APPLICATIONS (PARALLEL SESSION)</u>	
A	OVERVIEW & UTILITIES USE OF REMOTE SENSING - William R. West 1-200
B	OIL EXPLORATION & NUCLEAR SITING - Catherine A. Kitcho 1-201

TABLE OF CONTENT

	<u>PAGE</u>
C NEW RESEARCH LOAD FORECASTING & PLANNING USING REMOTE SENSING - H. Lee Willis	1-202
D APPROPRIATENESS IN USING LANDSAT IN DEVELOPING ENERGY RELATED DATA BASES - Eric Harnden	1-205
APPENDIX A SPEAKER PROFILES	A-1
APPENDIX B LIST OF ATTENDEES	B-1

SESSION I

30 MARCH 81

MONDAY (AM)

WESTERN REGIONAL REMOTE SENSING CONFERENCE
CONVENED AT THE
MONTEREY HOLIDAY INN
2600 SAND DUNES DRIVE
MONTEREY, CA

SPONSORED BY

NASA AMES RESEARCH CENTER
MOFFETT FIELD, CA

A

INTRODUCTION

Alfred C. Masy (Conference Chairperson - Manager WRAP
Information Services)

Good Morning and welcome to the Second Western Regional Remote Sensing Conference. The first three days are sponsored by NASA Ames Research Center and the fourth day is sponsored by NOAA's National Earth Satellite Service.

NASA's conference while designed to enhance users' awareness, will serve to establish a benchmark on current uses of Landsat data and a perspective on new applications. Not only should it provide an opportunity for information exchange between users, but also it should provide a forum for user/industry communications.

Topics scheduled to be covered during this period include remote sensing issues; implementation and institutional factors from both federal and state perspectives; industry in remote sensing; remote sensing applications in forestry, agriculture, urban areas, range, wildlife habitat and general land use; updates on technology and future application developments and software/hardware selection and acquisition.

In addition, a summary of one of the most comprehensive Landsat projects in the West, The Pacific Northwest Story, will be addressed. Other topics will define the considerations of energy and remote sensing, the progress of geographic information systems and a summary of the NASA Technology Transfer Program.

Our first two speakers will provide the setting leading into our scheduled sessions. Susan Norman will present an overview of The Western Regional Applications Program followed by Alex Tuyahov who will speak on the NASA Technology Transfer Program.

B OVERVIEW - WESTERN REGIONAL APPLICATIONS PROGRAM (WRAP) STATUS

Susan M. Norman (Assistant Branch Chief - Technology Applications -
NASA Ames Research Center)

On behalf of the staff of the Regional Applications Program and the Technology Transfer Program at Ames, I would like to welcome you to our conference. We very much appreciate your attendance, which indicates both your interest in the program and your support. This is our second conference and, as I will explain later, your support can potentially play a very important role in whether or not there is a third regional conference.

This morning, I will take a few minutes and give you my view in three areas. First, I will comment on the status of our program and the progress made during the past few years. Second, denote what we had planned to do in the coming fiscal year, which will begin in October. For the third topic, present a brief status report of our budget for FY 82 and how this budget may impact our plans for our work in FY 82.

From a NASA perspective, the Regional Applications Program was started during 1978. The charter provided for interfacing with state and local governments, in particular, to assist them in using NASA developed technology. The emphasis was placed on remote sensing technology. The most current platform for remote sensing is the Landsat satellite. Consequently, the program emphasized applications that utilized this satellite. During the past 3 years, we have had interaction with all of our 14 western states. We have been encouraged by the response received.

I want to present an overview of achievements and accomplishments for the past 3 years and emphasize this from a NASA perspective. You are aware of the program from your point of view and I thought it might prove helpful to tell you how we at Ames view the program.

Basically, we see the program as having two parts. The first is an outreach & training program. The second is specific activities with states and we call these demonstration projects or pilot tests. With respect to our outreach and training program, one aspect that we are pleased with has been the MATE (Mobile Analysis & Training Extension) Van. During the past 18 months, since its inaugural visit to Monterey at our first regional conference, we have had more than 2,000 visitors. The Van accommodates only 5 visitors at one time, so that represents quite a large number of individual demonstrations. If you have been inside the Van you can appreciate that it is difficult to accommodate more than five persons at one time. The MATE Van has visited ten states

in our region. Of course, it would be difficult to get it to Hawaii or Alaska, so we are pleased that of the 12 states in our region, we have had it to 10. In addition, six governors have toured the van and we have had several briefings for legislative staff as well as agency heads throughout our region. The van will be here for the conference's duration and our staff is available to give presentations. I encourage you to sign up if you have an opportunity because we do have new material.

In addition to the MATE Van, we have also had many training classes at Ames. In fiscal year 1980, we had 14 formal training classes and 35 workshops. If you add that up, that is either a workshop or a training session every other week, so we have quite busy at Ames. We consider this an important part of our activity. The most recent training session we held was a VICAR training class. Six different states were represented, including several of you attending the conference today.

In addition to the MATE Van and training, the University program is also a very important part of our outreach activity, although it has been minimal. There are other NASA activities which support the university programs, so our activity has been limited. Our University program has centered around the Remote Sensing Science Council which has a member from each state. The council has met about four times during the past two years. We also provided software assistance to universities which felt this would be helpful to them. In return, many of the universities in our region have helped us give training classes for state agencies. They have either provided instructors or facilities where the training could be conducted. This has been particularly valuable from our point of view, because we like to encourage the interaction between state agencies and universities.

Another major area of progress has been in our demonstration tests with state agencies. The state activities have been primarily concentrated upon completing these demonstrations and in helping those states which have elected to do so to obtain an operational analysis capability. We are pleased that a number of states have elected to implement Landsat analysis software. As a first step in achieving an operational capability, many of the states in our region have decided to adopt a NASA developed software. Because of the preponderance of IBM type systems, they have elected to install a VICAR system which is compatible with that series of computers. For example, in the past six months, the states of California, Nevada, Utah and Arizona have installed the VICAR software on their own computers as a step toward obtaining a more complete analysis capability. Others, such as Colorado, have had the funding to purchase a commercially available system. In addition, the states in the PNW have an operational capability and have recently augmented their basic capability with the interactive video display

systems. VICAR is currently operational in Idaho, Washington, Montana and more recently, Arizona, Nevada and Utah. We have also had requests for assistance with ELAS software, which is a NASA-developed software by a sister group at NSTL. It has been primarily universities, ABAG or regional government and also Colorado who requested assistance in this area. Hawaii and Colorado are also evaluating installation of Landsat software capability. In addition, several states have decided to integrate Landsat capability with geographic information systems. These are Utah, Colorado and California. Several others are considering this.

In addition to our state demonstrations, we have begun to look at needs for substate governments. Preliminary assessments of needs and applications have been made by the Upper Plains Innovation Group, PNW Innovation Group and also the Denver Urban Observatory. Later in the conference, Larry Shadbolt of the Pacific Northwest Innovation Group, will give you a summary of what we have accomplished in that area.

In regard to our state demonstrations, I'd like to give you a quick overview of what we have been doing. If you have read the latest issue of the "Plain Brown Wrapper," it gives you more detail of the activities in each state, but let me just briefly go through each state.

I'll start with Arizona. Primarily we have been working with the Arizona people and the Dept of Water Resources to map irrigated land by water district. We have also worked with the Dept of Game & Fish and the US Forest Service for mapping wildlife habitat on the Kaibab Plateau, north of the Grand Canyon. The Dept of Natural Resources has recently received authorization by the state legislature to begin developing a geographic information system and we hope this will incorporate Landsat analysis capability.

In Nevada, we recently completed a forestry project. We are currently working with the state and several federal agencies to develop plans for a cooperative statewide effort.

Hawaii has had a multidisciplinary project involving agriculture land use and urban issues. The final report from that project will be published shortly.

In Colorado - It has also been a multi-disciplinary effort, involving agriculture, forestry, wildlife and planning as well as a Pueblo Area Council of Governments. Montana already has a basic operational Landsat

analysis capability and we have been assisting them with a substate project in the Flathead region. Tom Dundas will tell you more about that in a later session.

In California and Alaska, as well as the PNW, we have had more extensive projects. There will be a full session on the PNW story, so I think that should also be very interesting. Both the California projects and the Alaska projects have been multi-disciplinary involving many agencies.

In California, it has been primarily agricultural and forestry aspects as well as some work with the counties. For example, the San Bernardino County. The California Dept of Forestry has elected to begin to install the VICAR software and the Dept of Water Resources currently has plans to purchase some equipment.

In the state of Alaska - our projects have been primarily in the south central region and also in the Tanana River Basin. We also have a research project in Alaska regarding wetlands.

In the State of South Dakota, they have an operational Landsat capability. We have provided technical assistance in helping them upgrade their software.

In North Dakota, we recently had the MATE Van there. Unfortunately, we are always in the Northern part of the region in January and we were in Phoenix in the summertime with the MATE Van, so we can't quite get our schedule coordinated with the weather. In North Dakota we were able to give several legislators and agency personnel a briefing on the current capabilities in the field.

In Wyoming, our involvement has been primarily working with them in a planning stage and also providing some U2 imagery.

With that as a basic overview of our past activities, I would like to turn now to our second topic, which is to tell you what we had planned to do in FY 82, which will begin in October, 1981.

I am sure you are aware we had planned to continue to work with states that we have not had an opportunity to conduct demonstration in. We also planned to work with those states which had requested technical assistance. We primarily will provide technical assistance in the area of VICAR support and ELAS for those states that are currently using those systems.

We also planned to assist states such as Arizona and Nevada who are going through their first time application on their own system. We had planned a substate effort with regional government or county, and we have done some preliminary user needs work, so it was our plan to initiate some selected demonstrations throughout our region.

With that as an overview, I would like to turn now to my last topic which involves the status today of our program, and the impact that the current budget will most certainly have on our plans.

I am sure most of you are aware that the administration budget for FY 82 which has been submitted to congress and is currently under review. The current NASA line item for technology transfer is zero. For those of you who are not aware, it is my understanding that the administration and the OMB made a decision that federal technology transfer programs were not effective, so all of these activities were cut across the board. The NASA program was included in this cut although we at NASA Ames in particular, have had some strong indications from some of you that you consider the NASA technology transfer program effective and are willing to support it.

I would like to be very clear on the impact of this budget cut. We at Ames are funded under two separate programs. The first one is a Technology Transfer Program and this includes the ASVT's that we have in Alaska and in California, and the regional applications program. As I indicated, this program has a zero budget beginning in October of this year. The second program is a research and development funding from the Resource Observation Division at NASA Headquarters. This is a separate budget and this funding was not affected by the zero budget for technology transfer. The implications to us at Ames of course, if this should stand as it is currently written, means that our activity in technology transfer which is primarily with those of you in state governments, would be very limited after October 1981 if there is any activity at all. For the ASVT states, specifically California, the CIRSS effort and Alaska, we hope to be able to phase down these efforts during the next year by using some modest carryover funds. Any further work would depend on the suitability for an R&D type project. What this means specifically to your project depend almost entirely on the results of the congressional budget hearings which are occurring within the next few weeks and months. At this time, I am unable to give you any specifics on your particular project.

Later speakers this morning will give you more information on what is happening in Washington, but I did want to let you know that our staff at Ames is committed to Technology Transfer. We feel that our work

with you during the past three years has given us at Ames an excellent understanding of what the issues are in the West and where remote sensing can be successfully applied. We feel that remote sensing has made a contribution to resource management issues in the West, and we are looking forward to continuing, at least at a minimum, the applications development part of our program. If however, Congress should reverse the budget decision, we would support a continuation of the technology transfer program.

If you have questions over the next few days, I urge you to meet with any of our staff and we would be happy to answer any questions that we can at this time.

C. PERSPECTIVE - TECHNOLOGY TRANSFER PROGRAM

Alexander J. Tuyahov (Chief - Space Applications Development
Branch/Technology Transfer - NASA
Headquarters)

It is a pleasure to be here. What I will try to do today is give you a national perspective of where we stand with the status of the technology transfer program and also to talk about the future as well as some of the things that Sue Norman spoke about.

We have essentially three regional applications centers. They are involved in 91 application projects within 22 states. This is our technology dissemination function. We also have approximately eight application system verification transfer projects. These are technology verification efforts involving those types of organizations.

We have approximately 21 university applications branches to develop capacity in the academic community in space applications. Seventeen branches are involved in remote sensing, and we have some basic discipline centers now being started. For the last four years, we have institutionalized liaison activities with public interest groups, such as the National Congress of State Legislatures, the National Governor's Association and others. We also have user requirements activities that conduct user needs studies through our NASA field centers in cooperation with user panels, and conduct conferences, symposiums and other liaison activities.

There are many ways to talk about technology transfer programs but I thought I would go through it in a chronological sense. That is, how did it evolve? Before I do that, let me give you a breakdown as to where we work primarily in technology transfer.

Many activities concern the area of land use for various purposes, such as development, suitability and planning. Another large area is in forestry, range and wildlife, the whole aspect of forest inventory and other types of vegetation inventories. Then we have two major other areas in agricultural-related and water resources activities. Most of our activities are in these four areas. The remaining activities, the materials processing for our university applications programs, R&D, geology activities, geodynamics and coastal zones.

NASA became involved with technology transfer primarily after Landsat was launched in July 1972. The first efforts were investigation efforts.

We have had 327 Landsat investigations, 119 Landsat II investigations. These primarily were directed at the university community, although other users were involved. We first became involved in technology transfer through the university applications programs, which were formed in 1971. Their purpose was to develop a capacity in the nation for applying space applications technology. That has been going on ever since. We have worked with about 30 universities with an emphasis on remote sensing. Now, we are developing an emphasis of understanding disciplines such as geology - what do you need to measure in geology and what observables do you need to measure from space for future systems?

As to the status of our university applications program, we have worked with 31 universities since 1971. We initiated three programs in 1980. We will not be initiating any in 1981 due to budget problems.

In our branch activities, we have essentially, three major functions. First, we try to develop a capacity in the university for applying space applications. Second, we try to develop an educational process so that a cadre of people will evolve in the future that know remote sensing as it can be applied from civil engineering, geology, etc. The third is technology transfer. These are the subsets of those types of activities. That is what the grants are for.

Each university is normally funded for about five or six years to develop enough momentum to get a center going at that university. They may have 40 to 50 projects at that university. For example, the University of Nebraska started on irrigated lands inventory in 1973. Pivot irrigation was using a lot of fuel and the project was conducted to develop planning data for people who are distributing the fuel positioning storage tanks, etc. In this case, the university developed a map of irrigated lands and became independent. The state started funding this. I have had a growing demand for this type of very simple map for the agri business community, petroleum community, the state agency and so forth. We try to get the university started, develop an area of expertise in space applications and then spin them off independently. In most cases, we have been successful in doing that.

Our first program focused on university applications. The purpose was to develop capacity with work primarily in the academic area. Following that, we realize things were proven out - technology was proven - we had to work more with end users. In 1974, the Applications Systems Verification Transfer program was developed to work with end users, in an attempt to transfer and verify that technology in the users own home setting. We looked at the economics of the applications and what kind of adaptive engineering has to be done to make it work in a real environment.

We have approximately eight or nine ASVT's. Some of these have been completed. We are working with the National Park Service right now completing an ASVT program in identifying such things as fire hazard areas and tailoring information products to that particular customer. They are developing a center in Denver and preparing equipment for a Landsat data analysis facility. We are also working with the State of Alaska in a multi-disciplinary activity involving some federal and state agencies and the State of California, involving vertical data integration, working with counties in this state and private industry. One of our ASVT's is with sub-state government. The Florida Water Management District. This project is primarily aimed at ecological problems in Florida. For example, the withdrawal of fresh water from the Swanee River and what impact does it have on the estuarine. The PNW which you will hear a lot about, in a multi-disciplinary project.

We finished a project with the Corps of Engineers, involving water mapping in support of the Dam Safety Act. We have completed a project with the Appalachian Regional Commission to identify gas deposits. The Appalachian Regional Commission is going to drill so we will know the real result of this ASVT. We do not know the results until something is found or not found. We are going through that process now. In addition, we worked with 13 agencies in the State of Texas, and conducted snow cover mapping with the Corps. We are working through Ames with the public utilities to determine power demand and power line citing.

One example involves the National Park Management project. We have a format here of presenting a problem and solution. The key in using Landsat is geobased information systems. This project is a good example of using Landsat in combination with other data.

Just to illustrate something that is very typical of all our projects, we had a Landsat Project which provided us with nine group land cover classifications. Then, through adding elevation and aspect data, we were able to get 21 land cover categories. This is over Olympic park. Then by adding slope, we produced what the user wanted, a fire hazard map. This is rather typical of all our projects by combining remote sensing with a geobased information system approach.

I am not going to talk too much about the regional program since you are already most familiar with this. The program's purpose was primarily to aid state and local users in a very organized national scale of the dissemination demonstration activity. The 1976 administration policy review affirmed that we needed a program to address state and local needs. There was a study that said NASA is great if you have technology up there orbiting the earth and providing data, but you have to teach

users how to use it. We had a lot of congressional testimony. Out of this came a commitment for a regional program to address local and regional problems in a unique way. We formed the regional applications program.

We have the nation categorized in three regions, with a distinct responsibility that each center has for all the states. Prior to this, we had an informal regional program. One of the problems we faced was that several NASA centers might be talking to one state, and a lot of confusion resulted. One of the reasons for developing this program was to eliminate that.

We had universities to build a long term capacity, ASVDs to verify technology dissemination for the regional program - user requirements and awareness and we are looking to determine what needs to be done in the future to see how NASA R&D will develop and progress. One successful program in accomplishing this involves our relationship with NCSL, NGA and the National Association of Counties.

We are conducting user requirement studies in the field center in support of that. After the user needs are determined - areas of deep economic uses - we conduct feasibility studies to determine if something will work in a particular area. The utilities project was started in that way to determine if the technology is feasible in this particular industry. After completion of that, we normally phase into the ASVT program. We are working with a national innovation network on American landscape, the Architects Association. During the last year we worked with NOAA. One example is this conference co-sponsored with NOAA.

On 10 March 1981, President Reagan sent to congress the new administration budget for FY 82 and a revised budget for FY 81. They contain significant changes for our program. The President's budget has the objective of reducing federal expenditures as well as improving and trying to revive the economy. Therefore they eliminate programs that competed with the private sector or provided a partial or what the administration considered an unnecessary subsidy to users who should pay for this service. This is some of the philosophy that was used toward technology transfer. Technology transfer was cut throughout the federal government. Very few federal technology transfer programs survived because the administration considered these programs that should be carried out and funded by the private sector. One of the recommended cuts in the Reagan budget was to phase out and terminate the regional programs - the ASVT and user requirements and awareness programs at the end of FY 81. The university applications program will be phased down and terminated by 1985. The overall implication is that there is a more rapid phase-out of the federal government's role in

remote sensing with more reliance on the private sector. The private sector should do a lot of things that we are doing now. There will be a reduction in the low risk opportunity that has been offered to programs, such as the regional program. We will try to put a lot of emphasis during the next six months on documentation and techniques, and make it available to the private sector. We will review the ongoing projects in the next month and develop a strategy. Essentially, we will complete all our present project commitments, phasing down some projects prematurely. No additional projects will be started and no continuous assistance provided.

There has been a substantial user development completed. We have conducted demonstration projects in 36 states. We have trained more than 2,000 state, university and federal officials. Depending upon how you define the word operational, 15 states are in operational status. We have good university centers of expertise in 20 states.

The NCSL and NGA developed a national network for communicating with states in the remote sensing field. We have also had cooperative projects with federal agencies and have developed interest and appreciation of remote sensing in state programs. All these things in combination with an emerging private sector industry slowly will enable this whole process to be carried out independently, or with less involvement with the federal government.

NASA will continue working with the user more in an R&D capacity and an applications development capacity and not in a national scale of administration way. Although there is much more that could be done, I feel we have made a tremendous start with the users. The next six months to one year will tell us what will happen as the congressional process takes place.

D OVERVIEW - NASA REMOTE SENSING PROGRAMS

Dr. William P. Raney (Assistant Associate Administrator - Space
& Terrestrial Applications - NASA
Headquarters)

My talk this morning is an overview of our present status and applications and what we expect in the future.

There is an essential complication in applying applications in a functional and efficient capacity. We have to encompass different sources of activities. Unless there is a proper scientific base for the applications we are going to apply, we could adapt very expensive systems with people doing a lot of things and then suddenly stand back and ascertain that we are not quite sure what it means. There is a component of science that has to go along with development of the applications. We must work closely with users to make certain that we are not doing things that everyone considers useless. Just standing back and waiting for someone to say I need to do that, completely negates any gains that can be made out of the opportunities that arise from fresh ideas in technology. There must be a balance between technology and applications.

The next process involves how you actually do something with practical technology. You need to create a working system to demonstrate that the system is possible without actually putting it in operation. We have discovered in working through the Landsat program and other programs at NASA, that very often you really do not get the full perspective of what is necessary for an operational system without trying an operational system.

Finally, there is the process which involves transferring the technology into the operations to someone who will carry this on in the future. Transferring technology is the functional process, aside from who spends the money that will be required to do this. We wish to gain knowledge of mineral and geological resources in a systematic way. We start with recognition of a problem, in this case, we then work on various ways of contributing to the solution of the problem technologically. Work out a program plan, work out the details of how we are going to interact with the cooperating agencies and then, finally, develop capabilities to do what we believe will support some improvement in solving the international problem.

In the Earth remote sensing area, we have three functions. One of them is understanding the basic mechanics and behavior of the earth. That

does not have much to do with remote sensing, but is one of the major scientific and practical problems facing everyone in the world. For example, our better understanding of the earth may lead to understanding earthquake phenomenon and prediction, and lead to steps to prepare for earthquakes. It has a great deal to do with understanding where minerals have been formed in the crust. Therefore, in the final analysis, it will provide a better understanding on where to look for minerals that can be extracted with some economical potential.

The second one is a more mature function of evaluating what is available in the way of minerals and hydrocarbons on a general scale. Finally, the third goal is simply the types of things we have been working on in the Landsat program for some years now and to arrange for a scheme that will allow us to manage the national assets.

The tools of the trade are the Landsat series for remote sensing of the land system. I am happy to announce, if you have not heard already, that Landsat 3 is working again, the multispectral scanner is working. Now we have two satellites and the instruments on the satellites are both working. We are looking forward to a successful launch of Landsat 'D', with both its major instruments, in the third quarter of 1982. At this point, we do not see any major impediment in being able to launch that satellite on schedule. The new budget has cut off the series after Landsat 'D'. What eventually happens, of course, depends on the details of our interaction with the private sector in taking over the system and making it run. Our technology development for the next series is multi-linear array and will get started when Landsat 'D' flies, leading into a potential next family of operational satellites. We make no pretense at this point who may be in charge of the operational satellites. We still have it as part of our mission to contribute to technology development. The MLA Program is to develop a push scanner and prove technology throughout resolution with specific emphasis on bands in the short wave infrared which are research and useful in some of the mineral classifications and botanical classifications.

I will give you a brief status of the French and their operational system. They are coming along well and still plan a May 1984 launch, followed by a few months of checkout following the 1984 launch. The SPOT system is different from anything we are flying at the moment. The satellite will have a push broom scanner, align array, and 2 instruments similar to Landsat with high resolution and visible range. It operates in 3 Bands which span the visible and the near infrared parts of the spectrum. The swath determined by two instruments are different from the Landsat swath. It is 60 kilometers on the side, looking straight down, and there are two instruments side by side, with an overlap. You can program each instrument to work separately. They have a mode to provide high resolution

about 10 meter instantaneous field of view resolution and the 20 meter is the standard output. The 20 meter is better than Landsat 'D' can do in terms of nominal resolution, but the resolution by itself is not the end of the story, as many of you who have tried to interpret data understand.

The particular orbit for SPOT - about 830 kilometers - is different than anything we are flying. It is a bit higher than Landsat 'D' and lower than Landsat 3. It will have a 26 day repeat cycle. The orbit is a peculiar one and it offers a number of chances because they can tilt instruments and take another look, although not exactly the same look. You acquire the same look every 26 days. They can look at the same areas several times during one of the 26 day cycles, and there are several opportunities where you can get a look at the same area from off the side on 1 day spacing, or 4 or 5 day spacing. There is just a different set of operational capabilities that they have planned. The equator crossing time is different than Landsat. It is 10:30 rather than 9:30 and corresponds to the fact that it is optimized for looking at regions of higher latitude and look at what the sun angle is at the higher latitude. SPOT is optimized for Europe while Landsat is optimized for North America and the United States. There are no resource looks. We have had numerous conversations with the French so that they can attempt to make their data streams compatible with people at the ground stations that have arranged to see Landsat data. They hope to work a number of deals with foreign receiving stations and they plan a processing/distributing system on a semi-commercial basis. There would be some type of corporation set up which will have government agencies and private sector agencies as members. A vigorous promotional campaign was launched to prepare people to buy the products. It is quite clear from the details that the product will not be exactly the same but it will have many interesting characteristics and people will be able to make good use of the data. Since they are going to be able to tilt the instruments on SPOT, there is a possibility of being able to generate some sort of stereo imagery. They are not going to hold the orbit closer than + or -5 kilometers, and the timing of the orbit except for specific points is not going to be closer than + minus 15 minutes. They are trying to put the pairs of imagery available through the SPOT system together into a massive stereo pair.

In the United States we have no capability to offer in stereo imagery. I believe the SPOT people are trying to work out an arrangement with US firms to handle the distribution of SPOT imagery in the United States. They may be doing some talking about trying to arrange for commercial retailing of Landsat 'D' information to their sets of customers.

The French will be offering several levels of processing, pre-processing etc., giving several degrees in quality of radiometric, geometric

correction, including what they call Mobile 4 which involves removing all distortions and then generating photographic products. They have not told us what the prices will be. In fact, I think people who are planning on using either Landsat 'D' information or SPOT information, really ought to recognize that both of these are going to be new systems as far as data handling is concerned. Both systems will take some time to perfect. We discovered quite painfully over the eight or nine years of Landsat operation, that there are many details that have to proceed smoothly to get regular and easy access to satellite information.

In both cases, Landsat 'D' and SPOT, the rate at which data will be provided, and the complications in processing must be worked out in detail. We hope to provide good quality products from Landsat 'D' within a few months after the launch and SPOT is programming a few months to solve any discrepancies in their system.

In the remote sensing program we will continue to work on renewable resource activities. The AgRISTARS program will continue, although at a reduced level. We have made considerable progress in learning how to separate and distinguish between confusion crops. You need to measure at the right time during the growing season to distinguish various pairs of crops that look similar from the satellite. At some time during the growing season, the methods used to distinguish crops are a hopeless mess, but there is a window there, where if you look at the right time, you can get a clear distinction and make an accurate classification, for areas where you are unable to get in on the ground and do the classification. If you wait too late, you can not do it so the timing is critical.

As we look forward to the future, and the R&D Program, we will be investigating the utility of other sorts of observations that can eventually be combined with observing systems. We are going to try and look a great deal more at the use of fluorescence. There are certain areas where microwave measurements can display certain characteristics which do not show up in the normal visible spectrum. We have other programs in hand. We will be flying Synthetic Aperture Radar on the shuttle to give us our first opportunity to make repetitive data measurements. I am aware of a vigorous and valuable business in flying radars on aircraft, but if you must pay for sending an aircraft in for repetitive measurements or if in some places you cannot send an aircraft in without having an unfriendly reaction, there is still some value in finding out the limits of what you can do with radars of this sort from a satellite.

The geological applications program is attempting to put together information derived from a number of sensors and a number of wavelengths

that will eventually allow us to interpret this information and generate geological maps. These maps have to be put together using a certain amount of theory about the way the crust develops, as well as sub-surface features, for the first approximation unless you can do field measurements. You can not read below the surface of the earth. You need to acquire all information to understand the geological applications, so the capability eventually has to come from satellite observations from the surface, and various wavelength bands combined with a vigorous program of modeling. In this way, you can infer from the surface measurements as to what lies below, and, therefore, eventually get to resource evaluation.

Related to the solid earth observation, are observations of the oceans and atmosphere. They have a good deal of commonality in instrument type but are looking at different sorts of things. There is radiation coming in from the sun, radiation going out from the cooling of the earth. This radiation emitted back and forth, establishes balances or imbalances, and drives the chemistry in the atmosphere. There are heat inputs, winds, circulatory motions. All that has to be understood to determine how it interacts with the troposphere and eventually, the surface of the earth.

There are several general thrusts in the environmental quality business. We are working closely with people and instruments. We receive observations from the NIMBUS Program, which provides data, plus new theoretical interpretations to try out new instruments and provide research demonstrations. The major component we are working on will ultimately give us some handle on environmental quality. We are trying to understand the chemistry of the atmospheric constituents and the dynamics of chemical species movements throughout the atmosphere.

The national climate office is attached to NOAA, and NASA has a congressional mandate for contributing to the understanding of climate. It comes in 2 parts. One is the influence of climate on man's activities and the other is the influence of man's activities on the climate. This gets us into the long term effects of things such as chlorophyll methane. Man's dumping of particular matter into the atmosphere.

Our major experimental activity in this area at the moment is still the radiation budget experiment which is coming along nicely. They expect to be able to fly a pair of satellites in a few years, which will provide one of the major components we need to understand the climate. The details of the interaction of the incoming radiation from the sun and the outgoing radiation from the cooling of the Earth.

Finally, we have been reminded during the last few years that handling the flood of satellite data is a major problem. We can do it, waste the federal investment and miss opportunities if an adequate system is not in place to capture the data, massage it, and deliver it to the people who actually need it. We have found that a single source of satellite information is seldom exactly what is wanted or needed, but that it almost always has to be put together with information from other sources.

We are trying to do a better job of understanding how you put together data from a number of satellite sources and get it registered properly so it can be overlaid, used and put together into analysis needed to make proper decisions.

To that end, we have a data systems program. We are trying very hard to understand what people's requirements are for data and how they insist the data be available and put together. Our hope is to be able to get an investigator who needs data from any source, draw the data out, get it in a form that can be used and then processed and managed in a way that will be useful. That means a fair amount of new technology in the system that connects among the various data sources.

The danger of course is that all that lovely technology is missing the point. It is fun to play with, but does not wind up doing useful things with the data. That means there is a lot of philosophy and software, and there is a lot of very careful planning that has to be carried out to work out the systems in a way that will end up being useful. We decided some years ago on a global information system and everyone choked. We dropped back to a national information system and everyone still choked. We dropped back to a NASA information system and then to an applications office system. That was still too general and we decided to do the thing that technical people always do and break it down to a simple problem. We developed some pilot systems, which function in each of three major areas. We think we have an over-arching way of thinking about the problem that will allow us to develop practical working systems in each area and get it ready to provide essential ground work in putting together at least an application office-wide system. Judging on that success, we will then be able to determine whether we have learned something, and then spread it out to a broader application for all of NASA, as well as some major segments of national interest.

We are going ahead with the revised budget cuts, because I think everyone recognizes that this is where the payoff is of remote sensing systems. This is a choke point to the benefits from remote sensing systems.

Unless we solve the data handling problems, most of it is going to be a wasted investment.

That gives you a picture of what we have going. Very few new hardware starts will occur. The major ones that are important for land observing are going forward on schedule. Landsat 'D' is headed for a successful completion. The downstream replication of Landsat 'D' satellites is very much in doubt, depending upon our future relations with the private sector. The essential parts of the atmospheric observations and ocean observation systems are still alive and going forward in a reasonable fashion. The applications data system is coming along with a substantial effort in trying to solve continuing problems on how not to waste the space investment.

E

STATE RESOURCE MANAGEMENT & ROLE OF REMOTE SENSING

Huey D. Johnson (Secretary for Resources - The Resources Agency
State of California)

From the Brown Administration viewpoint, we are indeed facing the reality of limits. There is the subject of carrying capacity. We have always responded to issues involving the reality of supply and demand on resources. We constantly face a demand for more water. More water for Southern California for what becomes non-existing sources in the North. That leads to a lot of problems. Without question, I would agree with Theodore Roosevelt. He suggested that we know we will face an ironless age, but we can not afford to live in a woodless one. So as a major theme for my agency, I have argued that we need to upgrade the productivity of the state's natural systems. One of the realities for me, as a Resource Manager, and anyone else in this position, is making decisions without an adequate data base. It is decision making in the dark. Those are serious decisions and affect the quality of not only individual lives but whole sectors of society. Being a budget manager, an executioner as it were, you are getting some news this morning. Having to sleep with those kinds of decisions and conditions constantly goes with the reality of the job these days. Not the least dilemma of not having adequate information is constant controversy. Being a regulator of oil and gas, forestry, fisheries, geology plus general environmental quality and development means that you have to stand up and take a lot of heat, and be able to respond with the best information you can come up with. My frustration is that I rarely have adequate information. My task assignment each day is to feel those issues where no one else wants to make a decision, or no policy base exists for it. I find it to be a very exciting position and one worthy of a one time stint at public service. But I am certain that the future can be managed better, and that remote sensing people can provide important information and thus enhance the quality of both of our fields and the quality of our future.

Remote sensing has given us a breakthrough in the information we have, and in being able to produce that detailed information visually. Until recently, I have been very skeptical about the real value of satellite technology for making down-to-earth decisions that confront resource managers today. Two experiences in particular have recently reduced my skepticism and are the reasons I have accepted this invitation today. I would not have done so six months ago.

One resulted from a recent visit to Kenya where I visited the United Nations on a program. While there, I had a chance to see a remarkable program resulting from satellite imagery which concerns mapping soil types and conditions in North Africa. The type of capabilities that I

wish we had in California. The other experience that reduced my doubt has been in seeing some of the positive results from satellite imagery programs conducted by other departments and agencies. I tend to be a very practical person and must consider the pressures that government people work under today. It is only when I see practical results that I can defend in the public arena for budgets and that I can honestly become enthusiastic about a project. So here I am. I even had a wonderful discussion with a colleague who is on the governor's cabinet and a strong proponent of NASA and its satellite programs. I told him that I have had a transition.

While satellites are new, remote sensing is not. Geologists, foresters, soils scientists, wildlife biologists, and other specialists have relied for years on aerial photography for primary data. In addition to detailed information that can be obtained quickly and inexpensively by photointerpretation. The broad overview presented by such photos allows a graph of resource relationships which is difficult or impossible to get on the ground level. Satellite imagery expands that overview and further increases our conceptual grasp.

Looking to the future, as I feel we must, I believe California needs to upgrade the productivity of its natural systems. As a result, I have put together a 20 year plan for the State of California's resources. It includes a major section entitled data base. One of the themes argues that we must take income from non-renewable sources that will only be with us once - for instance, one time oil revenues - and invest part of that income into upgrading these programs, which includes data base.

I entitled the program "Investing for Prosperity" because by investing in resources today, we can assure both a continued economic strength and a satisfactory quality of life for all our citizens and tax payers. It is having interesting success. It was launched after Proposition 13 was passed. In fact, I believe until Prop 13 and a tax rebellion occurred, it would not have been listened to. Until society had to slow down and start making some judgements and selecting priorities, we could not have been heard nor would our argument have made sense, but we have done very well.

We passed five bills after that proposition. This legislation includes funding that allowed us to create a new forest improvement program for the state. We discovered that with 17 million acres of the best timberland in the world, five million had never been replanted after being cut. Many of the potentially productive streams had been blocked for a hundred years. We unplugged 100 miles this year, and we will double that next

year. Interesting uses of technology have been planned. A pilot desalter project was put together to desalt agri waste water this year. We started distribution of water conservation devices to every household in the state. Not only does it save fuel because the water people do not use remains unheated, but more importantly, it involves the public and increases their understanding for the importance of supporting programs such as this one.

Here is a brief overview on portions of the program which seem likely candidates for use on remote sensing techniques.

We have carried out some of the activities for quite some time, obtaining needed data by traditional means of aerial photography, as well as more sophisticated techniques, which can help us make more accurate decisions and design the best programs to implement these decisions. Our forestry and wildlife program will seek to reverse the serious decline in productivity of California's forests by reforesting 1.1 million acres and by salvaging 11 billion board feet of timber killed by insects and disease. In addition, through an aggressive vegetation program, we hope to increase forest production, wildlife habitat and to improve survival of seedlings along with the growth rate of young timber.

An important part of vegetation management is chaparal management. One of the most effective visuals I have ever seen is a statewide mosaic of Landsat imagery which shows in a striking manner, extent and location of the chaparal areas of California. The picture has been an effective aid in demonstrating the need for a new approach to fire control through vegetation management, as well as possible energy uses from chaparal and other factors.

To describe, verbally, chaparal problems to a busy legislative committee, or a busy group of reporters is time consuming and often a hopeless task. To be able to show them that photograph and allows everyone instantly to know what the potential was. In fact, we have 100 million acres of Chaparal in California. Between 10 and 20 million acres of that is choked with brush, making it relatively unusable. The Landsat derived photos gives me a position to present my case.

Breaking the fire and flood cycle is an important factor in a mediterranean climate like California. We designed a program using helicopters and new techniques for controlling and burning of dense, chaparal areas which present fire hazards. This program will need extensive and detailed surveys of vegetation type, age and density, as well as information on soils, sludge and geology. I foresee a positive role for Landsat technology in providing this information in a timely and economic manner.

Our Fish & Game program will increase wetlands and other important habitat of fish and wildlife. It will also improve our ability to protect habitat in part by making available better data on fish and wildlife itself. There are many areas that need research, such as measuring ocean biomass which constitutes a very critical issue, although virtually no information is at hand. This is an important factor if we are going to manage the productivity of our globe as we must, in my opinion, to maintain the quality of our lives.

The data we need can be partly acquired through remote sensing, including vegetation, age and density, and human activities on lands that constitute important habitat. You will note that this dovetails neatly with the needs of the forestry program. Similar overlaps will be seen in many of our programs as they develop. This cross functional use in information is important because it will help reduce costs. Even more importantly, will help us break past traditions of single research decision-making and provide a sound basis for integrated management wildlife resources.

Our water related programs are intended to help eliminate or reduce ground water overdrought. Presently, much of the West is committing suicide, plain and simple. Palm Springs, a lovely vacation community in California, has 50 golf courses and, as a result, the water table is dropping six to eight feet a year. In the Rocky Mountain area, water is being used faster than it is being replaced. The San Joaquin Valley, one of the richest agricultural areas in the world and very important in feeding the population of the United States, is also in difficulty because of overdrought of underground water.

Other problems in these soils include salt buildup and a lack of drainage. Increased urban and agricultural water use pressures plus other factors, require that we implement far better water quality programs, including soil erosion and other data management techniques. Remote sensing can help identify the location, amount and type of crops being irrigated in overdrought areas, the extent of soils poorly drained and affected by salt. Crop information to help us plan and carry out water conservation programs, and periodic assessment of soil erosion in related land use that affect the quality of such areas as the Lake Tahoe Basin.

One of our most serious areas of neglect in this state, in fact in this nation, is soils. Civilizations live and die historically by how they treat their soils. We have tended to ignore ours. A statewide soil program calls for incentives to maintain and restore soil productivity on private forest, agricultural and wildlands. Data will be collected

to monitor areas where erosion is increasing and production declining due to inadequate management. This data will also be used to expand soil vegetation mapping, identify variable erosion hazards, and enumerate periodically, the location and extent of land uses affecting corrosion and productivity.

Another factor concerns protecting coastal resources. The coastal resources program will provide a thousand more access sites along the coast to protect wetlands and natural coastal areas. Remote sensing will provide basic information to monitor land use changes that threaten these resources.

The Parks & Recreation Program involves acquiring and developing lands for park facilities. We need to measure change in our landscape designated for recreational purposes. For more efficiency in gathering data, all these programs will help meet the needs of general resource management and improve the exchange of data among all levels of government.

As you may know, a number of major satellite link programs are already in progress within the resources agency. The Department of Water Resources is using satellite imagery to inventory irrigated lands. Research is continuing in crop identification, which will help greatly in several water management programs.

Irrigated land use and crop data will allow DWR to basically determine how much water is used, estimate future water use, identify potential water shortages and implement improvements in reservoir operations.

The Department of Forestry has been using Landsat data for three years. A general cover classification was created in 1978 and 1979. Cover types were tabulated by acreage and county. Currently, Forestry and NASA are working on a second phase to classify data at the species level in five test counties - Santa Cruz, Humboldt, Nevada, Placer, Eldorado. Forestry is installing a computer program which will give it and other users the ability to process Landsat data.

The Department of Conservation is funding an important prime land map series. They are also developing a statewide computerized farmlands data base. Both will be updated regularly to provide information on prime land conversion as requested by the Governor, the state legislature and other key decision-makers. A proposal has been submitted to NASA Ames Research Center to explore the possibility of using Landsat data to update the map series and the data base.

Researchers at the University of California - Santa Barbara, have achieved promising results using Landsat and high altitude imagery to monitor the conversion of farmlands. We hope such techniques will mean significant dollar savings in these programs. With NASA's help, the state's electronic data processing system is now being inventoried to identify what additional equipment and programs are needed to process satellite data most efficiently.

What I have given you today is an admittedly incomplete review of the resource management needs of California which might be satisfied by remote sensing. We have many other activities that require research data and a large number of programs for which to collect such information. Many of these programs might benefit from improved techniques using Landsat data. Last week, we infact, requested and received a summary of all potential types of data and research of the various departments that I am responsible for.

In the future, we want to find out where satellite imagery can be used to improve our resource programs and then plug it in. It promises to be an exciting program, one with fruits we have not yet imagined.

Finally, we appreciate a letter received from NASA asking us to serve as a Coordinator of the California Integrated Remote Sensing System. Since we do have departments already utilizing it, we happily will accept that opportunity and believe we will increase the use of programs that you people are responsible for, and look forward to cooperating with you. The era of single purpose decision-making or single agency dominance of the budget process is behind us. Success will come in the future for all of us, as it has with resource agencies in the past two years, by linking together programs that are relative to each, focusing on applied process, and enhancing the quality of the state and the nation through that effort.

F

OPERATIONAL LANDSAT REMOTE SENSING SYSTEM DEVELOPMENT

Daniel J. Cotter (Acting Director - User Affairs Office - NOAA
Washington, DC)

A few weeks ago, President Reagan's new budget was announced and this has upset our plans. For FY 1982, the Landsat Development Program was \$ 123.7 million dollars. On Tuesday, 10 March 1981, it became \$ 2.1 million dollars. We have not adjusted to all of that very well yet.

These budget cuts have taken place and my purpose here this morning is to outline how we expect to contend with these changes. It is also to emphasize that the most important implication of President Reagan's budget for the people in this room and people concerned with remote sensing, particularly the Landsat program. The budget for FY 82 provides an administrations commitment to the continuity of Landsat data through 1988. We must also bear in mind that the Presidential Directive of 1979 that looked forward to and directed the implementation of an operational land system, also called for the transfer of that system to the private sector, where the private sector entities become the owners and operators of that system sometime during the 1980's.

Under President Carter's budget outline, we had until 1992 to accomplish those purposes. Under President Reagan's outline, we have until 1987 or 1988 to have the private sector committed to continuing the system. So it is a change in time, in one respect, and in scale, because some of the resources that we anticipated that would allow us to do this job next year and subsequent years, have been withdrawn, at least for the moment.

NASA is funded to complete and to launch Landsat D & B and in addition, funded to implement the new MSS data processing and pre-processing system to be put on line at Goddard Space Flight Center sometime next year.

The EROS Data Center at Sioux Falls experienced essentially no budget impact. Under the budget guidelines, they are committed to supporting user activities and user needs in the Landsat D era. As far as NOAA/NESS are concerned, we are funded for bringing the system into operation. We are funded to continue the system management and for the operation and maintenance of the ground/space system. We are also funded to establish a relationship with the EROS Data Center under conditions yet defined. This money will allow NOAA to interface and service with the users.

NOAA does not have a lavish budget to complete all of this. As most other federal agencies, NOAA is taking a significant personnel cutback. The minimum implication is that NOAA/NESS will have to really strain to do the assigned tasks under the new budget and personnel cuts that now exist. The NASA/NOAA budget for Landsat activities in FY 82, contains \$ 2.1 million dollars. \$ 1.4 million is to continue the present management and coordination activities that we have been involved in. The remaining 700,000 dollars is for transfer to the EROS Data Center so that it can upgrade the MSS Data Processing System to accommodate the D series of spacecraft data.

One of the primary tasks that NOAA has been working on and preparing for, involves the transfer of the operational system operational management to private sector ownership. Someone asked if the private sector is ready and willing to become active in this. I attended a meeting a week ago with 25 people from the private sector. The question was asked, is anyone here making money through providing Landsat data services? One gentleman raised his hand and the other 24 went over and borrowed money from him. But they are interested.

The conditions of transfer over to private ownership have yet to be determined. Congress has not got into it yet. If I were the private sector, I would be hesitant too. But the outlook is that the system can only continue in the 80's if the private sector is involved, and if the private sector markets the products properly.

We at NOAA are preparing and have proposed legislation for congressional consideration or enactment to establish conditions under which this private sector ownership transfer will take place. The details have not been fully resolved by the administration and will be argued out in the halls of congress. We do anticipate that proposals for private sector transfer will be reviewed. As soon as that takes place, NOAA will be in touch with private sector entities to discuss the subtleties and ramifications of this suggested legislation. We intend to obtain their opinion and feedback, so that when hearings take place late spring, we at NOAA will speak on behalf of the private sector.

The private sector will testify before congress. It is a very complex area. Hearing and discussion will play an important role. Beyond FY 82, the NOAA budget projections call for \$ 30 million a year to continue with management activities we are now engaged in. To operate and maintain the system, to continue user services that will be effected out of the EROS Data Center.

It should be noted that we have no money for capital investment, and at this moment we have no money projected for investing in an operational TM data handling system. (TM operational system will await NASA investigation and developments and the design and pre-processing data handling system.) We are confident that once the work on TM has been completed, we can make a good case to come up with an operational system sometime in the latter part of the 1980's.

A few times this morning, prices of data have been mentioned. I am sure that anyone who has been in contact with the EROS Data Center, is well aware that due to inflation, it is going to raise the price of the data products. So look for a data price increase.

NOAA, as proposed manager of the operational system, is working out a scheme that will impose price increases spaced over the years of system operation. The size and details are not fully known yet. We have been directed to recover the costs of operations and maintenance of the system through the sale of data products and services for the years that we operate it.

At the present time, data sale income from Landsat data sales is about six million dollars per year, and our anticipated cost in operating and maintaining the system is about \$ 30 million dollars a year. Right now we are considering in general terms to gradually step up to 5 times the data price.

We do not know what we will do concerning specific products and levels of increase will be a specific rate or price. Only by having an attractive pricing structure, and discovering that the pricing structure works, will the private sector be attracted to invest in the system. As mentioned, the National Ocean Satellite System has been deferred. The budget for environmental satellites for NOAA/NESS remains essentially unchanged, compared to previous years and projections for future years. We do not expect any major difficulties in operating our environmental satellites. We are losing some people, however, so we may be a little less responsive to the users.

For the past 18 months or so, NOAA has been actively anticipating and working toward the day when we become manager of the operational land satellite system. One device to make us more cognizant of data users needs that we had projected, was the development and establishment of an Advisory Committee.

We are in the process of establishing an Advisory Committee and seek nominations for people to sit on it with us. That will reflect in the federal register probably within the next two weeks. It was mailed last Friday to the publishers at the register. If you make any candidates for this committee - non federal people, knowledgeable of various aspects of the uses and needs of remote sensing - I would be happy to hear about it.

Finally, I would like to mention that on Thursday, through the courtesy of Ames Research Center, NOAA will have the opportunity to talk with you for a full day. David Johnson, NOAA's Assistant Administrator for satellites will be available. We will ask you to participate with us on Thursday, through working groups centered around state and local government interests, university and training interests, as well as commercial interest, and tell us what you would like NOAA to do for you as we approach this operational date.

G

USDA/FEDERAL USER OF LANDSAT REMOTE SENSING

Richard Allen (Chief/Remote Sensing Branch - US Department of
Agriculture - Washington, DC)

The title assigned to this presentation is quite appropriate - the United States Department of Agriculture does feel that it is a major "user" of global remotely-sensed data in both research and operational programs. Crop condition assessments, renewable resources inventories, crop acreage estimation, conservation practices inventories, and water management are a few examples of the varied applications for remote sensing in USDA.

The Department considers Landsat as one of a multitude of information gathering tools which can be used to accomplish its statutory responsibilities for agriculture and natural resources. Other information tools to be used include ground collected data, weather data, aerial photography, in-situ sensors and aerospace sensors other than Landsat.

Since the launch of the first Landsat satellite (ERTS 1) in 1972, USDA has invested large amounts of resources in research and development of space remote sensing as a major source of more timely and accurate information. This better information is required for a multitude of decisions affecting global economic conditions.

The USDA has broad statutory responsibility for agriculture and renewable resources. A critical element is acquisition, analysis and timely dissemination of information on crop supply and demand. Timely and reliable information on major crops, including forecasts of production and supply is a significant element of National economic and political decision-making. The value of this information can be traced across a broad spectrum of public and private sectors. Some readily identifiable groups are US producers, consumers, agricultural marketers, exporters and shippers and government policymakers.

The value of crop information has increased in recent years as the countries of the world have become interdependent for food supplies. Exports of agriculture products is one of the bright spots in the US Balance of Payments. Constant improvement of information on the potential grain production levels of the United States' customers and competitors in the world market will allow for greater stability of economic conditions within the US.

It has been hoped, within the USDA, that improved sensor systems might allow for forecasts of production levels in countries which are

currently recipients of US food assistance programs. Better monitoring of individual country needs for food could avoid needless payments from the US Treasury for some of these assistance programs.

The extensive droughts of the past decade in the United States have increased the interest in monitoring the effects of weather upon crop production. Water shortages also highlight the need for information about water availability from underground sources as well as from current rain and snowfall. Evaluation of water supply and soil moisture conditions are important factors in intelligent use of US cropland resources. Satellite imagery such as that provided by Landsat, with its synoptic coverage, can be an important water supply information source in the future.

Since there is a later presentation in this conference which deals extensively with the AgRISTARS Program, I will not provide details on that program in this session but will try to focus on the broad aspects of uses within USDA.

USDA Agencies Using Remote Sensing

Several agencies have developed techniques which currently use remote sensed data for information needs or are developing such programs. The US Forest Service has long used aerial photography in conjunction with on-the-ground information to inventory its vast holdings, to make arrangement decisions, to detect and monitor disease and insect problems, and as an aid in fighting forest fires. The Forest Service Nationwide Forestry Application Program is exploring uses of Landsat data for monitoring and management. The techniques being studied not only provide point-in-time estimates, but also estimate annual increments of change. The Landsat analysis techniques were proven quite successful compared to conventional methods in the first phase pilot test involving one county in South Carolina. The next phase involves several counties in South Carolina with a full state demonstration planned for Idaho next year. Other remote sensing interests of the Forest Service include use of airborne thermal scanners for forest fire detection and mapping and the development of a forest fire deployment model in Southern California which monitors the total amount of fuel present as an aid to positioning fire fighters.

The Soil Conservation Service (SCS), is utilizing enhanced Landsat images as an improvement in its basic soil mapping and conservation monitoring programs. SCS is interested in improved land use mapping, using Landsat data. Monitoring of snow pack and prediction of subsequent runoff and water supplies, is another key need for SCS for which

procedures and models are being tested. SCS is especially interested in the development of insitu sensors which will be able to monitor soil moisture availability and transmit that information.

The Economics & Statistics Service (ESS) has developed procedures for matching probability collected ground data with Landsat data for improving estimates of major crop acreages. These procedures are now being evaluated for transfer to State Statistical Offices of ESS. Also of current interest for ESS is to adapt these procedures to land cover and land use change estimates to gain multiple advantages from Landsat data sets. Landsat imagery is also used by ESS as a first stage mapping tool for construction of area sampling frames stratified by land use both for the United States and for foreign countries.

The Science & Education Administration (SEA), is involved in basic research for a number of remote sensing applications. These include models for early detection of disease, insect and moisture stresses; soil moisture determination; crop condition assessments; and identification and monitoring of pollution. SEA has research centers across the country involved with specific research projects which are mostly now coordinated under AgRISTARS.

Development of Operational Approaches

A goal of USDA remote sensing efforts is to transfer techniques from research units to operational units as rapidly as possible. The goal of the Forest Service Nationwide Forestry Application Program is to develop procedures that can be used by managers within each National Forest. One major emphasis under the AgRISTARS Domestic Crops and Land Cover Project is to involve ESS State Statistical Offices each year in increasingly more of the necessary steps to edit, capture, and match ground data with Landsat data for major crops. Tied to the major crops acreage estimates, is the cooperation of ESS state offices with local and state agencies to identify new uses of Landsat imagery. The operational Area Frame Construction Unit of ESS is now developing sampling frames for the AgRISTARS Foreign Commodity Production Forecasting Project.

The primary objective of the Crop Condition Assessment Division (CCAD) of USDA's Foreign Agricultural Service (FAS) is to operationally provide USDA with prompt and reliable information about the conditions and expected production of foreign crops of economic importance to the United States. This information is used by the Department's Commodity analysts in developing its worldwide agricultural supply and demand estimates for distribution to the public.

The CCAD routinely receives, processes and analyzes digital Satellite and meteorological data to monitor high priority foreign crop producing areas. In carrying out these functions, the CCAD utilizes mini-computers located in Houston, Texas and Washington, DC. During 1980, the CCAD produced condition assessment reports for 10 major countries/regions and about 15 crops. In preparing these reports, the CCAD analyzed about 15,000 Landsat images covering more than 500 million acres.

USDA Adapts Procedures to Needs

Although the main emphasis of this topic is uses of space remote sensing it may be of interest to describe quite a different remote sensing approach that the USDA has developed. The other end of the continuum, so to speak. The Agricultural Stabilization & Conservation Service (ASCS), has the responsibility for administering various crop production programs of the USDA. Some of these programs require determinations of specific crops. In order to qualify for the benefits of the program, a farmer must register with the local ASCS office and certify which crops are planted in each field on the farm. ASCS then has a responsibility to the general public to monitor and check compliance with the planting restrictions.

Traditional compliance monitoring methods have involved selection of a sample of farms and determination of actual acreages by on-the-ground measurements or measuring on rectified photo enlargements. In the past few years, ASCS has gone largely to an approach of flying production areas with 35 mm cameras using color film. This flying is at low altitudes in light aircraft for which state offices have made arrangements. ASCS has purchased the cameras and ASCS employees do the photography.

These current color slides are used as the main vehicle for checking compliance. They can be projected onto rectified photography for marking field boundaries and planimetry. ASCS is also acquiring equipment which allows determination of acreages directly from the slides by establishing a numerical relationship between the slides and a rectified enlargement. The cost effectiveness of this 35 mm photography approach over the conventional methods is approximately 3-1.

Other agencies of the USDA have found the 35 mm photography now available in most county ASCS offices (about 1800-2000 counties are covered in part or totally) helpful for other purposes. The Federal Crop Insurance Corporation uses the 35 mm slides for monitoring crop conditions. The Economics & Statistics Service uses duplicate slides or prints for precision editing of field boundaries for ground data segments in its Landsat studies and is exploring use of prints as an aid in interviewing

farmers in operational surveys. Other state and local agencies and individuals have realized the value of these slides for planning and other purposes. ASCS county offices will select coverages for individual requests and send slides out for commercial processing for the cost of reproducing plus a nominal service charge for handling (usually \$ 1. for selected slides, \$.50 per slide for full county coverage). The only restriction is that the office is not currently working with the slides for compliance at the time of the request. This availability of high resolution, current coverage may prove to be of value to many of you in the audience.

USDA Concerned About Data Continuity & Cost

The USDA has supported decisions to establish an operational space based land remote sensing system. Landsat data have shown great potential but this potential will only be achieved by insuring a steady flow of time, quality Landsat type products at reasonable costs. Cost comparison of Landsat data utilization with other alternatives will be the key management concern in determining the amount of operational use within USDA.

Many within the Department have been concerned with the long term effects if an extended data gap of Landsat data is encountered. If a gap occurs, there will be a loss of initiative related to operational developments and the gap may create an inertia which will be harder to overcome than were the initial hesitations about beginning Landsat utilization studies. Already the "doom and gloom" merchants within the Department are raising flags about the appropriateness of continuing present development efforts, in view of the present uncertainties in the Landsat program.

Some of the utilizations now being considered by the USDA can be pursued with retrospective data but many can not. For example, ESS would be able to utilize recent Landsat data for land cover estimates by matching against current ground data but it would not be possible to improve specific crop acreage estimates by the use of retrospective data. The Forest Service could continue much of its evaluations of new techniques with retrospective data but would not be able to achieve the true goal of the Nationwide Forestry Application Program without current data.

The Crop Condition Assessment Division of FAS has taken specific steps to bridge the data gap until Landsat D and insure continuity of procedures by utilization of data from NOAA 6. The infrared Bands of NOAA 6 (Bands 1 & 2) are similar to Bands 6 & 7 of the MSS on Landsat. Software adjustments have been made and CCAD is utilizing NOAA 6 data on a regular basis as of March 1981.

CCAD now has a contract to get tapes daily from NOAA (Camp Springs/MD). Tapes are shipped by air express, overnight, to CCAD in Houston, TX; time from acquisition of data by the satellite to receipt by the CCAD analyst in Houston is 48-72 hours. Although the resolution of the NOAA 6 data is gross (1 km vs 80 meters, Landsat MSS), CCAD is able to make useful qualitative assessments of crop vigor based on relative "greenness" of the observed vegetation. At present, coverage is obtained over most major crop regions of the world with a 5 day repeat cycle. (Data is not being collected for some Southern Hemisphere areas by NOAA 6. For example, Australia and South America.) Launch of NOAA 7, which should permit coverage of the areas currently missed, is expected in May 1981.

USDA Supports Future Improvements

Many of the data information needs of the USDA would require very fine resolution data in order to adapt from conventional procedures to Landsat utilization. Detailed soil mapping and development of specific conservation plans for small areas are examples of USDA programs which require very specific, high quality data for a point-in-time rather than repetitive coverages.

ESS has limited its crop acreage estimation work to date, mainly to states which have relatively large fields and which have only a few major crops. It is felt that the current ESS procedures would not be applicable to crop acreage estimates for many eastern states, given the resolution of the Landsat MSS sensors. Implementation of the Thematic Mapper (TM) Sensor, with its finer resolution, should allow extension of crop acreage studies into states with smaller fields and to estimates of acreages of more minor crops in states presently being studied.

There has sometimes been some confusion about USDA plans for utilization of TM data when available. If TM results in an improved procedure over the use of MSS data and one which is cost effective, then the TM data will likely replace the MSS data. It is not assumed that many applications will process both MSS and all TM data for the same purpose. It will be essential to continue the flow of MSS data until determinations of applicability of TM and adjustments of processing procedures have been completed.

The USDA hopes that the TM sensor does prove successful and that the new spatial and spectral characteristics improve the usability of present Landsat techniques and make new utilizations feasible. However, the USDA supports continued development of new or improved sensors and

platforms. Improved camera systems for vehicles such as the Space Shuttle would be very helpful to the soil mapping and conservation monitoring requirements of USDA. Similarly, aerospace radars which might improve soil moisture monitoring ability might be extremely helpful since soil moisture is such an important factor in crop yield and early warning models and in other crop condition assessments.

SESSION II

30 MARCH

MONDAY (PM)

WESTERN REGIONAL REMOTE SENSING CONFERENCE

A WELCOME ADDRESS

C.A. Syvertson (Director - NASA Ames Research Center - Moffett Field, CA)

There are some essential differences between the Applications Program and most other NASA activities. Perhaps the most important difference is that NASA itself is not the end user of the technology, but rather there are some well defined customers who are. One other part of the NASA Program has a similar characteristic, and that is the Aeronautics Program. Most people consider NASA synonymous the space and either forget or are unaware of what the first 'A' in 'NASA' represents. I would like to start off with a few words about Aeronautics for two reasons. First, Aeronautics is Ames biggest program and, combined with Applications, represents about two-thirds of our effort. Second, and more importantly, Aeronautics is a more mature program, and I believe that there are some important lessons that can be learned from our experiences there that can make the Applications Program more effective.

Let me begin by saying a few words about Ames. The center was established 40 years ago, just before World War II. The site was selected for three reasons: ample and low-cost electrical power to run our facilities, proximity of major universities, and good flying weather. These three factors are still applicable today. The cost of power has gone up, but it is still only about one-third of what it is on the East Coast.

These three factors have shaped Ames mission over the years. Today that mission has eight major elements. In Aeronautics, we specialize in Computational Aerodynamics, Simulation Sciences and Human Factors, Helicopter Technology, and short-haul Aircraft Technology. Our role in Airborne Science and Applications is in many ways, a marriage between Space and Aeronautics. In this work, we use more or less conventional aircraft as platforms for carrying scientific instruments. I will, of course, have more to say about this area later on.

Our two major roles in space are associated with planetary atmosphere probes and life sciences. Finally, we try to provide support to many organizations with our resident expertise and our facilities.

As you may guess from these roles, there are four major tools we require to carry out our mission, especially in Aeronautics. These four are computers, wind tunnels, simulators and aircraft. Ames has strived to develop the very best research facilities in each group, and we believe

we have achieved a measure of success. We have a fine computer complex headed currently by the ILLIAC IV. The ILLIAC is one of the largest scientific computers and was perhaps 10 years ahead of its time. More modern machines can match its speed, but still no available machine can match its memory of 8 million words. Ames's complex of wind tunnels and simulators is unmatched in the world. And, the Ames Air Force may not be the largest, but it certainly has some unique members. Ames facilities are very important to the center. I have occasionally joked that I have been uncertain about NASA's future, but never been uncertain about Ames. Our facilities and the expertise resident with them are exceedingly important to the Aeronautics Industry and accordingly, to the nation. Virtually every new high performance aircraft developed during the last 40 years has been studied in our facilities.

This is the first lesson from Aeronautics: to make useful contributions in a high technology field, you must have good facilities. Two of the Aeronautical facilities I have discussed are equally important to Ames role in applications: Aircraft and Computers. The two U2 high altitude aircraft currently at Ames have been used in support of many research programs. One of the first programs supported by these aircraft was the collection of simulated earth resources technology satellite (now called Landsat) multi-spectral scanner data. Subsequently, the U2's flew many underflight missions to collect color infrared photographs used by ERTS principal investigators to assist in analyzing the new data being obtained from the satellite. These and several other aircraft are still used in the development of prototype instruments.

We will soon take delivery on an advanced model of the U2, designated the ER2. This aircraft will have greater range, payload, and on-board power capabilities than our other two high-altitude aircraft. The ER2 will thus represent a much improved facility for the type of applications work we do at Ames.

Our computer facilities at Ames have also been used extensively in the Remote Sensing Program, and I understand, many of you have remotely accessed our system during the training phase of our WRAP activities. Much of the software used in processing digital imagery data from Landsat was developed as part of the Planetary Exploration Program, since imagery data of distant planets are also transmitted in digital form. Most of the software was developed at JPL. We have made use of these techniques at Ames, and I understand that many states are currently using this NASA-developed software for Landsat analysis. We are in the process of upgrading our computer complex at Ames. We will soon have a Class VI machine at the center, and we are in the design and development process for a much larger machine called the Numerical Aerodynamic Simulator, which will be about 10 times as powerful as a Class VI

machine or about 200 times as powerful as a CDC 7600. While the primary purpose of this new machine will be associated with fluid mechanics, it will also be very useful in processing imagery data.

When we develop an Aeronautical Research Aircraft at Ames, we often do so jointly with another agency. One of our STOL was developed jointly with the Canadian DITC, and our Tilt Rotor and Rotor Systems Research Aircraft were developed jointly with the US Army. The close involvement of a technology user in a research aircraft program helps assure proper focus of the project as well as prompt transfer of the technology.

We have followed a very similar pattern in the Applications Program. The relationships developed early in the ERTS Program between Ames and the remote sensing community, particularly in the Pacific Northwest states of Idaho, Oregon and Washington, led to the desire on the part of those states to begin a cooperative project with Ames. In 1974, the first such Ames project was initiated with the support of the Governors of the PNW States together with a Federal Co-Chairman under the auspices of the Pacific Northwest Regional Commission. The PNRC formed a Task Force consisting of a representative from the United States Geological Survey (USGS), and a plan was developed for the Landsat Resource Inventory Project which had as its objectives:

- 1 To provide opportunity to resource planning and management agencies. To extract, utilize and evaluate information derived from satellite and aircraft remote sensing.
- 2 To conduct a comprehensive evaluation of the application of advanced technology within a realistic setting of governmental procedures, state and local agency charters and responsibilities, information needs for management, budgetary processes, personnel training and technical requirements.
- 3 To achieve cooperation among federal, state and local agencies to transfer the necessary technology for resolving natural resource management problems.
- 4 To evaluate alternative institutional mechanisms required for providing continued and effective use of remote sensing by user agencies.

These objectives are probably familiar to any one of you in the audience today who have participated in a cooperative project with the Western Regional Applications Program, because in one form or another, they apply to all the cooperative projects in WRAP.

The Inventory Project was conducted from 1974 through 1977 during which time we learned to apply Satellite Earth Resources technology to the needs of the user community in the West. During this program, over 20 separate demonstration projects involving more than 40 resource management and planning agencies in Idaho, Oregon and Washington, were carried out. More than 140 state and local agency personnel participated in the projects and received training in the techniques used to analyze Landsat data. Projects relating to urban planning (Puget Sound, Portland and Boise.

- Forestry - Douglas County/Oregon - 500,000 Acres Inventoried
- Western Washington - 10,000,000 Acres Inventoried
- Southern Idaho - 8 Million Acres Inventoried
- Agriculture/Idaho - 46 Million Acres Surveyed for identification of 3.9 Million Acres of Irrigated Lands
- Oregon - Seven Western Counties analyzed for infestation of a noxious weed (Tansy Ragwort).

Wildlife habitat identification were conducted in each of the three states.

These products were considered sufficiently successful that a second project with the PNR, USGS, Ames and the states, was initiated in 1978. This project, the Landsat Applications Program, had as its objective - "To establish in-state capability for the use and application of Landsat data by state and local agencies in their decision-making and resource management process." Here we were able to assist the states with their computing capability to develop an in-state Landsat analysis capability. The Landsat Applications Program will conclude at the end of this month having achieved the establishment of significant operational capability in Washington, Oregon and Idaho. Washington and Idaho have each installed NASA-developed, software, VICAR/IBIS (Video Image Communication & Retrieval/Image Based Information System), on in-state computers (Washington - Washington State Computing Service Center - Idaho - State Auditor's Office by Idaho Department of Water Resources), and on commercially available, interactive mini-computer based analysis systems. Oregon, which has an excellent facility at the Environment Remote Sensing Applications Laboratory (ERSAL) at Oregon State University, is building its state capability around that institution. You will all have an opportunity to hear more about these activities at this conference.

Regional Applications Program Charter was to work only with state and local governments. It was not to be a government grant program. Instead, it was designed to transfer understanding of remote sensing techniques to the staff of government agencies. The opportunity to participate in a trial test case, or demonstration, was perhaps, the most critical part. The test cases were, however, to be selected by the agency - not by NASA. If we at NASA have learned anything from this program, it has been the importance of this approach.

In 1977, Ames Research Center was designated as The Western Regional Applications Program (WRAP) Center. The Center was given responsibility for Technology Transfer activities in 14 Western States including Alaska and Hawaii. In the last 3 years, Ames has been involved in Remote Sensing activities with the users in most of these states. Projects include statewide inventories of forested and irrigated lands, county land use assessments, fire hazard identification, rangeland utilization and wildlife habitat assessments, just to name a few. Over the next 2½ days, many of these activities will be described in detail.

Most of the states in our region have chosen to adopt some form of remote sensing technology. As might be expected in a research environment, not all approaches were successful. However, there is often as much to be learned from failures as from successes. On balance, though, the acceptance rate has been high.

Where do we go from here? Well, as we heard this morning, NASA, NOAA and USDA have a continuing role in remote sensing this coming year. Ames is committed to be an active participant. Our aircraft program will continue to provide the service it has for the last decade. In our involvement with the Satellite Remote Sensing Program, we will continue to emphasize research and applications development.

In closing, I would like to mention one place where the Aeronautics & Applications Programs currently differ. Perhaps some of you remember that 4 or 5 years ago, many airlines - United, TWA, Western and others - celebrated their fiftieth birthdays. What event back in the mid twenties caused all of these systems to be founded in a period of only 1 or 2 years? In the early twenties, virtually all the airplane passengers were mail bags, not people. In 1926, however, the then Postmaster General established a policy by which the Post Office would not give air mail contracts to airlines, unless they carried people. I don't know if the Postmaster General recognized the significance of this decision, I suspect not, but he had a tremendous effect on the growth of air transport in this country. His decision was probably as important as later technology advances in this country's developing the world's finest air transport system.

The space applications industry, if I can call it that, has not yet experienced such a milestone. I don't know if, or when, one will come. Some of us might think about the problem. But if there is some similar commitment, remote sensing and its application have the potential of being just as important to the public in the future as air transport is today.

B REMOTE SENSING IN ALASKA - OPPORTUNITIES & POLICY IMPLICATIONS

Dr. Jay H. Moor (Policy Specialist - Policy Development & Planning -
Governor's Office - Juneau, AK)

Since this is a conference on remote sensing, I would like to draw a rough sketch of Alaska, as the context for my further remarks. Alaska's size, in square miles (586,000), doesn't mean much to outsiders, so we often lay a map of the state over one of the US at the same scale. Excluding the Aleutian Chain and Southeast, Alaska would stretch from Duluth to Dallas and from Chicago to Denver. Because of its size, rugged terrain, inaccessibility, and sparse population, many events in Alaska are only assumed, never witnessed. It's a place where it's possible for isolated forests to burn and remote rivers to flood unrecorded. Earthquakes, volcanic eruptions, tsunami, and avalanches may register as mere curiosities.

Alaska's lands support wildlife that has virtually disappeared from the Lower 48: caribou, moose, brown bear, mountain sheep, goats, wolves, wolverines and bison. In Alaska are the wetland nesting grounds for migratory geese, swans, ducks, herons and terns. Alaska supports a thriving raptor population. The Chilkat River near Haines is the gathering spot for over 3,000 bald eagles each autumn. Alaska's 6600 miles of coastline is greater than that of the rest of the United States, in total. Its rivers and coastal waters are the rich spawning and feeding habitat for five different salmon species, char, trout, and bottom fish, like halibut; humpback, bowhead, beluga and killer whales; seals, sea lions, walrus and an increasing number of sea otter.

For thousands of years, Native peoples hunted and fished this stock of protein in a subsistence pattern - cultures in balance with carrying capacity. Human populations were never large because the food producing ecosystems, where the growing season is so short, are spread extraordinarily thin - life support zones are broad and fragile. Species need space to find precisely the right conditions for nourishment and growth. Alaska's critters are noted for movement and adaptation. This is also how Native populations survived: moving with the food stock and adapting their cultures to changing conditions.

Western man first came to Alaska to harvest the furbearing animals, so well husbanded for centuries. The next wave brought gold mining, only the first in a continuing series of extractive industries that have had no dependent relationship with the ecosystems of Alaska. The economic history of Alaska, since the Russians depleted the sea otter, has been one of the ups and downs, a roller coaster of boom and bust, riding high

and then bottoming out, most often bouncing along in a depression dependent upon world prices. The one major stabilizing factor has been the federal presence. Especially important to the economy has been the Bureau of Indian Affairs, the Federal Aviation Administration and the military. At the start of World War II, Alaska had only 75,000 people, one third of which lived in the Southeast Panhandle. By 1960, that population had tripled and Southeast had only 16% of the total. The Interior had developed a strategic importance requiring the installation of radar and communications equipment, construction of air bases, roads, the railroad and all the services that go with new settlement.

With statehood in 1959, the state began to select its entitlement of 104 million acres, a process to be completed by 1984. Lands valuable for non-renewable and renewable resources were selected, as were lands critical for wildlife habitat. A major issue for the first state constitutional convention was federal mismanagement of salmon stocks. A great segment of the population - native and white - was made up of subsistence users, and the state wanted to control wildlife on a sustaining basis.

Discovery of oil at Prudhoe Bay reinvigorated interest in Alaska's resources. Energy shortages in the 1970's made Alaska all the more crucial as a source of supply for the country. New construction, project management, an expanding revenue base, and consequent growth of the public sector induced a migration to Alaska that has extensively altered its patterns of land use.

State population grew from 300 to 400 thousand in the 1970's. Anchorage tripled its population. The Kenai Peninsula is now described by some as a "recreational has-been". A pipeline bisects the state as does the road that follows it. Tens of thousands of acres of forest are being cleared for agricultural production. Coal development is on the horizon. New fisheries are being opened and the state is pouring hundreds of millions of dollars into capital projects all over Alaska.

In the meantime, Alaska's Natives, who had never fought a war with the US or signed a treaty, laid claim to valuable lands that were being selected by the state. This put the brake on state selection of entitlement lands until Congress passed the Alaska Native Claims Settlement Act (ANCSA) in 1971. This Act established 12 regional Native corporations and some 200 village corporations which were entitled to a combined 44 million acres, to be chosen before the state's selection could continue.

Among other things ANCSA did was to provide for the designation by Congress of national interest lands - national parks, monuments, wildlife

refuges and ranges - that would be held by the federal government. These lands were finally set aside this year when President Carter signed the Alaska Lands Bill, doubling with the stroke of his pen, the size of America's national park system. When all conveyances are complete, the federal government will control 59% of Alaska's lands. The state will control 29% and 12% will be privately owned.

In the meantime, sides are being taken, lines drawn and conflicts maturing. Alaska, the storehouse of America's resources. Alaska, the developable is up against Alaska the conservable, the last extensive wilderness in the US. Clearly, a balance among the competitive uses must be struck, where the major land managers - federal and state agencies, Native corporations and municipalities will have to become objective referees as well as active proponents for differing points of view. Playing well, these multiple roles in a political context demands objective evaluation capabilities that have been, until now, poorly developed. Fundamental to these capabilities is data and information and, because of the enormous amounts of time and expense needed for its acquisition, a cooperative willingness to share what data and information is available.

In 1972, acts of Congress and the Alaska state legislature established the Joint Federal-State Land Use Planning Commission (FSLUPC), giving it a 7 year life and charging it with the task of inventorying and planning for Alaska's public lands. A pattern of cooperation had been established with this commission. By the mid 1970's, FSLUPC, with the Governor's Division of Policy Development & Planning, the Arctic Environmental Information & Data Center, had produced, among a number of other studies, a set of large-format, regional atlases covering all of Alaska. In 1978, during its final year of existence, FSLUPC put together a remote sensing task force that included federal, state, university, local and Native representation. At the same time, FSLUPC drew up a funding agreement between several agencies and NASA for the acquisition of high altitude black/white and color IR photography covering the whole state. To date, 54,000 data miles have been flown while 22,000 miles remain. The imagery is excellent and should - I stress, should become a valuable resource management tool for all agencies working in Alaska.

Two and a half years ago, the Division of Policy Development & Planning, surveyed all state agencies to determine the existing levels of awareness and use made of remote sensing. Of 112 potential applications identified, black/white or color photography (not color IR) had actually been used in some way in only 43. Color IR had been of value to 10 of the functions. Thermal IR to two and Landsat had been applied to only one function. The use of radar was nonexistent. Since then, over a dozen people from three state agencies have participated in demonstrations of Landsat technology, increasing their skills in using advanced

techniques for vegetation classification, wetlands identification and other basic resource management tasks. The state will soon be acquiring synthetic aperture radar imagery. Nonetheless, the general level of remote sensing expertise among agencies remains quite low. The reasons for this are elementary, having to do with awareness, technical skill, utility and budgets.

Lack of awareness is a major obstacle to the application of innovative technology. Among program managers and executive directors, remote sensing is someone else's jargon. They have little time for it, even though the benefits may be obvious to their own technicians.

As Alaska develops its capabilities for the management of millions of acres of land, these acres must be inventoried and classified. The state must distribute at least 100,000 acres of previously unsurveyed lands to Alaskans every year. We are selecting thousands of acres of potential farming lands for development. We must plan and build dams, roads, bridges, housing and protect against the environmental degradation that can come from each of these activities. All of these tasks could benefit from some aspect of remote sensing, including the use of satellite imagery. Yet, the paradox is that these activities occupy so much time and consume so much energy that few managers can take advantage of opportunities to learn what they need to know to do their jobs well.

Last year, by way of example, BLM put on a half-day seminar for managers on the cost effectiveness of remote sensing. All state resource agencies were contacted twice before the meeting. Not one person from the state attended. And, these are the people that must be made aware of remote sensing's capabilities before technology transfer can succeed. These are the people that develop budgets.

An important point, briefly noted, is that technologies are constantly changing, and potential users must be made aware of advances that can come from outside demonstrations, new technology and experimentation. We still talk to agency people who refer to Landsat as ERTS and wonder what earthly good such small scale pictures can be.

Awareness and skill are inseparable where technology is being developed and applied. Executive managers in Alaska must somehow break through the barrier of not having time to learn what they need to know to manage effectively. Effective management then must incorporate the notion that development of remote sensing skills is a good investment. This can only be done through increasing the upper level awareness of remote sensing utility.

In the case of satellite-derived information, demonstrations of specific applications are absolutely necessary in the transfer process, and continuing education is also critical - keeping abreast of new methods and innovation in technology. Landsat data has a metallurgical quality to it. Through sophisticated technique it can be refined and blended with other data to produce an alloy of exceptional quality. But, each application requires the blending of more-or-less unique data resources, representing a unique location - not yet a standardized procedure and certainly not a standardized product. This is analagous to having each state and local area develop and maintain the skills and equipment needed to produce a high quality steel of unique formula, for local application only. For states and local governments to proceed with confidence under such conditions requires continuous assistance in the form of expertise, training, processing, demonstrations and education in the fundamentals of the technology with which they are working. We cannot be expected to apply complex technologies simply by coattailing one someone else's epiphany.

To make matters more difficult, Alaska has a constantly deteriorating store of human capital. We are at the end of an informative chain. We still hear echoes over phone lines; electrical networks may go dead for hours and days. Mail is slow and library resources are less than comprehensive. The professional in Alaska is recycled from agency to agency. An in-state hire preference insures this.

One way for the state to acquire a greater degree of skill among its technicians has been to pirate federal expertise. Federal agencies have a much broader pool of talent from which to draw and have had the most advanced remote sensing programs, historically. As state agencies look for aqualified people, federal agencies are seen as a natural resource. This of course, depreciates the federal programs and suggests another reason for cooperation in resource management.

In spite of the politically inspired vocal belligerence, there is a good recent history of cooperation between federal and state land managers - at least in the area of data and information management. Cooperation has been established through ANCSA and FSPLUC. The Alaska Lands Bill of 1980 provides for a follow-on Land Use Planning Council having broad federal and state participation. A 1978 interim agreement, signed by the Secretaries of Agricultural, Interior, the Governor of Alaska and the Chairman of the Alaska Federation of Natives, set up the Land Managers' Cooperative Task Force which voluntarily brought together policymakers and technicians from the major land managing agencies in Alaska. Subcommittees were established to address such common problems as flood plain management, Bristol Bay fisheries, reindeer herding, vegetation classification and information management. This last subcommittee has become a forum for the discussion of information systems development and has subsumed the previously independent remote sensing task force. The new Land Use Council may or may not

take over the functions of the various subcommittees. If it does, it will become an important policymaking body. A forum for coordinated budgeting between governmental levels.

At this point, I would encourage all agencies managing resources in Alaska to use such forums as the Land Managers' Cooperative Task Force or the new Land Use Council to develop a coordinated program aimed at improving all resource management capabilities. New information and data sources will be a key, for which such a program must provide continuing education, training, demonstrations and evaluations if Alaskan's are to enhance their resource management abilities.

C OVERVIEW - INTERGOVERNMENTAL SCIENCE/ENGR/TECH ADVISORY PANEL (ISETAP)

Leonard Slosky (Governor's Assistant - Science & Technology -
Denver, CO)

State Implementation - Policy Impacts & Institutional Issues

In 1978, the Intergovernmental Science, Engineering & Technology Advisory Panel (ISETAP) in the White House conducted a major study of Landsat use by state governments. The study concluded that "Landsat is an important technology that is presently making and can continue to make significant, often unique, contributions to the information base required for state government's management of natural resources." The study identified the principal characteristics which make Landsat data valuable to state governments.

The study determined the operational and R&D applications of Landsat data by state governments. The study assessed the commitments which state governments have made to utilizing Landsat. It was concluded that Landsat is now cost effective for a number of applications and will become more cost effective in an increasing number of applications.

ISETAP identified 8 major constraints to the utilization of Landsat by state governments —

- Data timeliness
- Indadequate federal technology transfer
- Ill-defined federal agency responsibilities
- Failure of federal agencies to use and encourage Landsat use
- Lack of state involvement in Landsat decicion-making
- Lack of federal understanding of state governments
- State constraints to the use of Landsat

The ISETAP Study made six major recommendations —

- The federal government should make a firm commitment to assure Landsat data continuity and compatibility
- The Landsat system should be federally supported
- Federal agency responsibilities should be clearly defined
- The Federal government should make the commitment to prior consultation with the states in Landsat decisions.

- The Federal government should make a strong commitment to a systematic and ongoing technology transfer program
- The data processing and delivery system should be improved.

Following the ISETAP study, the President issued NSC Directive 42 in June 1978. This Directive stated that —

- The United States will develop and operate on a global basis, active and passive remote sensing operations in support of national objectives.
- The United States will encourage domestic commercial exploitation of space capabilities and systems for economic benefit and to promote the technological position of the United States. However, all United States earth-oriented remote sensing satellites will require United States government authorization and supervision or regulation.
- Advances in earth imaging from space will be permitted under controls and when such needs are justified and assessed in relation to civil benefits, national security and foreign policy. Controls, as appropriate, on other forms of remote earth sensing will be established.
- Data and results from the civil space programs will be provided the widest practical dissemination to improve the condition of human beings on earth and to provide improved space services for the United States and other nations of the world.
- The Directive established a NSC Policy Review Committee to provide a forum to all Federal agencies for their policy views, to advise on proposed changes to national space policy, to resolve issues referred to the Committee, and to provide for rapid referral of issues to the President for decision as necessary.

Under the direction of the Policy Review Committee, the Private Sector Involvement Study and the Integrated Remote Sensing Systems Study were conducted. The Private Sector study explored mechanisms for expanded commercial involvement in land remote sensing. The study concluded that the private sector was not prepared to invest in the Landsat space or ground system without major government guarantees or subsidies. The Integrated Systems Study explored the feasibility of integrating land, meteorologic and ocean remote sensing space and ground systems of the civil defense agencies. The study concluded that certain integrations were technically feasible and could result in a cost savings of 15 to 20%. Institutional and technical barriers precluded more extensive integration particularly between civil and defense systems.

These studies culminated in Presidential Directive 54 in November 1979. This Directive assigned to NOAA the responsibility for managing the US civil operational land remote sensing activities. NOAA was directed to prepare a comprehensive transition plan and to establish an Interagency Program Board for continuing federal coordination and regulation. The directive restated the goal of eventual operation of the civil land remote sensing system by the private sector.

In mid June, NOAA submitted the Transition Plan to the White House and presented discussion document to the Congress.

The Transition Plan does not adequately address several of the key issues identified by the ISETAP report.

Now, the proposed Reagan budget cuts, further threaten the ability of state governments to utilize Landsat data. The current state of affairs will be discussed in more detail.

D OVERVIEW - MONTANA STATE'S LANDSAT PROJECTS

Thomas R. Dundas (Administrator - Research & Information Systems
 Division - Montana Department of Community
 Affairs - Helena, MT)

Thomas Dundas, representing Montana's Department of Community Affairs, presented a general overview of the state's Landsat projects and predicted that satellite technology would have a "bright future" in Montana, as well as other states, if the program continues.

E

IMPLEMENTING AUTOMATIC GEOGRAPHIC REFERENCING IN UTAH

Bruce L. Plott (Systems Specialist - Utah Geological & Mineral Survey - Salt Lake City, UT)

It was very interesting listening to the previous speakers. I wonder, with the State of Alaska and the State of Montana and the State of Utah, what percentage of total Federal landholding is represented there. We are here at a Federal conference representing the state and yet we are also representing a good hunk of the Federal investment as well.

I have been most impressed with what has been said here this morning. I am hearing some very interesting and exciting phrases being used. Phrases such as "integration of multiple data types", not just remote sensing data, but all kinds of data. Statements about technology transfer and the phasing out of technology transfer. Now that may sound a little bit strange, but as the federal government recognizes that its technology must be transferred to the next level of state government, whether the question of timing is right, that is something else. But state government must look at technology transfer. In other words, the state government cannot accept or pick up the gauntlet and be the expert now. It must be moved out to the operational aspects of state government, to the conservation officer in the field, to the geologist in the field, to the law enforcement officer in the field. It must be moved to local government. When we talk of technology transfer, we have just started. Technology transfer, that NASA began, and evidently, with recent developments, we are starting to see the closing moments of, this is just a beginning. What is being done must be moved out to where the operational aspects can take place and utilize those aspects in the hands of the individual.

This is the approach and activity of the State of Utah. We are not as far advanced in the actual application of remote sensing, the application of the new technology, as some state are. Listening to the gentleman from the State of California this morning - tremendous things they are doing. They are doing the things that Utah is now contemplating. Utah is ahead of some states. We are behind a larger number than we would like to be. However, we are moving and I think we are moving in the right direction.

Utah is trying to take a fully integrated approach. You heard terms this morning concerning data bases. You heard terms concerning coordination and computer capacity. This is an overall view of what we are talking about accomplishing. The total picture must be considered. Just as the federal government looked at the whole picture, so must

state government. We cannot just consider remote sensing alone. Remote sensing is an extremely valuable tool, but unless integrated and properly utilized, it is not going to be of any great value.

As we look at all aspects, let me explain to you a little bit about why I am in this field and doing what I am doing. I am not an earth scientist. I am not a remote sensing expert. What I am, is an individual who has fought for many years to integrate data, to view data as a valuable resource. To view data and information as a resource to be managed. To be managed in much the same manner as you manage your personnel departments, as your finance departments manage the dollars, as your computer scientists manage your computer capacity, so must information be managed and coordinated and integrated.

One of the major problems we face in looking at the true operational aspects of what is going on, we see the geologists in the field taking core samples, measuring faults, doing, (as I say, I am not an earth scientist), but doing what geologists do. Or the property assessment valuator, who is in the field putting values on property, or the Department of Transportation that is studying the feasibility of a major communications corridor. What are they doing? They are gathering data. They are gathering data that to them, becomes information because they are going to put it to specific use. But can that data then be used and become information to someone else? Can the data that is gathered in a remote sensing application, be valuable to a highway department for corridor analysis? Can the same information, the same data, that is used to study slopes and fuels in a forestry application for fire prevention. Can the same data be used by the Department of Transportation for corridor analysis? Or by the Taxation Department for property valuation? Or the Geological & Minerals Survey Department for earthquake hazard evaluation? Can this be done? Can we share the common data and mould it to make it information for each of our needs?

The State of Montana for instance, discovered that there are a lot of common needs. The key issue here though, is the question of common needs as determined from about or the common needs as defined by the individual, by the user, by the man in the field that is going to make things happen.

This leads us to what I really want to say today and explain to you what the State of Utah is trying to do. We are trying to establish a core operation within the state to make some upfront investment in hardware, software, technical expertise, not sufficient to do the job, not sufficient to make it all happen, but sufficient to make the people, the operational people, in the field, aware of what can be done. It

will be their decision when remote sensing or integrated geographical referencing takes place. Decisions based on their needs, not on a need dictated by someone at a central site, the whims of a legislative body. But based on their needs that they are willing to go out and fight for and to make it happen. That is what it all amounts to. The term technology transfer is an excellent term because it has to be continued until that transfer is all the way down to the operational people at the base level who are making it happen.

The State of Utah is progressing with a slow, small approach. The key to our operation is to facilitate, to coordinate and to educate. The word "do" does not exist. We will not "do it" for the agencies. The agencies must do it for themselves based on their needs, their desires, their capabilities and their payback.

I do not have anything else to say. I think the point I wanted to make here is that the State of Utah does not want to go into it in a large way and try and do it. We want to continue the trend of NASA in the technology transfer concepts and continue that transfer down the line until it gets down to the working level.

F

STATE/FEDERAL INTERACTION OF LANDSAT SYSTEM & RELATED
TECHNICAL ASSISTANCE

Paul A. Tessar (Director of Remote Sensing Project - National
Conference of State Legislatures - Denver, CO)

I would like to cover four general topics in my talk this afternoon. First I would describe in more detail, the background and state involvement in Landsat systems planning and related efforts. Secondly, I want to discuss the status of state Landsat use and share with you, a couple of snapshots of where the states were at various times in utilizing this technology. Thirdly, I will discuss the federal government's future plans for the Landsat system, and what I feel the impacts of the recent budget decisions will be on that system. Finally, I want to talk about the FY 82 budget process.

NCSL first became involved in Landsat in 1976. A study on user requirements for Landsat D was conducted by one of our first Landsat committees. At that time, it was called the Remote Sensing Task Force. We currently have a Natural Resource Information Systems Task Force which is a descendent of that group. There are three representatives from this region on that task force. They are well aware of various Landsat issues, and have been involved with the task force for several years now. If one of those gentlemen is in your state, I would recommend that you sit down and visit with him and find out what their interests in Landsat technology are, their feelings and perhaps you can share with them what your interests and plans are and what you would like them to be.

Coming out of these first user requirement studies, a number of technical recommendations on the configuration of the Landsat System were made including appropriate wavelength, resolutions, etc., for various applications. In addition, a Landsat D support campaign was initiated. It was not at all clear back then, whether there would be a Landsat D and a number of people got involved in this question, wrote many letters to Congress, and OMB. Their voices were heard and, as a result of that, there is a Landsat D program and the spacecraft that are being constructed.

At that time, the study on state needs for technology transfer was conducted. This study made a number of recommendations regarding what should be included in such programs and the direction they should take in their focus. These recommendations in conjunction with the General Accounting Office, report that Alex Tuyahov mentioned, were instrumental in getting the RAP program started.

Over the years, we have looked at these various issues for the spacecraft and the system and have made a number of recommendations. We have been involved in a number of user awareness activities with state legislatures, various committees, state agencies, state universities including committee briefings, workshops. We produced a number of publications that we have developed, some of which are available in the display area. Products such as Land Satellites Guide to Natural Resource Information Systems, a number of data requirement surveys and our newsletter, the NIRS Newsletter.

In late 1978, the Governor's Association, through the Council of State Planning Agencies, initiated the Earth Resources Data Project, of which the Earth Resources Data Council- was a part. They are more or less, a counterpart of our NIRS Task Force on the agency side of the game.

In conjunction with the ERDC, our NIRS Task Force has made continuing recommendations on the operational system and technology transfer requirements of the states. The AGA project has engaged in a number of user awareness activities in conjunction, sometimes with us, sometimes independently, sometimes with NASA. I will not go into detail on the Isotap studies. Leonard covered that quite well, but we were an active participant in the Isotap study and spent many hours developing data to support the recommendations that were made a part of that study.

Over the years, the states have taken part in the Congressional process and have provided support and comments on a number of initiatives operational of lines of that program, namely, the Mossville, the Fordville, the Stephensonville, the Schmidville and I imagine there will be a state participation in and comments upon future villes which I can be anticipated at least from Senator Schmidt and perhaps from Representatives and the Senate bill, at least, should be available by summer and it will be on both the short and long term issues related to the Landsat system. That is enough I think, on state involvement in Landsat. What I have said, together with what Leonard has said, should make it clear that we have indeed been in the trenches for at least the last five years trying to convince the Federal establishment that this Landsat system is useful to state and local governments if they will give us the kind of help we can use to make it useful and if we know it is going to be there.

In terms of the status of state Landsat use, in July 1976, there were four states that had analysis and applications capabilities for Landsat data, mainly, Texas, Georgia, South Dakota and Mississippi. At that time, there were initial stirrings of interest from a number of different states as to the applicability of this technology to their information needs.

In July of 1978, two more states had developed analysis and applications capabilities, New Jersey and North Dakota. At that time, there were about 20 states beginning involvement with the NASA regional applications centers. Largely as a result of that involvement, today we see 16 states with visual Landsat capabilities, Georgia, Idaho, Iowa, Kansas, Louisiana, Maryland, Maine, Minnesota, New Jersey, Oklahoma, Oregon, South Carolina, South Dakota, Texas, Vermont and Washington. In addition, 10 states are planning on developing capabilities at this time, Arizona, Alaska, Florida, Kentucky, Mississippi, Michigan, Montana, New Mexico, North Carolina and Virginia. I feel these are conservative estimates. There are other states that may be moving ahead that we have not included, and if you are one of the, please let me know so that I can update my list here.

By July, 1982, half of the states will be routine users of Landsat data (at a minimum), I think the NASA Regional Applications Program can take the lion's share of credit for bringing this technology to the users and fashioning it to meet their needs.

Federal Landsat planning has been going on for quite some time - back to the late 1960's as a matter of fact, where the early Landsat missions, had its ups and downs. I would like to discuss one particular up and one particular down with you now.

What I would call the best case scenario for the Landsat program is the budget submitted by President Carter early in January. This program consisted of a space segment which was to build Landsat D3 and D4, or D double prime and D triple prime, depending upon whether you prefer the NASA or the no and notation. There was \$ 103 million dollars to begin procurement of those two spacecraft. The ground segment included an operational data processing system at Goddard and a quick look capability. The third segment, which often is not recognized by Federal bureaucrats and policymakers, is the user application segment. They can visualize the hardware in space, the space segment and the various facilities on the ground to retrieve the data, the ground segment, but they really do not recognize this user application segment. I guess they go by the better mousetrap theory.

Under the Carter budget, the NASA Landsat Technology Transfer Programs to aid state and local governments in examining Landsat technology was funded adequately. It suffered, I believe, a 10% cut, which was reasonable. NOAA was scheduled to initiate a market development program to work with other user sectors.

That was the up. Now we come to the down part. It felt quite good for a period of time. Those of us who had been in the trenches for a number of years, finally felt that we had made a mark. We had compelled the Federal Government to listen and succeeded in our plans and desires to get this technology institutionalized and operationalized. Well, along came David Stockman and things changed. We were back on the downslide. I believe that the Administration and Congress is probably going to examine the very commitment of the previous Administration to an operational system. That has become clear by some of the policy decisions that they have made. In fact, there is an implicit reversal of PD 54 by the budgetary actions which OMB and the President have recommended. The \$ 100 million dollars, plus Bill D3 and D4, has been eliminated from the budget. I view this as the single most significant impact. We are told that two satellites will give us data continuity through 1988. Well, if everything works out right, maybe so. But assuming a 10% failure among successful launch for each of two satellites, and a 10% probability for premature malfunction or the thing conking out before its design life, that gives us 65% chance of data continuity between the launch of Landsat D and the end of 1988. Apparently that is good enough for OMB, close enough for government work, they might say. I am not sure. I felt a lot better having D3 and D4 coming down the line, and some built-in redundancy, in case there was a premature failure or unsuccessful launch.

The enhancements to the ground data processing system proposed by NOAA in the transition plan, fell victim to the very first round of Reagan budget cuts. The money to build what NOAA would term, a data processing facility was eliminated, some ten or eleven million dollars, and NOAA was instructed to work with EROS to provide data to users. Now maybe this will work out and maybe it won't. All I know is, I've heard many complaints from people waiting eight months to get a CCT. Perhaps they will tighten the operation up - perhaps the new preprocessing facility for Landsat DMSS data will help - perhaps it will not. I side with NOAA on the need to have something of a more operational data processing system. Maybe it can be done by putting more money into EROS rather than building an entirely new facility. Perhaps that would be more cost effective, but the current budget calls for a \$ 700,000 band-aid upon the EROS Data Center and that will be our operational user service facility. The people at EROS claim that it is adequate, but the people at NASA also say that the private sector is going to provide its technology transfer system. I guess I am glad to see all the Feds standing up here like good soldiers and telling us how we are going to be so much better off under this new budget, and it is really all right. Well, I do not believe it for a minute and I hope you don't.

Finally, and what perhaps from a state and local government standpoint is the most crucial cut in the budget, is the entire elimination of the NASA Landsat technology transfer activities. This fell victim in that.

last round of cuts when they said, "Oops, we must cut another six billion dollars. We added wrong." Well, we are going to suffer from that, that mistake and those cuts. NASA and NOAA programs in technology transfer and market development have been entirely eliminated from the budget. The regional applications program, the user requirements program, and the ASVT programs are to be terminated by October, 1981. In fact, there is revisions to the current fiscal year's budgets and the RAP centers are beginning to shut off demonstration projects in midstream, I believe. Some will be finished, additional resources will be put in, finish off those that are near - perhaps some that are just getting started will be shut down cold and we are on our own now, or will be shortly.

This, I believe, is a very serious cut. The RAP Program has provided valuable service to state governments in particular, and the NOAA market development activities would have provided valuable services to other sectors of the user market.

We do need an operational Landsat system and I am not sure that the current FY 82 budget is going to provide that system. The Carter budget would have done so. I would like to discuss in detail, some of the reasons we need this operations system.

One of them has to do with the general shift in resource planning and management to the states. The Federal Government is pulling out of a lot of programs - coastal zone management is one good example - and they are cutting funds to the states to participate in these activities. They are lumping them all together in one pot called block grants and they are cutting them in half and they are going to let everyone at the state level fight it out for the half that is left. Now you can make the argument that perhaps 20 or 25% of the categorical grants were a waste, but we are talking about 50% of the money, not 75%. So there is a lot of valuable things that are going right down the tubes as a result of these cuts and Federal aid and as a result of this supposed savior of block grants.

I was very disappointed at the recent NGA meeting to see the governors going for this. They apparently like the flexibility of block grants. I think they will change their minds when they try and do 75% of the work with 50% of the money. I predict some very intense scuffling on the state level when it comes to divvying up that pork barrel.

State budgets all over are very tight. In Michigan, for example, they face an eight billion dollar deficit this year and they have had to do more with less and eliminate a lot of things.

This Landsat technology was developed by the Federal Government at about a cost of about one billion dollars. Sounds like a lot of money but it is only as much as four XM tanks or whatever they are. I believe the states and the people of this country should benefit from this one billion dollar investment. I don't feel it is long-sighted of the Federal Government to eliminate technology transfer activities in portions of the operational systems after we have accomplished this much. Shall I say in all charity that it is penny-wise and pound-foolish.

There is some national policy implications here. We are the leaders of the world in space technology. But what do you think of the idea of Toyota-Sat? Perhaps we are going to be using that type of data. We are already thinking of using Japanese communications satellites because we have relinquished our lead in that area by deassigning NASA from responsibility for our centers. And as was mentioned earlier, the French are active. We must have data continuity and reliability. United States leadership in this field is very much challenged and I am disturbed by the national policy implications of this. Now this does not really affect the states per se, but it is an important argument I think.

We also have a very strong need for a NASA Landsat technology transfer program. As I pointed out before, the space hardware and ground segment are only one part of the overall system. The Federal Government needs to recognize and service the user application segment.

For six million dollars a year, I believe we can assure that the state and local segment and the public sector users benefit from this one billion dollar Federal investment and it is really penny-wise and pound foolish to cut out these last few million dollars to assure the benefit of this one billion dollar investment.

I feel the private sector will not do technology transfer on its own. They want to sell services and products, not develop self sufficient users. The NASA technology transfer program, in fact, has helped create business for some private sector firms selling Landsat classifications and hardware and so on and it is very short-sighted of these users to stand up and say things that like NASA, is competing with them when in fact, they are creating a market for them to service.

Technology transfer is rather cheap. As I pointed out before, one tank costs 250 million dollars or something ridiculous like that. No, it is two and one half million dollars. For the cost of two tanks, we could have a very credible Landsat technology transfer program. May I suggest that the Administration put out only releases on the number of tanks created and perhaps add a little bit more butter instead of the guns.

I don't think the Russians would miss two tanks. We could just tell them they are there and they will not know any better. Or perhaps we could build the next shuttle with a few less tiles. Take off the chrome on the dashboard on the shuttle - there must be some way that NASA can reallocate their funds and help assure the dissemination of the technology they have developed.

We need to recognize that the states are very conservative and do not take risks. They are very conservative in developing new programs. Our Governors and Legislators are all from Missouri when it comes to evaluating new technologies and I just wonder how many of the states here that have had Landsat demonstration projects, would be willing to pony up 50 to \$ 100,000 for a Landsat demonstration project sight unseen. The answer is, the person suggesting that would be shown the door very quickly. We need this low-cost, low-risk opportunity to evaluate Landsat technology. Given this opportunity, most states have decided to invest. Without the demonstrations, they would not even have investigated the technology, much less invested in it.

The private sector serves the largest users and lets the small ones go. This was perfectly illustrated in the Goddard conference in Boston (or outside of Boston) when someone stood up and made this observation. It is that the private sector goes after the big part of the market and perhaps, you know, this little tail end will get serviced. In terms of the dollar volumes of Landsat sales, states are small users - 6 - 8% of the market at best. In terms of the public policy significance of their applications, however, the states are very important users. The states manage resources, and provide stewardship to assure that these resources are not depleted and that they are here for future generations to use and enjoy without abusing.

This idea of a private sector market as applied to Landsat is very fallacious. This private sector model is irrelevant to state and local government. Landsat technology is a very complex issue. We are not talking about supply and demand for widgets which is what economists like to talk about and things like that. It is a very complex matter. It assumes that the states are rational entities. I would submit that that is not necessarily always true and for good reason.

Natural resource data needs cannot compete with more immediate needs such as funding for Medicare, food stamps and welfare. There is a lot of votes for those things - there is not a lot of votes for Landsat systems and in the budget crunch we know how things are going to turn out and perhaps that is how things should be - that is the way they are.

This private sector better mousetrap argument does not deal with this at all. It ignores the public policy significance of usage by resource management agencies. What is the value of one acre of prime agricultural land preserve or one stream cleaned up based on using Landsat and other data to find out where the soil is eroding and clogging it up.

You are not going to find the fish standing up and screaming to restore funds for data to clean up their streams. You are not going to find many economists that are going to put a value on the relative marginal utility of cleaning streams. This sort of shortsighted argument on the part of the new Administration is really very frustrating. It is really shortsighted to terminate technology transfer. I think Huey Johnson this morning, provided a perfect example of the need for Landsat technology transfer. He stood up and said he was very skeptical. He was from Missouri and then Landsat and NASA proved themselves to him. The private sector is not going to invest \$ 50 or \$ 100,000 in convincing Huey Johnson that Landsat is valuable.

It is the resource base of our country that is going to suffer from the abuses allowed by inadequate state knowledge of environmental impacts, and the negative effects of certain resource development projects. The criteria for moving ahead on different things is switching in case you have not noticed. The short term market and financial reasons are going to determine which resources are exploited, not their environmental sensitivity nor the long-term issues related to their depletion. Now, perhaps, these are facts and we have to face up to them. As someone who has been in environmental and conservation things for awhile, I find it most discouraging that our values are taking a radical shift and this whole Landsat cut business is just one part of it.

G MULTIRESOURCE ANALYSIS & INFORMATION SYSTEM CONCEPTS FOR
 INCORPORATING LANDSAT & GIS TECHNOLOGY INTO LARGE AREA
 FOREST SURVEYS

Dr. Philip G. Langley (Director of Forestry Applications - Earth
 Satellite Corporation - Berkeley, CA)

This paper addresses the problem of relating different classifications at each stage of a multistage, multiresource inventory using remotely sensed imagery. A solution was needed to complete the concepts development for a Multiresource Analysis and Information System (MAIS) for the USDA Forest Service.

In many existing methods, with more than two stages, a single parameter is estimated (e.g., timber volume), whereas with multiple parameters, such as land use proportions, only two stages are generally used. In the latter case, the traditional approach has been to make the first stage classification (e.g., Landsat), conform to the second stage, ("ground truth"), as closely as possible by optimizing the classification accuracy. A perfect classification accuracy is seldom, if ever, attainable, however, in the case of multiresource inventories. Therefore, much emphasis has been placed recently on "co-occurrence" matrices which describe the correspondence between classifications of adjacent stages.

A new type of co-occurrence matrix has been developed, termed a class transformation matrix, which allows one to convert a set of proportions at one stage (e.g., spectral class proportions), to a set of proportions at the subsequent stage (aerial photo class interpretive proportions), through the use of a linear model. In this context, the emphasis is on a good correlation between two classification systems rather than on the classification accuracy for one stage. The class transformation matrix and its associated covariance matrix can be rigorously estimated from the proportions derived from a set of matching sample units using regression estimation techniques. The sample units (currently one square mile in size), are manipulated and stored using GIS technology. A cell system is used for the Landsat-type remote sensing data, whereas a polygonal system is employed for high resolution aerial photo interpretation data and maps, as well as ground data. The row sums of the class transformation matrix must add to one and the elements must be greater than or equal to zero. These constraints are enforced through the use of inequality constrained least squares estimation. A quadratic programming algorithm was used to obtain the matrix elements and a special variance computation method was implemented to compute the covariance matrix of the elements.

The technique was tested by applying a prototype MAIS system to Kershaw County, South Carolina. Correlation coefficients of 0.76 (land use) to 0.99 (water), and highly significant F statistics were obtained for correlating unsupervised Landsat spectral classifications with aerial photo land use interpretations. Using the linear model, these correlations were then exploited to estimate land use proportions for the entire county. In turn, these proportions were used to stratify current annual increment (CAI), field plot data to obtain a total CAI estimate for Kershaw County. This estimate differed by only 1% from the published figure, while the estimated standard errors were comparable (7.56% and 7.25%). In addition to estimating CAI, the flexibility of the system was demonstrated by estimating potential sediment loss as well as a variety of land use classifications based on published ground land use definitions.

H SOME PRACTICAL APPLICATIONS OF LANDSAT IMAGERY IN CHEVRON
OVERSEAS PETROLEUM INCORPORATED EXPLORATION PROGRAMS

J. Vandemakker (Remote Sensing Specialist - Chevron, USA - San
Francisco, CA)

Since Landsat 1 was launched in 1972, Chevron Overseas Petroleum Inc., has used Landsat imagery for many different purposes in many parts of the world.

Landsat has several times solved urgent problems for us within a tight time schedule and Landsat technology is a helpful, supporting tool in our exploration program. It is applied in supporting geologic interpretation, planning and carrying out geophysical, pipeline and other engineering activities. This is through Landsat's effective depiction of surface geology, terrain and bathymetry.

We have had good results, but it has to be kept in mind that Landsat in its present form has its limitations.

Future improvements, such as better resolution, improved rock discriminating capability and good quality, cloud-free worldwide stereo coverage available in the US would greatly improve its scope and usefulness.

I JOINT GEOSAT NASA/JPL TEST CASE PROGRAM

Dr. Frederick B. Henderson III (President - The Geosat Committee, Inc., San Francisco, CA)

The Geosat Committee was organized to recommend Landsat supplementary sensing systems optimizing geological remote sensing from space. The recommendations include rock/soil sensitive spectral bands, worldwide, high resolution film (Large Format Camera), Landsat-compatible stereoscopic digital imaging data (STEREOSAT), and synthetic aperture radar. Potential space remote sensing systems are being evaluated under the joint JPL/NASA Geosat Test Case Program. The study includes an evaluation of sensors, data processing techniques and interpretation methods in 8 oil/gas, porphyry copper and uranium sites.

The international industrial geological community represented by the Geosat Committee has worked with NASA, JPL and others to demonstrate the potential benefit of the Landsat system and additional satellite capabilities to be realized in the 1980's to the energy and mineral exploration community. Capabilities to be added to current Landsat systems should include fixed and pointable stereoscopic coverage, increased resolution (to 10 meters IFOV), additional rock/soil sensitive bands, the synthetic aperture radar and corresponding ground segment systems for digital data processing and applications.

The Geosat Committee recommendations are influenced by recent national and international developments, the 1979 Space Policy, OSTP studies on military/civilian remote sensing systems integration and private sector involvement, Presidential Directive 54, Senate & House action in 1978, 1979 and 1980 on space policy and the development of an operational earth remote sensing system, the activities of Comsat on STEREOSAT development. Some Geosat recommended data may become available through France's SPOT, Japan's MOS/LOS, Germany's ARGUS and other non-US earth remote sensing satellites. Geosat hopes these systems will be Landsat-compatible.

SESSION III

31 MARCH

TUESDAY (AM)

WESTERN REGIONAL REMOTE SENSING CONFERENCE

A STATUS REPORT FOR LANDSAT 2, 3 & D

Vincent V. Salomonson (Chief - Earth Survey Applications Division -
NASA Goddard Space Flight Center -
Greenbelt, MD)

Introduction

The Landsat series of satellites has been producing observations useful for studying and monitoring the dynamics of surface features of the earth and the performance of earth resources management activities. These observations have been found to be useful in monitoring agricultural practices including the acreage, growth and development of crops and forests, the extent of snow and ice cover and other water resources management surface features such as water bodies, irrigation practices and wetlands, the scope and character of geologic features aiding mineral and petroleum exploration, and general land cover mapping useful in land use planning and management and demographic studies.

The observations from the Landsat satellites, in total, have been found to be sufficiently useful in resources management to provide the fundamental impetus for the issuance of a presidential directive (PD 54) in 1979 establishing the National Oceanic & Atmospheric Administration (NOAA) as the agency to manage all operational civilian remote sensing activities from space (NOAA 1980). This was a significant development in that it provides an institutional framework within which continuity of data is assured. This subsequently signals agencies and industries that have found these data to be useful in the past that they may proceed with long term plans and commitments that will enable them to incorporate Landsat data and acquire associated equipment and personnel in such a way as to allow them to better meet their responsibilities and commitments.

This paper will summarize the status of the existing Landsat 2/3 satellites and the associated NASA ground data processing activities. It will also provide an updated view of the progress in the Landsat D program, because the Landsat D program is to provide the primary systems and observations that will support the operational earth resources satellite system in the 1980's.

Landsat 1/2/3 Status

Landsat 1 was launched in July 1972 followed by Landsat 2 in January 1975 and Landsat 3 in March 1978. For much of the period between 1975 and 1980, there were two satellites in operation although Landsat 2 did

experience difficulties during the period of November 1979 to May 1980. Landsat 1 ceased operations in March 1978. The MSS instruments on Landsat 1/2/3 have provided the substantial majority of observations in four spectral Bands (0.5-0.6, 0.6-0.7, 0.7-0.8 and 0.8-1.1 micrometers), at 80 meter spatial resolution. Return Beam Vidicon (RBV), panchromatic cameras for Landsat 3 have also provided a very useful set of observations at a spatial resolution of less than 40 meters. Due to a failure in the multiplexer circuitry associated with the MSS on Landsat 3, the MSS was removed from operational service in December 1980. Figure 1 shows the progress of Landsat RBV and MSS scene acquisitions in 1979 and 1980.

With Landsat 3 MSS not in operation, only MSS data from Landsat 2 will be available until the launch of Landsat D in 1982. The tape recorder associated with MSS data on Landsat 2 have been inoperative for some time. MSS data for US applications, other than that available from direct readout of Landsat 2 over the United States (except Hawaii), must be obtained by other means. Tape recorders able to store MSS data for routine shipment to the US are being placed at ground stations in Brazil, Sweden and Australia. A recorder developed by the Japanese is being used in Japan. RBV data are still being acquired from Landsat 3 and the on-board tape recorder.

Since February 1979 (September 1980) the processing and archiving of the Landsat MSS (RBV) data has been digitally based as opposed to the image-based system used earlier. This strategy has encountered some significant challenges in achieving a fully operational status. The image processing facility (IPF) at Goddard Space Flight Center wherein this strategy was instituted, accumulated a backlog of MSS and RBV images to be processed. The MSS backlog status is shown in Figure 2. Data production rates for MSS data are expected to range between 850 to 950 scenes per week over the next year. The scene production rate for the RBV data has been near 175 full frames per week and is expected to be near 200 full frames per week during the next year. This should gradually reduce the backlog to zero by the end of 1981 or shortly thereafter. The median cycle time in the IPF, extending from receipt of current data at the IPF to shipment date to the EROS Data Center (EDC), has been near 14 days.

Landsat D

The Landsat D program has been revised and updated in the past year and this section will describe the essence of the program as it now stands. For a more extended discussion of these plans, see Salomonson (1981). Landsat D is now scheduled for launch in the third quarter of 1982. A second spacecraft, Landsat D (Prime) is to be ready for launch 12-15

months following the launch of Landsat D. Data will be acquired from Landsat D using the present Ground Station, Tracking & Data Network (GSTDN), until the Tracking & Data Relay Satellite System (TDRSS) becomes available in 1983. Both Landsat D and D prime, will have an MSS instrument in the payload. The advanced multispectral scanner termed the "Thematic Mapper" will be flown on Landsat D if it is ready in time for launch and will definitely be included in the payload of Landsat D prime. Figure 3 provides an overall concept of Landsat D systems. Figure 4 schematically describes basic elements involved in the Thematic Mapper (TM) operation.

In concert with the establishment of NOAA as the operational earth resources satellite agency, the processing capability for MSS data from Landsat D will be developed and transferred to NOAA by January 1983. Much more research and development is required for the TM data products. This processing capability, therefore, is not planned for transfer to NOAA until January 1985. Table 1 summarizes Landsat D production requirements. The total ground processing system for Landsat D and D prime, has been conceived to separate the processing of the MSS and TM data, to accomplish operational status independently.

Conclusions

Landsat MSS data are being provided for domestic use by Landsat 2 using real time US readout capability and recorders placed at some foreign ground stations. Return Beam Vidicon data continue to be received from Landsat 3. The processing and delivery of these data is gradually improving with the disappearance of backlog in RBV or MSS data by 1982. This should set the stage for the acquisition of data from Landsat D MSS and, possible the TM. Pending the firm establishment of the operational earth resources satellite system, the production of Landsat D MSS data for the user community should be achieved by 1983 and TM data by 1985.

SCENES PER WEEK (AVERAGED MONTHLY)

1-71

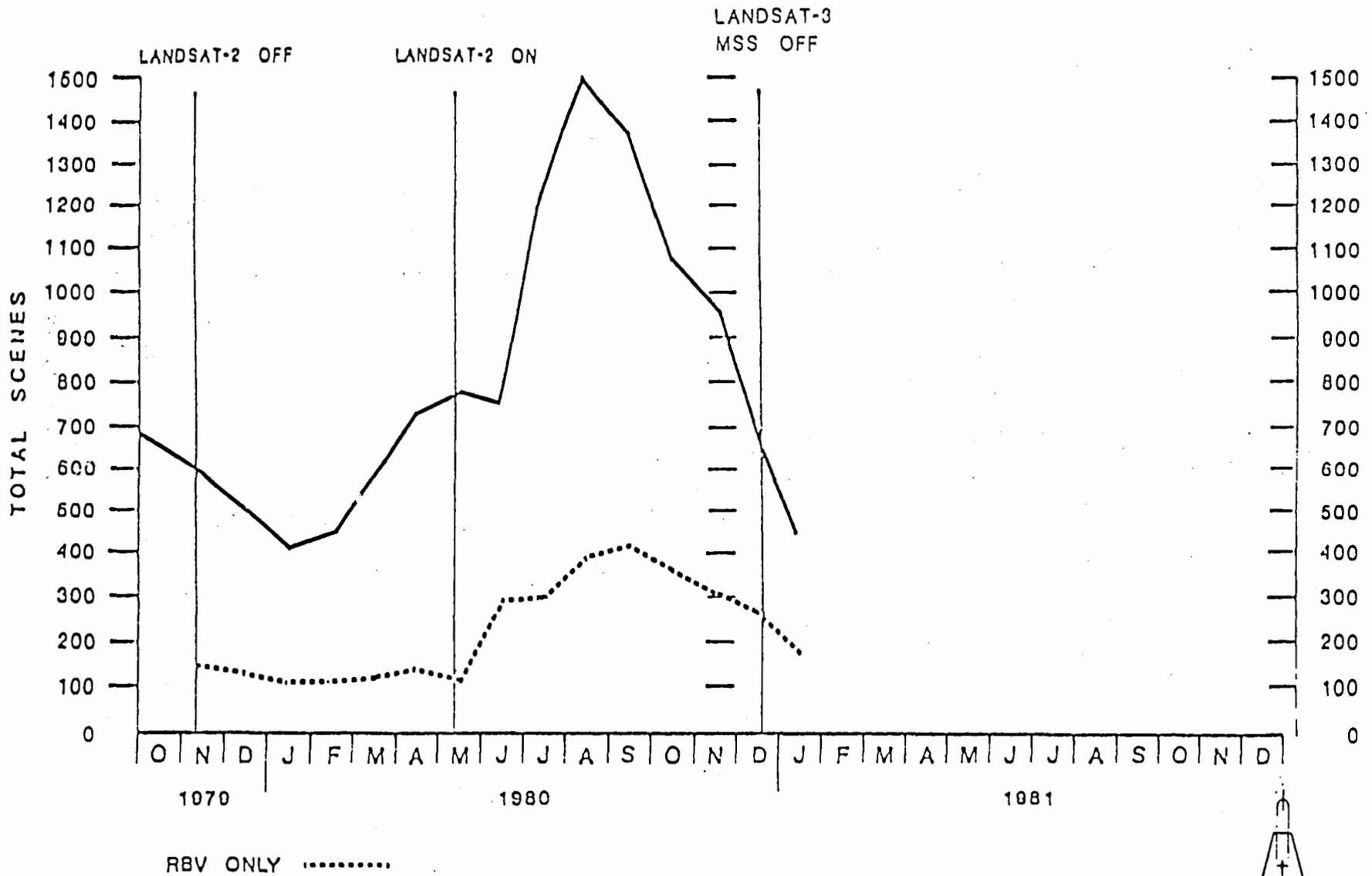
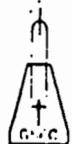


Figure 1 Landsat 2 MSS & Landsat 3 RBV/MSS Acquisitions



1-72

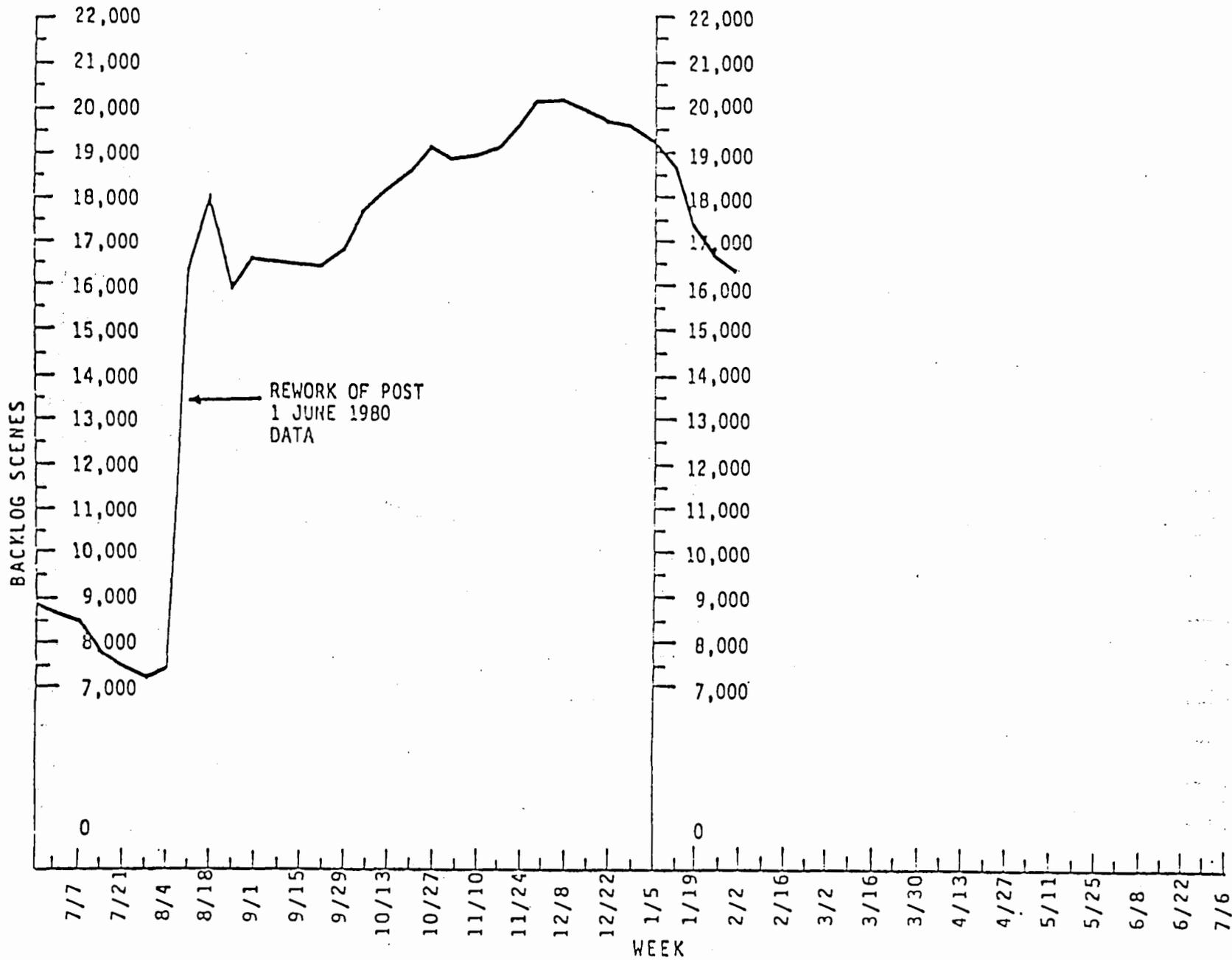
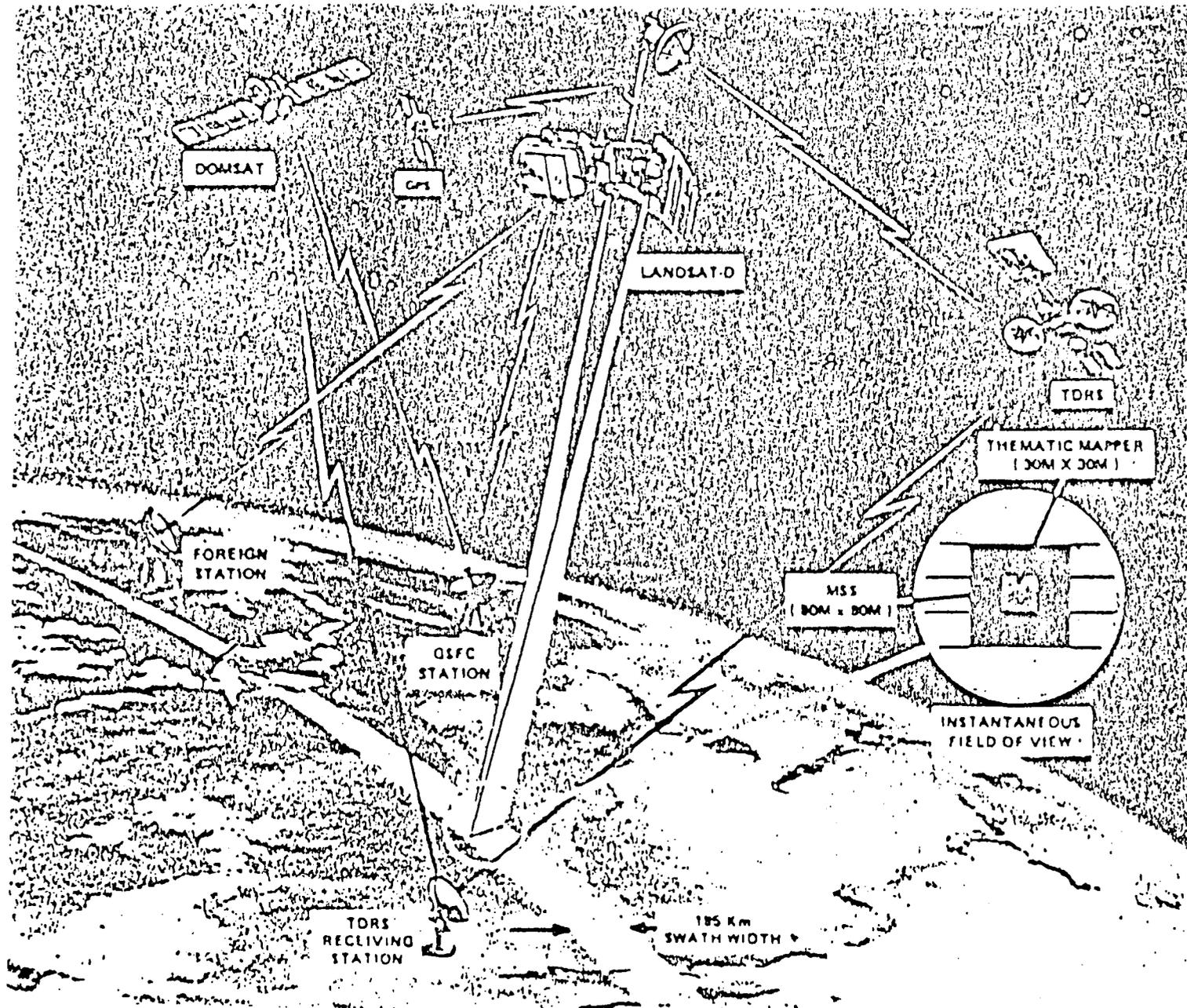


Figure 2 Landsat IPF Backlog (MSS)





1-73

Figure 3 Landsat D System

1-74

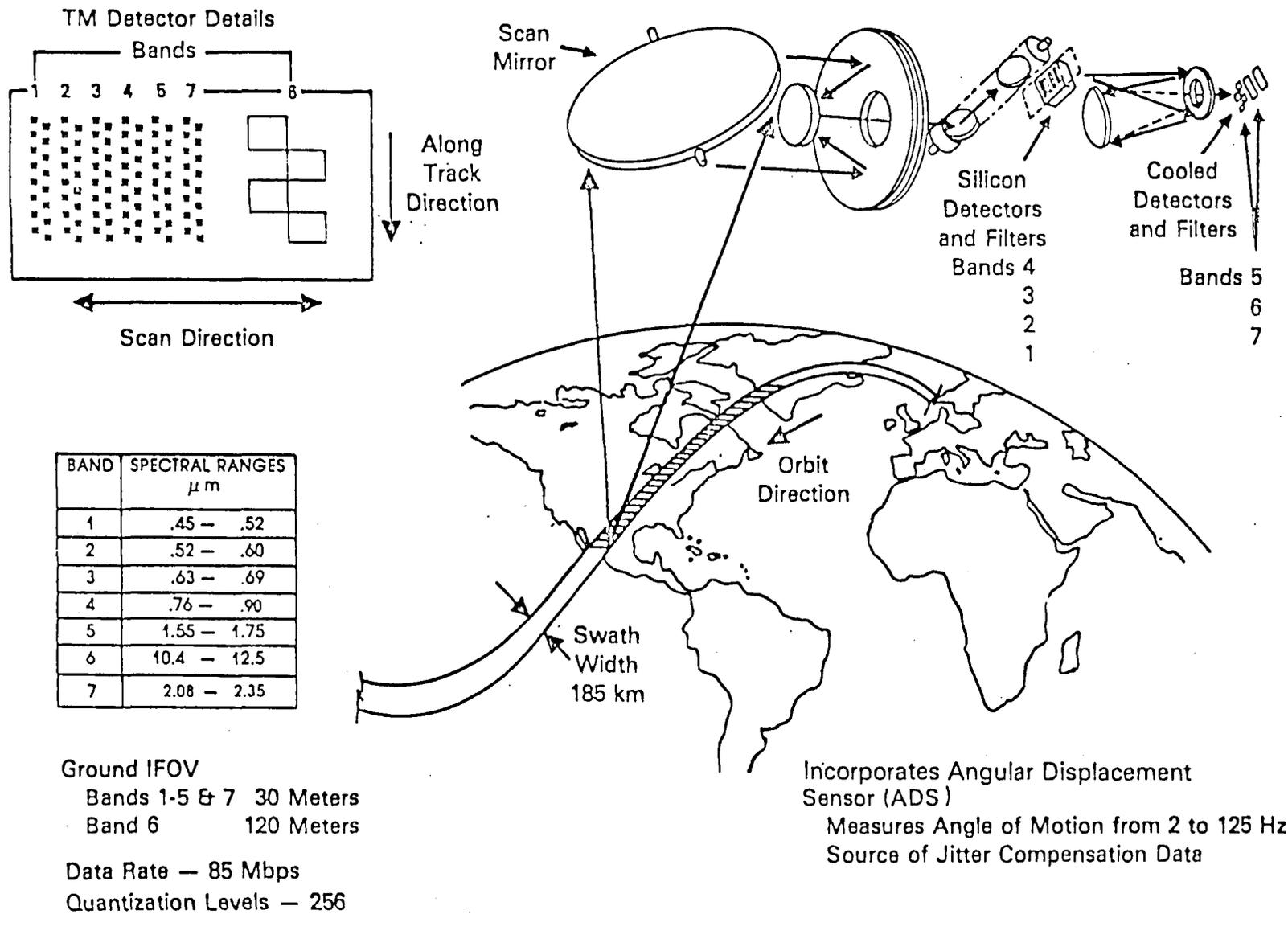


Figure 4 Landsat D Thematic Mapper (TM) Sensor

Table 1 Landsat D Production Requirements

<u>Product</u>	<u>Quantity Required for NOAA (Scenes/Day)</u>	<u>When Available</u>
1) MSS A Tape (HDT) (User Product) MSS 70 mm Film (Q.C. Product) (One Band)	200	A. Capability for 200 Scenes/Day at Launch B. Turn Over Operational System to NOAA, 200 Scenes/Day at D Launch Plus 6 Months
2) MSS CCT (A or P) (Q.C. Product)	2	At Launch of Landsat-D
3) MSS 241 mm Film (Q.C. Product)	4	A. At Launch of Landsat-D: 2 Scenes/Day B. Launch + 90 Days: 4 Scenes/Day
4) TM A Tape (HDT) (User Product)	100	A. In July 1983, 12 Scenes/Day With A Priori Jitter Correction B. By April 1984, 12 Scenes/Day Must be Demonstrated* C. Turn-Over Operational System To NOAA, 100 Scenes/Day, in January 1985*

1-75



Table 1 Landsat D Production Requirements (Cont'd)

<u>Product</u>	<u>Quantity Required for NOAA (Scenes/Day)</u>	<u>When Available</u>
5) TM P Tape (HDT) (User Product)	50	A. In July 1983, 12 Scenes/Day With A Priori Jitter Correction B. By April 1984, 12 Scenes/Day Must Be Demonstrated* C. Turn-Over Operational System To NOAA, 50 Scenes/Day in January 1985*
6) TM CCT (A or P) (User Product)	10	A. In July 1983, 2 Scenes/Day B. By April 1984, 2 Scenes/Day Must be Demonstrated C. Turn-Over Operational System to NOAA, 10 Scenes/Day in January 1985*

NOTE Scenes/Day are Defined as Output With a 48-Hour Turn-Around Averaged Over a 10-Day Period.

*Assumes a Thematic Mapper was Launched by July 1983

C

OVERVIEW - REGIONAL & STATE LEVEL REMOTE SENSING APPLICATIONS

Paul M. Wilson (President - Geo Group Incorporated - Berkeley, CA)

Many state and regional agencies, in their quest for tools to assist in their resource management and resource planning activities, have turned to remote sensing techniques. This type of tool is especially effective in western states, where the geographic area of agency responsibility is typically large and the environment is often complex.

Applications have ranged from forestry to agriculture to urban problems such as air pollution, and the number of successful projects has grown significantly every year. Still, however, the potential of remote sensing for state and regional agencies has not been reached. How will these organizations apply remote sensing techniques in the 1980's? And how do we remove the technical and institutional barriers which have limited past applications?

Advances in the technology (new sensors, better resolution, improved processing capabilities), should solve many of the technical barriers which now exist. The ability to capture and use remotely sensed data will be within the reach of almost any agency, and methods of applying this data to specific problems should mature sufficiently so that these techniques reach an operational status in many organizations.

Institutional barriers may prove more idfficult to resolve. In a background of decreased public spending, many state and regional agencies will find it difficult to pay for new capabilities. The applications mix itself may change, as responsibilities for resource management shift from one level of government to another or (in some cases) transfer to the private sector.

Assuming that these barriers are overcome, how will remote sensing tools be used in the 1980's? The conversion of agricultural land to urban uses is one area that has begun to capture increased attention. Another is the environmental effect of increased energy exploration and extraction. A third is water, a growing problem in western states.

Perhaps the most significant use of remote sensing will be its marriage with geographic information systems techniques. Remotely sensed data may be integrated with data from other sources in a framework that can support many applications for many agencies.

D THE ROLE OF THE UNIVERSITY IN APPLICATIONS DEVELOPMENT

Dr. Barry Schrumpf (Director - Environmental Remote Sensing Applications Laboratory (ERSAL), Oregon State University - Corvallis, OR)

During his discussion of the university's role in applications development, Dr. Schrumpf underscored the importance of —

- Planning thoroughly at a project's outset to achieve maximum efficiency of user involvement
- Applied appropriate technology
- Advantages of cost sharing, while noting that "performance counts."

He further emphasized that the university must make changes gradually in programs so as not to leave users of technology behind.

In reference to proposed budget cuts, Dr. Schrumpf pointed out that the user community must look at the problem creatively and seek alternative funding through means such as private sources and licensing programs.

- 1 A Fundamental Research Program to strengthen understanding of basic phenomena and analytical techniques
- 2 Activity in renewable resources planning
- 3 Activity in non-renewable resources
- 4 Effort in planning for the next generation of sensors, data-processing systems and networks among researchers
- 5 Effort toward operational earth remote sensing systems.

SESSION IV

31 MARCH

TUESDAY (PM)

WESTERN REGIONAL REMOTE SENSING CONFERENCE

FORESTRY APPLICATIONS (PARALLEL SESSION)

A COOPERATIVE FORESTRY INVENTORY PROJECT FOR NEVADA

Ronan Thornhill (Forester - Nevada Division of Forestry - Carson City, NV)

The Division of Forestry considers the use of Landsat data for forest inventory projects, a reliable and low cost method which can produce accurate resource data. Landsat data is good by itself for many purposes, but its real value becomes apparent when linked to a Geographical Information System (GIS). A GIS system will link ownership, existing county planning maps, zoning maps, slope, elevation and aspect data together, thus providing the user with a wide variety of inter-related information sources to improve his own. For this project, the Division just touched a few possibilities concerning the combination of a GIS and Landsat inventory with results that were very positive.

The Division considers the training and constant cooperation of the Ames Research Center a vital part of this project. The many hours devoted to the project by a number of ACR personnel added greatly to the high quality results of the effort.

The area chosen for the demonstration project was a very difficult area due to the vast difference in vegetation types of both Douglas County and Carson City. To decrease the amount of misclassification for county-wide projects, the area was divided into three separate ecozones. These three ecozones were then classified after digitizing boundary lines between all three. Ownership data was produced and vegetation classes were tabulated per ownership. Desert vegetation may be easier to classify using the remote sensing techniques of Landsat due to the similarity of brush species, forest types, agricultural areas and riparian vegetation.

The final products of the demonstration project has created much interest among state/federal resource agencies in Nevada. Many agencies can see the potential value of such data for their own purposes. The forest harvestability map, big game habitat map, fire hazard map, plus the land cover map are all types of useable information sources for planners and resource managers.

Future Outlook

Through the efforts of the Governor's Planning Coordinators Office, Division of Forestry and Division of State Lands, a resource group has

has been formed to study the possibility of a new project covering several million acres. Each participating resource agency will assist with their particular data needs for the project. Most of the processing will be handled by the States IBM 360 - VICAR/IBIS software.

The Division of Forestry can foresee the potential use of such resource information being a real value to all planning departments and agencies. It is a low cost alternative which can be updated periodically and has the capability of using all existing data sources as overlays to Landsat base data.

The program has been a benefit for the Division and other agencies cooperating in this initial demonstration project.

Introduction

This pilot forest inventory project describes a use of computerized classification of Landsat data to inventory vegetative types in western Nevada. The pilot study was a cooperative effort between the Department of Conservation & Natural Resources (Division of Forestry & Division of State Lands), the University of Nevada, Reno, and the National Aeronautics & Space Administration (Ames Research Center), during May 1979 through August 1980.

From 1975 through 1980, a growing demand generated by state resource agencies to evaluate and monitor the natural resources under their jurisdiction, a joint project was initiated between the State of Nevada and Ames Research Center (NASA). Through the efforts of the University of Nevada, Reno, Renewable Natural Resources Department, a meeting was held which introduced many state agencies to Landsat computerized data for various resource related projects.

The State of Nevada is in a unique position compared to most other states in the Nation. Approximately 60.8 million acres, 86.3% of Nevada, is under direct management of the federal government. Currently, the management policies and practices concerning this vast resource area are strictly federally controlled with some input by various state resource agencies. Many state resource agencies are interested in acquiring needed resource information concerning Nevada. Through the use of Landsat computerized imagery, the Department of Conservation and Natural Resources hoped to map forest densities of timber types in Carson City (County) and Douglas County, Nevada. The agencies involved are the University of Nevada, Renewable Natural Resource Department.

Accurate and timely resource information is necessary in making the best possible decision concerning Nevada's resources. The possibility of using digital computerized information is one alternative solution. One basic reason for this required information was created through the "Sagebrush Rebellion" issue. The "Sagebrush Rebellion" is actually the nickname of the law effected by the Nevada Legislature 1 July 1979. Essentially, this law lays claim to "unappropriated, vacant and unreserved" lands in Nevada owned by the United States government. These federal lands, primarily administered by the Bureau of Land Management (BLM), comprise a majority of the entire State of Nevada.

Landsat Remote Sensing

The Division of Forestry is interested in demonstrating the feasibility of technologically advanced inventory methods. They are especially interested in the potential benefits of remote sensing for inventorying Pinyon-Juniper forest types. Remote sensing may be generally defined as the observation of objects or scenes without direct contact. Aerial photography has long been used in forest management planning and represents proven remote sensing technology. The Division of Forestry is especially interested in the NASA satellite series, Landsat, as a potential provider of resource inventory information.

Landsat satellite views the earth as a grid network of 1.1 acre data cells (pixels) and therefore, does not see individual trees as with the traditional aerial photographs. In contrast to color aerial photography, Landsat records only two of the colors recorded by color film, red and green. Furthermore, it records two bands of reflected infrared radiation which color film is not sensitive. Landsat data is digital (a series of numbers rather than tones or colors on a photograph), and therefore can be processed by computers. This numerical aspect of the data is the most interesting to the resource agencies.

B PRESENT/FUTURE CALIFORNIA DEPT OF FORESTRY REMOTE SENSING
ACTIVITIES

Nancy Tosta-Miller (Resource Specialist - California Department of
Forestry - Sacramento, CA)

Following completion of the statewide California mosaic two years ago, the California Department of Forestry (CDF), has been involved in several other projects utilizing Landsat data. These include the following —

- 1 Completion of supervised Landsat classifications —
 - Santa Cruz County, involving NASA Ames, CDF and John Brockhaus and Dr. Norman Pillsbury at California State University at San Luis Obispo
 - Humboldt County, involving NASA Ames, CDF and Ken Mayer and Dr. Lawrence Fox of Humboldt State University
 - Nevada, Placer, El Dorado Counties, involving NASA Ames CDF and the US Forest Service
- 2 Utilization of Landsat data as one layer in a Geographic Information System (GIS), in Santa Cruz County, to assess the usefulness of GIS for policy analysis purposes, determination of areas of reforestation potential, and identification of fire hazard areas, involving NASA Ames and CDF.
- 3 Determination of "Prime" timberland in Humboldt County, involving Humboldt State University and CDF.
- 4 Creation of line printer maps from the original unsupervised California mosaic Landsat classification at 1/24,000 (7½') quad scale.
- 5 Installation of VICAR/IBIS software package at the centralized state computing facility in Sacramento, Teale Data Center. (At the present time VICAR, Version 3, will not run on the IBM 370 at Teale, perhaps due to some incompatibilities with an IBM subroutine called SU 9).

As CDF's Landsat work has progressed, many questions have arisen, several of which we have yet to answer. One of these questions deals with classifications. It is one thing to decide before analysis, what the classification system should be. It is a totally different matter to fit the Landsat data to the classification. It is much easier to

fit a classification to Landsat than the other way around. Few classification systems in use are oriented to a remote sensing perspective, that is, the view from above. The question is, what types of classifications can be used to yield the most information from Landsat analysis of large areas, that have ecological meaning about the vegetation on the ground?

A second question deals with data aggregation. In the GIS demonstration, NASA utilized 100 meter square grid cells, representing 1 hectare on the ground. This level of information may be more specific than necessary, to provide data for policy analysis, and a data base built on this cell size for the forest lands of the state would require 16,000,000 cells. However, the question arises as to what results when the data is "smoothed" or aggregated into larger cell sizes, as large as perhaps, a square mile? What limits are put on variance? Are cells labeled based on proportions of types within? Or on the presence of "important" features? Is all specificity lost?

Another question deals with the topic of classification techniques, whether to use a supervised or unsupervised approach. Often a combination is used, but the question is whether to use supervised at all. The literature seems to support the theory that wildland environments, because they are so complex, are best classified using unsupervised techniques, resulting in lower costs and more accurate results. However, the supervised classifications currently underway in Santa Cruz and Humboldt Counties are yielding results of 85-90% accuracy. It appears that extreme care in the selection of training sites and editing of statistics, in addition to a detailed knowledge of the resource types in an area can yield highly accurate classification results. Certain classification routines may be more amenable to the development of supervised statistics than others. However, it also appears possible that a prestratification of the data into ecologically similar types and then performance of an unsupervised classification may yield accurate results. An analysis has not been done to determine cost trade-offs.

None of these questions have stopped CDF from utilizing and realizing the benefits of Landsat data, but before successful implementation of an operational Landsat analysis system, answers are necessary.

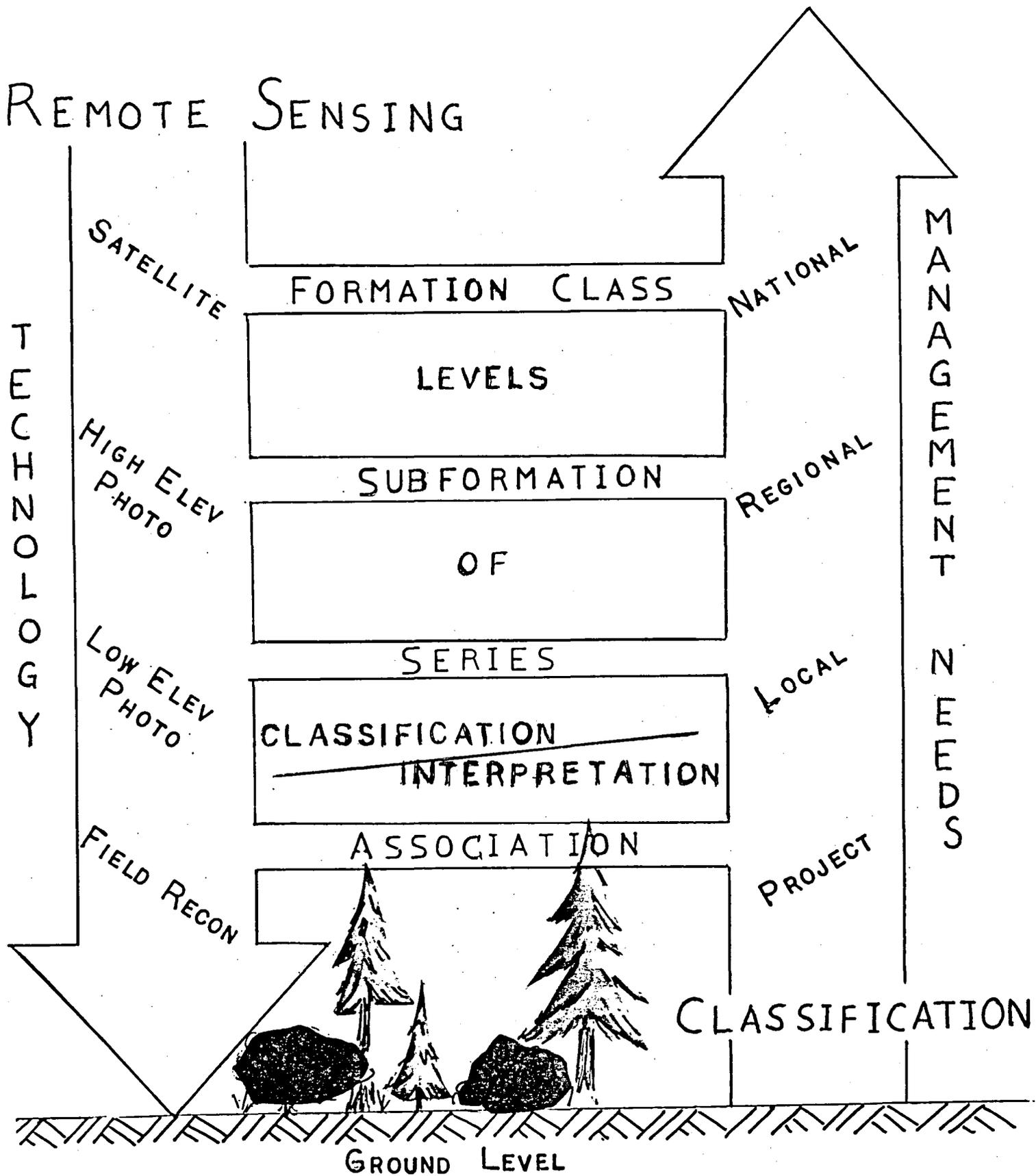


Figure 1 Remote Sensing & Vegetation Classification (Linkage Model)

Discussion

The CALVEG classification system is based on four levels of description. The system is aggregative, that is, the basic unit of description identifies a site specific vegetation community. All other levels of description are aggregates of this basic unit. The following describes these four levels and the application of each level to remote sensing technology for use by resource managers.

Association — The Association is the basic unit and the most detailed level of classification. This level of description identifies three separate vegetation strata and is site specific (on-the-ground). The three identified levels of vegetation stratum are: the tree overstory, shrub understory and herbaceous ground cover. Identification is based upon species dominance (canopy cover) within each stratum. Remote sensing technology can be useful in identification of Associations providing overstory canopy cover is less than 60%. This level of vegetation description is most applicable to field managers and specific resource projects that require on-site description of vegetation.

Series — The Series level of classification identifies the dominant species or group of species. This level of classification is an aggregate of Associations with identical overstory species and different understory species. Series are usually designated by a single dominant species (such as Ponderosa Pine or Greenleaf Manzanita). When two species codominate, a dual species designator is used (Redwood, Douglas Fir or Tanoak-Madrone Series). Remote sensing scales of 1:10,000 to 1:60,000, usually color or color IR photography are most applicable to this level of description. The Series level of classification is most applicable to resource managers planning 50,000 to 1,000,000 acres of land.

Subformation — Subformations are aggregates of physiognomically similar Series. As an example, three or four distinct shrub Series may be aggregated into a "Mixed Montane Shrub" Subformation. The publication "CALVEG - Mosaic of Existing Vegetation of California, 1979, describes existing vegetation based upon this level of description. Satellite imagery at the scales of 1:100,000 to 1:250,000 are most applicable to this level of vegetation identification and interpretation. Both visual interpretation methodology and computer assisted spectral analysis technology are applicable to this level of assessment. Subformations are most useful to resource managers at the statewide planning level.

Formation Class — This level of classification aggregates Subformations into units of similar physiognomy in the broad sense.

Eight Formation Classes have been identified: Conifer Forest-Woodland, Hardwood Forest/Woodland, Chaparral, Soft Chaparral, Sagebrush Shrub, Desert Shrub, Dwarf Scrub (Alpine) and Herbaceous. Remote sensing technology at scales of 1:250,000 to 1:1,000,000 are best suited for interpretation at this level. This level of classification is best suited for national/international classification of vegetation.

A unique feature of the CALVEG classification system is the development of "phases". Phases are additional descriptors assigned to any of the above 4 levels of classification. Herein are identified the various age classes, cover classes, or decadence classes within the existing hierarchy of classification. As an example, one might classify a sapling phase within the Douglas Fir Series, or a moderately dense, overmature phase of the Basin Sagebrush/Squirreltail Association. A complete explanation of phases and the use is contained in "CALVEG - A Classification of Californian Vegetation, 1981.

Application/Testing

The first application of the CALVEG system was development of a statewide map and description of vegetation Series. This endeavor was based on the standard USGS 1:250,000 quad base (42 Quads) and utilized visual interpretation of Landsat imagery of the same scale. Approximately 125 Series were mapped and described for the 102 million acres in California. Accuracy throughout this assessment was maintained at 80 - 90%. This accuracy was based upon approximately 10,000 miles of field verification and referencing of current vegetation maps. The effort required a total of 4 months, including field verification time and cost approximately \$ 0.0040 per acre. This cost equates to about 40¢ per one thousand acres of land area. This level of mapping is presently being used to determine vegetation types within existing ranges of wildlife species on a statewide basis.

A further application of the CALVEG system was development of a statewide vegetation map at a scale of 1:1,000,000. This application utilized the Subformation level of classification, and was derived by aggregating the previously developed, Series maps and vegetation descriptions. Forty one vegetation Subformations were identified, described and mapped. A composite of this mapping endeavor was created and published. This composite map, with corresponding descriptions of each Subformation, is currently being used by many resource agencies throughout California as the basis for statewide assessment of existing vegetation. Agencies include the US Forest Service, State of California - Department of Resources, and the US Fish & Wildlife Service.

Response during the past year fully supports the conclusion that this type of hierarchical classification is fully responsive to application of remote sensing technology and requirements of resource managers.

Economic Use of Remote Sensing Technology

Many applications of remote sensing technology are available. Maps have been compiled, reports developed and plans initiated based upon application of current remote sensing tools. One problem inherent to many of these remote sensing applications has become all too apparent - the lack of statistical verification of assessments utilizing remote sensing (Landsat) technology.

During this period of inflationary costs and reduced budget appropriations, remote sensing technology has found a viable place in economic assessment of natural resources. To fully utilize present and future remote sensing technology, and simultaneously verify any level of assessment, a multi-level strategy of assessment should be initiated. This proposed strategy encompasses two major concerns —

- Economy of assessment procedures
- Statistical verification (Data Elements Expand Capability) within the assessment.

This approach requires on-the-ground review of only a small percentage of the total area being assessed and achieves a considerable cost reduction over total field analysis.

Summary

Multi-level remote sensing is a cost effective tool for assessment of our natural resource base. In order to most effectively utilize the present and future tools of remote sensing technology, a hierarchical classification system for identification of vegetation units is needed. The CALVEG classification system has been developed, tested and determined to be an economically efficient tool for classification of both existing and potential vegetation.

Once the Resource Manager has answered the basic questions concerning what level of vegetation description is required, and how that level of vegetation description can best be communicated to others concerned, the appropriate level of classification is available in the CALVEG classification model.

References

- 1 CALVEG - A classification of Californian Vegetation, Regional Ecology Group, US Forest Service, Department of Agriculture, January 1981.
- 2 CALVEG - Mosaic of Existing Vegetation of California, 1979, Matyas, W.J. and Parker, I., Regional Ecology Group, Forest Service, US Department of Agriculture.

D FIRST DOWN & GOAL TO GO

Gene Little (Deputy Supervisor - Department of Natural Resources -
State of Washington, Olympia, WA)

Introduction

I think it is safe to say that we are in the beginning of a new era in the Landsat Program. The new era is a change from a research and development/demonstration mode to an operational mode. This has been a goal of all people involved in the Landsat Program since its inception in the late 1960's. At last, with our goal nearly at hand, we are now in a crucial phase to insure the development of a successful and operational Landsat Program that provides needed and timely resource information to Managers and Planners. The Landsat program would never have reached this important stage without the pioneering, innovative and tenacious efforts of everyone involved in this program. These years of dedicated effort have not been without confrontation and conflict within our ranks, but this has only served to strengthen our cause which is borne out by the fact that the operational program is at hand. This is an issue we need to learn to cope with.

Now is the time to draw together, assess the situation and outline a joint cooperative strategy for the 1980's to insure success. Today, I would like to touch on three elements: First, highlight past program accomplishments in Washington which have contributed to the present situation. Second, I want to describe this crucial interim phase between the faltering demonstration and the operational system. Finally, I want to suggest a game plan for the 1980s.

Past To Present

Landsat projects conducted cooperatively between NASA and Washington State Agencies during the 1970s, have established the Landsat system as a viable means of collecting and disseminating some types of natural resource information. Resource Managers have long recognized the potential application and benefits of Landsat since even before the launch of the first Earth Resources Technology Satellite in 1972. In the late 1960's, the usefulness of satellite data to state agencies was explored by studying simulated space imagery collected by NASA's high-altitude aircraft. Soon after the actual Landsat data became available in 1972, Washington agencies were ready and in a position to conduct research into its' operational value.

Many Washington State Agencies have been active in demonstration projects that have dealt with a wide variety of resource applications for

Landsat data. NASA and the Pacific Northwest Regional Commission have played an important role in the funding and execution of these projects. Let us review a few examples, by discipline, that will illustrate Washington's interest in making the use of Landsat data an operational reality. These projects have emphasized issues that are regionally important in the area of forestry, agriculture, water resources, land use and wildlife management.

Great strides have been made toward incorporating Landsat data into existing state forestry inventory programs. These forestry projects have focused on determining the level of detail of forest resource information extractable from Landsat, and on how the value of resource data from Landsat might be increased by using other data such as aerial photography, existing computer inventory data and digital terrain data. These studies have also examined how the type of forest resource data from Landsat compares with the type of inventory data currently required for present forest planning and management purposes. Landsat data has also been used to monitor forest harvest activities to supplement information reported to revenue agencies for tax collection purposes. In accomplishing these research/demonstration projects, we have learned a great deal about Landsat's role in the information process and in addition, we have been able to produce some valuable information about our forest resource base.

Land Use Planning

Another discipline in which Washington agencies have conducted Landsat studies, is land use planning. Studies were undertaken to provide local and county planners with land use statistics for comprehensive planning. These studies, have explored how Landsat data can be used with available federal, state and local data sources in a digital geographic multiple use information system concept, and have had a goal of providing planners with new types of information not available from traditional sources.

In addition to forestry and land use investigations, wildlife managers have used Landsat to identify prime wildlife habitats, and Landsat data has been used to aid in the development of optimal water use policy by identifying and monitoring high water demand land uses.

It is difficult to name a resource discipline that has not investigated the potential use of Landsat. I want to emphasize that these projects are research projects. They are not considered operational because Landsat data is not being continually relied upon to direct management decisions. However, they were successful because they demonstrated that Landsat can be relied upon to provide the kind of information we need. What remains is to work out a cost effective way to provide it.

This brings us to today. The interim breather between the old "demonstration" Landsat system and the launch of the operational satellite. The demonstration projects of the 1970's are complete. It is up to us to comprehensively re-assess all of the projects of the last decade and decide —

- What Landsat can do and cannot do
- How the Landsat data needs to be assembled
- How Landsat data can make the program cost effective
- What it could do if constraints on the old research and development system were removed, such as delivery time and format.

The opportunity exists to participate in the design of the operational system. The pathways for communication are open. Those of us who participated in the demonstration projects now need to participate in the design of the institution delivery system and now to the game plan for the 1980s.

Game Plan For The 1980s

I recognize this interim period we are in, is a time of uncertainty because of both funding and political reasons, but I see this as an opportunity. This time should not be squandered. Important issues need to be addressed and resolved regarding the implementation of the operational system. Past demonstration projects should now be reviewed carefully. Enough demonstration projects have been performed to identify consistent patterns emerging from the results. For example, Landsat can reliably provide general Level 1 and Level 2 resource data when used by itself, but this level of information is generally not needed. Additional resource data can be provided at Level 3 or 4 by incorporating other layers of data with skilled resource analysts. This adds considerably to the cost and complexity of the operation. It is, however, such Level 3 and 4 data that is most needed. These costs, the technology and personnel needed, to apply it, could price this kind of Landsat derived information, out of reach for many resource management/planning efforts.

The game plan for the 1980s, then, needs to focus on creating cost-effective Level 3 and 4 information and incorporating the data into existing programs. The way we can overcome the cost constraints is by using Landsat data as layer of geographical information in a geographic information system which many states, such as Texas and Minnesota, are presently developing or have in place. The Washington concept of a GIS is simply a service center that archives and disseminates resource

information. This concept is being proposed because many resource agencies use and need common data such as land use, topography, ownership, legal and political boundaries. When all agencies work cooperatively, the entire process of obtaining and using resource data is made more cost-effective. This is a particularly important consideration in these times of tight budgets. I believe the sponsors of this conference recognize the relationship between cost-effective dissemination/use of Landsat data and geographic information systems as evidenced by the program content of this conference.

We in Washington believe incorporation of Landsat data into a state multiple GIS will increase the potential for success of the operational program. The following points illustrate how incorporating Landsat into a geographic information system will improve the chances of success for an operational system —

- 1 The computer technology is similar. Both GIS and Landsat digital processing operate most effectively on mid-size computers with specialized graphic capability that are dedicated to the application. Such systems are costly for a single agency to acquire and use, but become more justifiable when their utility is expanded from solely an image processing system to the more general geo-processing system. An operational Landsat program can be implemented more cost-efficiently in this context by sharing equipment and costs.
- 2 Landsat data is more useful if combined and used in conjunction with other types of resource data presently required by resource managers. The increased cost and complexity of this kind of image analysis is largely due to traditional image processing systems being optimized to handle images of spectral data. The geographic ancillary data does not usually fit well in this environment, so that the processes of merging it with spectral data and subsequent analysis requires indirect and inefficient analysis. The geographic information system has streamlined these analyses so that by marrying the image system and the GIS, best procedures are provided, thus reducing the complexity of the solution and costs.
- 3 The large cost of entering ancillary data in a Landsat project, is reduced when analysis is performed through a GIS. One of the fundamental ideas in building a shared geographic data base is that much of the resource data is used in identical form by all users of the system. These high priority data layers would be the first entered so they would be

available without delay for future GIS applications, such as Landsat analysis. Most Landsat projects using ancillary data have not had the benefit of such a pre-existing data base so high costs of data entry run up project costs and delay delivery of results. In a properly planned GIS where Landsat is considered only a specialized data layer, the benefits of a GIS can reduce high costs of data entry and increase the timeliness of results.

To summarize these 3 points, the hassles involved with acquiring and using image processing systems, added to the hassles of obtaining and assembling Landsat and ancillary data, combined with the constraints of processing geoinformation in an image processing environment, causes Landsat's unique advantages to be diluted if not eliminated. These 3 problems can be resolved by creation of a GIS system with Landsat subordinated as a data layer. Landsat's advantages, such as synoptic view, will be improved and the reduced time and costs required for each Landsat project could allow more frequent analysis of Landsat's multispectral repetitive coverage. It is these characteristics that make Landsat unique and valuable. It is these characteristics that should be enhanced.

Summary

In conclusion, I want to say that in the State of Washington, we have developed a strategy - a 10 year game plan for transition to the operational system. This game plan is to carefully examine the results of past demonstration projects to identify successful operational applications, take advantage of geographic information systems, and finally, work toward reducing/eliminating constraints of the present system that are inhibiting operational use. We believe we have demonstrated our support of the Landsat program by sending a user representative to NOAA who is working for the next two years with that agency in the development of a user-oriented system. We believe Landsat has great advantages and we are working to make it a reality. We are currently sponsoring GIS legislation in the legislature of our state.

I believe, through dedicated efforts of all participants in the Landsat program, that we have experienced a highly successful research/development and demonstration program and achieved a measure of success toward the implementation of an operational program. All participants are to be congratulated. However, we are presently at a crucial turning point. We need to re-assess our position, be sure emphasis is on the right syllable, figure out how to take advantage of the efforts of the past 8 years, coordinate our efforts so as to enhance Landsat's advantages in a cost-effective manner, then proceed. This will require a different emphasis - a different mode of operation for most of us - one of interdiscipline, interagency, perhaps interstate cooperation - but if we can make the change, Landsat can deliver.

AGRICULTURAL APPLICATIONS (PARALLEL SESSION)

A APPLICATION OF REMOTE SENSING TECHNIQUES FOR IDENTIFICATION OF IRRIGATED CROP LANDS IN ARIZONA

Howard A. Billings (EDP Programmer/Analyst - Department of Water Resources, Phoenix, AZ)

Introduction

The Arizona Department of Water Resources contacted NASA officials in April 1980 to request information on the possibility of using satellite imagery in its effort to identify irrigated acreage for the 1980 Arizona Water Resource Inventory Report. DWR staff and representatives from NASA Ames, formulated a project to demonstrate remote sensing methods of determining irrigated acreage. The Maricopa Water District, lying just west of the Phoenix metropolitan area containing about 30,000 acres of irrigable land, was chosen as a test area. The district was selected because of the availability of reliable historic data and its willingness to provide the necessary ground-truth. In a typical year, about 23,000 acres of cotton, grain, vegetables, citrus and some specialty crops such as roses and nursery trees are irrigated in the district. In most years, cotton has accounted for between 50 and 60% of the acreage under cultivation.

Since all crops except fall lettuce and some miscellaneous crops are under irrigation in April and July, imagery for April and July were obtained in order that a multi-date analysis could be performed.

DWRs input to the demo-project was to establish project goals and to provide appropriate maps, resource information, assemble cropping patterns for the test site. DWR coordinated the program with the irrigation district managers.

Two types of analysis, band ratioing and unsupervised categorization, were chosen to perform the irrigated lands inventory. For both techniques, the irrigation district boundaries and section lines were digitized and calculated and displayed section by section.

Band Ratio

Since vigorous vegetation reflects near infrared light strongly and absorbs red light, a high ratio value is a good indicator of vegetative

cover. A threshold value was chosen by testing several values. The value which yielded results which best correspond with known crop patterns in the test area was utilized to represent an irrigated field. Natural vegetation acreage was excluded by identifying these areas on false color composites on the Landsat scene and confirmed by ground-truth.

Unsupervised Categorization

An unsupervised categorization was done for the April and July 1979 scenes separately and then for the two dates together. The clustered data was categorized and were identified as irrigated or idle and verified by using both ground-truth and false color composites.

The estimates from both techniques were quite close for July irrigated acreage and indicated that about half of the irrigation district was irrigated at that time. The district reported that 21,560 acres were irrigated in 1979. The estimates of April irrigated acreage by unsupervised categorization labeled some of the areas of natural vegetation within the district boundaries which were green in April as irrigated.

The following table shows that both estimation techniques were quite accurate in estimating irrigated acreage in the 1979 growing season.

Maricopa Water District Land Usage

Gross Acreage	34,700
1979 Reported Crop Acreage	23,700
1979 Irrigated Acreage	23,700 - 2,140* = 21,560

Maricopa Water District Land Use Estimates (Band Ratio Analysis)

Gross Acreage	35,969
April 1979 Irrigated Acreage	7,614
July 1979 Irrigated Acreage	15,939
1979 Irrigated Acreage	21,330

Maricopa Water District Land Use Estimates (Unsupervised Categorization Analysis)

Gross Acreage	35,969	
April 1979 Irrigated Acreage	10,412	(Single-Date Analysis)
	8,862	(Multi-Date Analysis)
July 1979 Irrigated Acreage	16,325	(Single-Date Analysis)
	21,399	(Multi-Date Analysis)

NOTE * District roads, ditches, buildings, right-of way

- Task II Estimation/Mapping of irrigated land using digital analyses techniques
- Task III Estimation/Mapping of crop type using manual analyses techniques
- Task IV Estimation/Mapping of crop type using digital analysis techniques

In 1979, a statewide test of the Task I techniques was made. The performance goal of $\pm 5\%$ at the 95% confidence level by each of the state's 10 major hydrologic basins was bettered in all but a few cases. The process used was photointerpretation of enlarged Landsat scenes (1:150,000 scale), adjusting the determined acreage using a regression estimator and ground truth data from 637 sample cells (total population of 6001 cells). Sample cells were allocated to areas stratified on the basis of field size and selected crop types. Interpretation of three dates of imagery was required to span the complete time during which irrigated crops are grown in California. Currently an operations handbook is being prepared which will incorporate modifications in procedures found desirable as a result of this test.

Task I was given the major attention during the projects first period. Now a larger share of time is being spent on the other tasks. For Task II, two major subject areas being addressed involve registration of multi-temporal data and classification procedures. In addition, work has been conducted on rotation of image to north as required for the map product. The Band 7 to Band 5 ratio classification procedure has received the most attention, with a preliminary analysis of a 16-7 $\frac{1}{2}$ minute test area in Sacramento Valley showing good results.

Task III focus principally on small grains identification, with the object of providing DWR with implementable techniques in the very near future. Irrigation of small grains has increased in California. This is an off-season crop which is only partially accounted for in our regular crop surveys.

The principal effort on crop identification is in Task IV. The major focus is on the crop types and/or groups comprising the bulk of the irrigated acreage in the Sacramento Valley, because there are fewer crop categories found here than in the other major agricultural regions of the state.

In summary, Task I has provided techniques for irrigated area estimation that DWR can now implement. Task II requires some refinement and testing. However, the Task II promises to provide DWR with operational techniques in the near future.

C APPLICATIONS OF DIGITAL IMAGE ANALYSIS CAPABILITY IN IDAHO

Kim A. Johnson (Director - Idaho Image Analysis Facility - Idaho
Department of Water Resources - Boise, ID)

The Department of Water Resources is responsible for administration, planning and development of water resources in Idaho. Water is important to Idaho, as it is to all western states. Agriculture, a major industry, is the state's largest water consumer. With 3.9 million acres of irrigated crop, Idaho which is second only to California of the states represented at this conference. The Department does require accurate and timely resource information in order to meet its operational goals. The benefits of Landsat data (potential/realized), have been recognized by the agency.

For the last two years, the Department has been responsible for developing a digital image analysis capability for Idaho. The capability has been established and is being used by several state/federal agencies within Idaho. Our digital image analysis is conducted using two systems. The major portion of our digital analysis is done using VICAR/IBIS which was developed by the Jet Propulsion Laboratory. VICAR/IBIS is a batch oriented software system that is installed on the State Auditor's IBM 370/168 computer. We use the International Imaging System's (I²S) Model 70 display device and System 511 software to conduct interactive display processing. The System 511 and display hardware is interfaced with the Department's DEC PDP 11/34 minicomputer. The PDP 11/34 supports Remote Job Entry to the IBM 370 and online text editing which facilitates the assembly and submitting of VICAR jobs.

Until recently, the task of establishing an image analysis capability has accounted for the majority of our remote sensing activities. Now that such a capability is present, we are changing the main thrust of our efforts from technology development to analysis applications. We are currently addressing a variety of tasks ranging from development-demonstration projects to rapid turn-around resource assessment projects.

An example of a development-demonstration project is the determination of urban land use conversion in Ada and Canyon counties of Idaho. These counties, located in southwestern Idaho, contain 27% (245,000) of the state's population and are experiencing a 4% annual growth rate. These counties contain 434,000 acres of irrigated cropland. Current information indicates that the majority of urban land use expansion occurring in these counties is involving irrigated cropland. This is not a situation unique to Idaho. The loss of agricultural land, principally to urban land use, has been identified nationally as a topic of concern.

The land use change mapping is being done by comparing 1975 and 1980 classified Landsat data for the two counties. The 1975 data were classified by the US Geological Survey Geography Program at NASA Ames Research Center during a previous Landsat Applications Demonstration Project. The 1980 data are being classified using VICAR/IBIS. Both classifications will be registered to a map base for comparison.

Information we hope to gain from the urban change mapping include acreages of change to urban land use, location of land use change and distribution of 1980 land use. These data will support ongoing investigations which are assessing the changing water use and demand for areas of changing land use. The information will be provided to local units of government in both counties.

The Department of Water Resources is conducting a major inventory of irrigated cropland in the Upper and Central Snake River Basins of Idaho. The project, known as the Snake Plain Irrigated Agriculture Inventory, is a cooperative effort involving the Department of Water Resources, the US Geological Survey Water Resources Division and the Water & Power Resources Service. The objective of the project is to produce an irrigated cropland inventory suitable for input, in digital form, for hydrologic groundwater models and to produce an irrigated cropland digital data base for the Snake River Plain. The Geological Survey will be using the inventory results as a component in their Regional Aquifer System Assessment (RASA), project now being conducted for the Snake River Plain, and the Department of Water Resources will use the inventory data for their own modeling efforts and regional water resource planning.

The Snake River Plain Inventory is characterized by those tasks that normally accompany a large area, 6 Landsat scenes, inventory effort including, regional stratification, ground data sampling, repairing bad Landsat data, establishing geometric control, multispectral classification and regression analysis for estimating inventory precision.

The other major task in the inventory project is the establishing of digital irrigation water source-service area data base. The data base will be used in conjunction with the Landsat classification of irrigated cropland. The various ground water models which the inventory results will be applied, require that the irrigation water source, ground water or surface water, be known. If specific surface water irrigation can be identified by diversion, where flows are measured, more precise estimates of irrigated practices and water use may be made. In order to add this dimension to the inventory data, previously existing irrigation source-service area maps showing the service areas of irrigation

districts, canal companies and areas of private (non-organized) surface and ground-water diversions are being converted to a digital data base using the IBIS (Image Based Information System) functions of VICAR/IBIS. These digitized maps are based upon the US Geological Survey 1:100,000 medium scale map series. Over 300 irrigation source-service areas are included in the data base to which Landsat analysis results will also be registered to.

Our work in the Big Lost River Basin is an example of remote sensing applications in its purest form. Unfortunately, remote sensing applications are often defined as a solution looking for a problem. But, in the case of the Big Lost, a problem was presented to us and we were able to quickly and effectively respond, fulfilling the frequent promises we make concerning this technology.

The Big Lost River Basin is an intermountain Basin located in Southern Idaho. The basin is approximately 2500 square miles in size and containing 63,000 acres of irrigated cropland. Both surface water and groundwater irrigation are present. Being a confined basin, there is a significant interplay between the surface and groundwater systems. In the recent past, there has been groundwater irrigation development within the basin. Recently, concern was expressed by surface water irrigators that increasing groundwater pumping was depleting the surface water availability. The Department of Water Resources has initiated an investigation of the Big Lost Basin Hydrologic system.

Early in the investigation, it became apparent that the amount of recent irrigation development in the basin has to be determined. Using data already on hand, we were able to provide a 1975 to 1980 irrigation change determination using Landsat digital data. The area of interest was subset from each Landsat scene and a Band 7/5 ratio was run for each scene. The data was then transformed, using a simple bilinear polynomial so that the ratioed scenes from the two dates could be coarsely registered to each other. Both acreage estimates and a composite multidate image was produced. We estimated that between 1975 and 1990, a total of 3800 acres of new irrigated cropland has been developed in the basin. In addition to the acreage estimates, the multidate image was most effective as it conveyed both the location and relative magnitude of the irrigation expansion that occurred. The analysis work including production of a multidate image and acreage estimates of change was accomplished in a two person-day effort. It is this type of Landsat analysis application that has given us the most satisfaction. We were able to respond rapidly, with an appropriate product, to an immediate information need.

Summary

The Landsat applications I have described, do demonstrate the activities of our Landsat/Remote Sensing Program in Idaho. This program is based upon several years of difficult work to insure that the key components were present to support such applications.

These components include a qualified and knowledgeable staff with an effective and versatile image analysis capability. Other important factors encompass the establishment of an adequate digital data and imagery library and most essentially, support from the resident agency.

URBAN & LAND USE APPLICATIONS (PARALLEL SESSION)

A LAND COVER CLASSIFICATION FOR PUGET SOUND 1974 - 1979

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Introduction

The Pacific Northwest was one of the first areas to be involved in Landsat demonstration projects and in the transfer of digital analysis capability to users. An overview of land cover classification work in the Puget Sound region will be presented here, including a description of the current effort being carried on at the University of Washington cooperatively with local agencies.

Landsat Applications - Puget Sound

Landsat activity in urban and rural land cover applications began in the mid 1970's in the Puget Sound Region. In 1975, NASA, USGS and the Pacific Northwest Regional Commission, began a cooperative Land Resources Inventory Demonstration Project with the Puget Sound Region identified as one of the urban test sites. Local agency personnel were involved in groundtruth collection and digital processing along with NASA and USGS participants. The classification work was initiated in 1975 using Landsat data from a satellite pass on 13 June 1974. This effort used 37 spectral classes which yielded 13 land cover classes.

A new land cover classification was undertaken in 1976 by NASA and USGS, using Landsat data from 23 July 1975, and incorporated 44 spectral clusters which were stratified and associated into 20 land cover classes. NASA also demonstrated the feasibility of spectral signature extension by using the 37 spectral classes from the 1974 Puget Sound work to classify data in adjoining Landsat scenes from the same date. This extended the 1974 land cover classification to Vancouver, BC, Canada and Portland, Oregon. Agency participants received lineprinter and color-coded map products from the 1974 and 1975 classification effort.

Agency use and acceptance of the Landsat products varied, and often depended on perceived accuracy of the Landsat data, and conflicts seen in comparing Landsat data with other land use data. A comprehensive accuracy verification was never done for the 1974 and 1975 Landsat products.

New Land Cover Classification Applications

Succeeding years saw several new applications of the 1974 and 1975 land cover classifications. The University of Washington Remote Sensing Applications Laboratory (UW/RSAL), used the 1975 data in a project to test methods for updating land use information in noise and accident zones around Air Force bases. McChord Air Force Base near Tacoma, Washington, served as a test site. In 1978, Washington State Game Department Biologist, Larry Brewer, contacted UW/RSAL personnel for advice on regional grouse habitat data collection. He was directed to NASA and the 1974 Landsat land cover classification. The Game Department used the extended 1974 land cover classification by reassociating spectral clusters into types useful for grouse habitat. The data was tabulated by management units and stratified by the 2000 foot elevation contour to develop habitat acreage totals.

VICAR/IBIS Software Selected

As technology transfer continued in Washington, the VICAR/IBIS image processing software was selected as the state Landsat data processing system and installed at Washington State University in 1978/1979. In 1979, UW/RSAL personnel underwent VICAR/IBIS training and embarked on a project to introduce the Puget Sound agencies to VICAR/IBIS.

All previous Landsat products for the Puget Sound were transferred in digital form to WSU to start a library of Landsat data tapes. This included raw Landsat data, classified data for 1974 and 1975, and Steve Friedman's work at JPL with Puget Sound Landsat data and census tract data. The local agencies used this data library for applications that included mapping impervious surfaces and vacant lands, tabulating agricultural lands and general land cover associations by census tract. Agency personnel became further acquainted with the complexities of the Landsat land cover data and the problems of accuracy determination.

In 1980, UW/RSAL researchers began a new land cover classification effort for Puget Sound on the VICAR/IBIS system. The best Landsat data available was a scene from 20 July 1979. General goals were to produce land cover classes similar to the 1975 cover classes, to verify the classification statistically, to integrate the 1980 census data with the classification and to attempt general change detection.

Agency personnel from the Puget Sound Region were involved in field checking of training sites. A supervised clustering approach using many of the same training sites from the earlier classification work, was selected. Classification statistics developed from the training

sites were tested and edited using a selection of windows from the Landsat scene. Assignment of 8,949,000 pixels into 71 spectral classes was carried out on the Amdahl 470 V8 at WSU in 23 minutes of CPU time at a cost of \$ 867. Because of disk space limitations, the Landsat scene was split vertically into two files during classification and the classified outputs were mosaiced.

The classified output was viewed on the Stanford Technology Corporation System 500 display in Olympia, Washington, for assignment of spectral clusters into 20 projected land cover classes and for location of stratification boundaries. Stratification into urban, rural and mountain regions was accomplished to improve the overall accuracy of the classification and to provide a more useful definition of some of the spectral clusters.

A general verification of the land cover classification is currently being conducted using a random sample of points, photointerpretation of the points and field checking where necessary. A 3 x 3 matrix of pixels will be used for comparison of the Landsat data to the equivalent area in the photointerpreted map file. Local agency personnel will be involved in accuracy determination for areas of interest within their own jurisdictions.

Following the verification of the classification, the 1980 census tract boundaries will be overlaid on the Landsat data using IBIS routines and land cover will be tabulated by census tract. The use of the 1970 census tract boundaries is planned, to develop land cover data which can be compared to the 1975 Landsat land cover tabulations for general change detection. Agencies participating in the project will receive color products and will have access to the classified Landsat data file on tape at WSU to print land cover maps or to reassociate the spectral classes for other uses.

Future Landsat Technology Applications

Through the Landsat land cover projects for the Puget Sound Region, agency participants are learning the advantages and limitations of Landsat. The process of education of new users continues, but becomes easier as more college graduates have experience with Landsat data. We continue to encourage the use of Landsat for users faced with new land cover data collection problems, usually in the urban fringe and rural areas. Categories of use include regional overview, reassociation of classes for special purposes and the combination of Landsat with other types of data. Future satellite systems will need testing with respect to urban and land use applications, but new types of data can

be well received if we continue a step-by-step approach, building on the existing user community in each region and addressing user-identified problems for which this technology can provide practical realistic solutions.

B UPDATING CENSUS URBAN AREA MAPS WITH LANDSAT DATA

Steven Z. Friedman (Senior Scientist - Jet Propulsion Laboratory -
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Background

Urbanized area (UA), maps have been produced as part of each decennial census since 1950 to provide a precise boundary between the urban and rural populations around large metropolitan areas. The UA boundary, a line enclosing the region of urban settlement, is primarily based on actual census population counts. Its location must be fixed immediately after the census to insure that statistics are published on schedule. The responsibility for locating and verifying the accuracy of the UA boundary rests with the Geography Division of the US Bureau of the Census.

An important precursor to updating an urbanized area boundary is the identification of a fringe of suburban territory to be considered for inclusion within the revised UA. The fringe zone must include all adjacent urbanized lands while minimizing the inclusion of large expanses of rural land. The outer line of this fringe is initially drawn prior to the census based on information other than population counts. When population counts become available, enumeration districts within the fringe zone are analyzed, and are included or excluded from the new UA. Finally, the outer line is modified to reflect these decisions, becoming the boundary of the newly revised urbanized area.

The preliminary mapping of the outer line is accomplished through a series of labor-intensive procedures involving manual analysis of many different source materials. The information must be assembled for preliminary work which begins at least two years prior to the census. Data are obtained in a variety of scales, sizes, formats and dates and include thematic maps, recent aerial photography, as well as political and statistical boundary information. Despite diverse origins, the information must be evaluated in such a manner that each UA is treated in a uniform and consistent manner. In an attempt to accelerate this mapping task, the Bureau of the Census is investigating ways to —

- Reduce the volume of source materials
- Obtain quick access to areas of interest
- Provide timely geographic coverage
- Insure that each UA is treated consistently.

The Census Bureau hopes that remote sensing technology, specifically the analysis of Landsat data, will fill this need.

The Census Bureau's experience with satellite imagery began in 1972 with an investigation into the utility of Landsat data for meeting the needs of developing countries for selected census and demographic purposes. With the success of this project and other work undertaken by the US Geological Survey, the Census Bureau became interested in using remote sensing for outer line delineation. Their initial investigation was based on analysis of Landsat photo-transparencies by means of a density slicer and additive viewer. Then, a follow-on study was formulated to determine if digital processing of Landsat data could be more useful for their purposes. Not being experienced in digital processing, the Geography Division entered into a relationship with NASA to develop an Application System Verification & Transfer (ASVT) project to evaluate potential contributions of Landsat to urbanized area work. Four research organizations cooperated in ASVT research: Goddard Space Flight Center (Borden & Williams, 1977 - Christenson et al, 1977), General Electric Company (1978A - 1978B), Computer Science Corporation (McKinney 1978, McKinney & Stauffer, 1978), and the Jet Propulsion Laboratory (JPL). Research activities conducted at JPL (Davis & Friedman, 1979, Friedman, 1980) are emphasized here.

Research Methodology

Three methodologies for analysis of urban areas were investigated. The simplest was the base level approach where color photographs and line printer maps were manually analyzed to locate the outer line. This approach emulated outer line mapping procedures currently in use at the Census Bureau. It was found that the enhancements alone were sufficient for mapping of geographic settings where abrupt transitions between urban and nonurban lands were present. In areas where suburbs intermingle with rural countryside, a land cover classification was also employed as source material. When these Landsat derived maps were compared to conventionally drawn outer line maps, it was found that the two boundary sets circumscribed the same general area. However, the Landsat products were analyzed in half the time required for mapping with the current technology.

A second approach was based on change detection. A simple image differencing routine was used to depict changes in reflectance values between the two anniversary Landsat scenes. This technique was tested for one urban region over several periods in time (McKinney & Stauffer, 1978). The results were similar to both the conventionally derived outer line and the boundary drawn with the base level approach.

From the base level and change detection research, it became apparent that Landsat offered both advantages and problems for the Geography Division. Positive features include —

- Timely & Expansive Coverage
- Adaptable Scale
- Variety of Formats
- Labor Saving Potential Noted

Evident limitations include —

- Lack of Resolution
- Need for Supporting Cartographic Information
- Possible Climatic Restraints

A wealth of information could be derived from the base-level and change detection approaches. However, these procedures required some amount of judgement on the part of the user in an attempt to standardize the products. It was hoped that with more intensive levels of computer processing, the analysis of Landsat data could require less human interpretation and results would be more consistent from urban area to area.

Geographic Information System Approach to UA Analysis

The use of an information system for Urbanized Area analysts provide the analyst with additional data for making qualified decisions needed for identifying areas of urban land cover and the position of the outer line. Although Landsat imagery alone is useful in mapping urban land, the use of additional data allows the delineation of outer line to be made more efficiently and accurately. For the Urbanized Area ASVT, the Image Based Information System (IBIS), was utilized to integrate Landsat data and other source materials. (IBIS is a subset of the Video Image Communication & Retrieval (VICAR), digital image processing system developed by JPL).

IBIS is a fully automated raster based information system (Bryant & Zobrist, 1977), comprised of a group of general purpose programs which can be organized logically into processing steps to handle complex spatial problems. With IBIS, raster, tabular and graphical data types can be integrated for the analysis of spatial phenomena (Figure 1). Image data, such as Landsat imagery or scanned aerial photographs, in addition to graphical data, such as maps, are utilized as IBIS data sets. Additionally, tabular forms of data, such as population counts, can be entered into IBIS via a table-structured input.

Digital image processing techniques are utilized to perform most data base storage, retrieval and analysis operations. Spatial registration

of image data planes and the removal of distortions related to differing map projections or other spatial aberrations are performed by automated rubber sheeting procedures. Consequently, several image planes may be registered to a common planimetric base for the analysis of geographic phenomena. When combined, these data planes are referred to as the IBIS data base.

Special purpose algorithms have been developed for the overlay, aggregation, and cross-tabulation of data from one image with data from other image planes. These analysis capabilities are further extended by algorithms designed to perform mathematical and logical arithmetic functions. Output products are commonly derived from image data planes and non-image data files. Both pictorial products and tabular listings may be obtained directly from any image data plane, a combination of image data planes, or from a combination of image and non-image data.

The Orlando/Florida Case Study

The population of the Orlando, Florida Standard Metropolitan Statistical Area (SMSA), increased significantly between 1970 and 1975. Consequently, it was expected that a substantial amount of urban area expansion would occur. To determine if any distinguishable features could be detected for locating the optimal position of the outer line, three types of data were integrated —

- Census Tract Boundary Information
- Census Population Statistics
- Thematic Data From Landsat

The derivation of urban expansion information required for this decision involved the completion of 4 processing steps —

- Preparation
- Identification
- Classification
- Data Set Integration (Figure 2)

In the data preparation phase, raw data was read and transformed into a standardized format, and all geometric transformations were effected. As a result, all image data planes were in common registry and could be overlaid during subsequent processing steps. For Landsat data, Computer Compatible Tapes (CCTs) were converted to a standard VICAR image data set format and a study area was extracted and saved for later processing.

To prepare the census data plane, a digitized census tract boundary file was transformed into image space after completion of a spatial rectification routine to insure a precise planimetric fit to the data base.

The identification of urbanized areas from Landsat and the census data required the extraction of particular signature information from the source materials. Spectral signatures for urban and nonurban land were derived from histogram analysis of the Landsat data (Friedman & Angelici, 1979). For census data, the identification of an urbanized area signature involved more complex processing. First, census tracts* within the Orlando SMSA were identified and measurements for each tract were determined. Then, census population data for 1970 were added enabling the derivation of population density levels through the use of a statistical package in IBIS. Finally, decisions were made, categorizing whether each tract had urban status or not based on a population density cutoff of at least 1,000 people per square mile.

After identification of urban signature characteristics, the data planes were classified. For the Landsat data plane, a thematic map depicting urban and non-urban land was produced through a thematic classification of the data based on the spectral signature information derived previously. The census data plane was processed in a similar manner yielding a map of urbanized census tracts based on computed 1980 population density levels.

The determination of urban expansion between 1970 and 1975 required the integration of the census based (1970), and Landsat based (1975) data planes. The process simply involved the addition of the two thematic data planes and an additional census tract boundary data plane for georeference (Figure 3). The resultant thematic map and a tabular listing (Figure 4), reporting urban expansion proved to be quite useful to the Geography Division.

Extended Applications

Data processing should not be limited to the steps outlined previously, for data may be obtained in many diverse formats, and several types of output products may be desired. In another phase of the study, potential areas of urban expansion were mapped for the Seattle/Everett SMSA. The processing steps were similar to those previously outlined, with the exception that 1975 data was obtained from a land cover classification of Landsat data provided by the US Geological Survey (Gaydos & Newland, 1978). The Census Bureau hopes to minimize their data processing load by utilizing all sources of classified Landsat data. As in the Orlando case study, the final maps depicting urban expansion between 1970 & 1975 appeared to be quite useful for locating the position of a new outer line.

The utilization of population density values as measured by census tract can only provide a rough approximation of the urbanized area boundary. The Geography Division must consider other more detailed geographic parameters when determining the urban fringe. In a final application covering the urban megalopolis surrounding Boston, Massachusetts, the actual 1970 urbanized area boundary for 7 individual SMSAs were digitized and converted into image format. This data plane was integrated with Landsat and other census data to indicate areas where urban expansion might have occurred since 1970.

Conclusion

The urban expansion maps and tabular listings generated through the implementation of IBIS are considered to be a significant advancement for UA analysis when compared to products generated from Landsat imagery alone. A geographic reference can be displayed in conjunction with land cover information. In most cases, data obtained from several diverse sources will not need to be analyzed independently as previously required for UA outer line delineation procedures. Furthermore, the outer line update process is now based on a set of procedures which can be repeated for any geographic region, permitting the evaluation of all urban fringe zones in a unified and consistent manner.

Another advantage of the system is the ability to build the data base over a period of time. New data planes obtained from various sources can always be added. Consequently, the development of a dynamic data base is possible. Urban expansion over several periods of time can be monitored, and urban expansion predictions may even become possible in the future.

The Bureau of Census' response to the IBIS methodology for mapping the outer line was favorable —

"The Geography Division considers a geographic information system where the data sources can be integrated by means of graphic screen displays and tabular listings to be a useful addition to their analysis capabilities. Possible system inputs are either land cover or change classification maps overlaid with choroplethic displays of population density. The information system provides a method to synthesize Landsat and other data in an optimum format to enable the user to make quick, reliable decisions with a minimum of interpretation" (Davis & Friedman, 1979)

Continued development of the methodology for mapping the outer line may lead towards implementation of an operational system at the Census Bureau.

* In this example, census tracts are used as units to display rural and urban area. Under actual working conditions, the geographic components of the urban fringe zone would be smaller units such as enumeration districts, block groups and blocks.

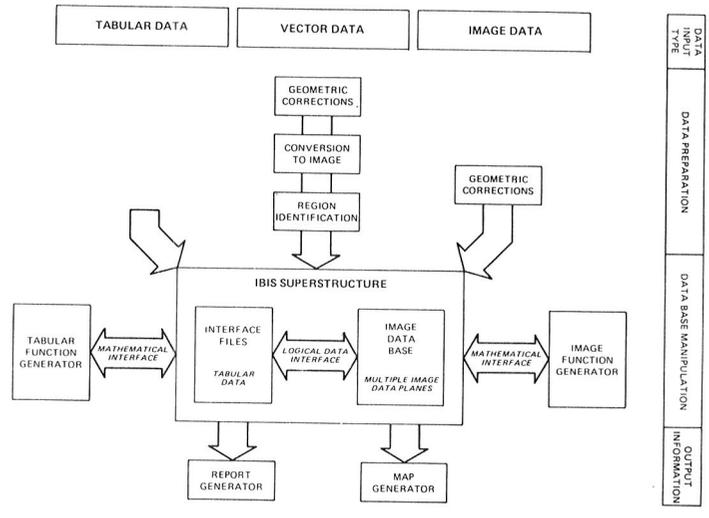


Figure 1 A configuration diagram of Image Based Information System. Major features of IBIS, including data input, data preparation, data base manipulation and data output are depicted.

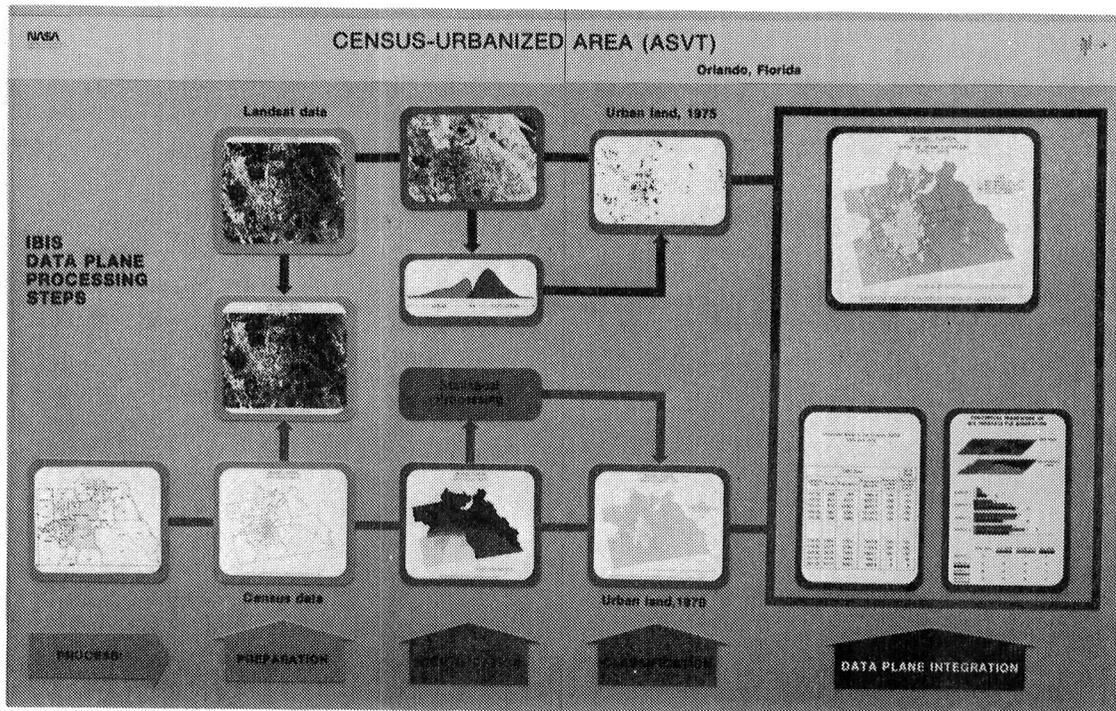
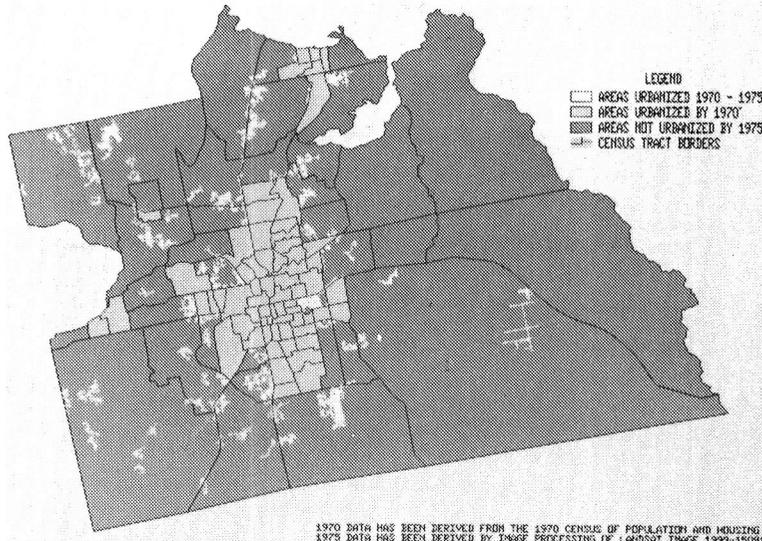


Figure 2 Overview of data processing for the Orlando case study

ORLANDO, FLORIDA
STANDARD METROPOLITAN STATISTICAL AREA
AREAS OF URBAN EXPANSION
1970 - 1975



1970 DATA HAS BEEN DERIVED FROM THE 1970 CENSUS OF POPULATION AND HOUSING
1975 DATA HAS BEEN DERIVED BY IMAGE PROCESSING OF LANDSAT IMAGE 1999-152884

*THE DEFINITION OF AN URBANIZED AREA FOR 1970 CONFORMS TO A STANDARD USED BY THE US BUREAU OF THE CENSUS
STATING THAT AN AREA IS URBANIZED IF THE POPULATION DENSITY IS 5000 PEOPLE PER SQUARE MILE OR GREATER

Figure 3 Integration of 1970 & 1975 data plane results in the depiction of urban area expansion between 1970-1975

URBANIZED LAND COVER STATISTICS FOR THE ORLANDO SMSA
ORLANDO, FLORIDA
1970 AND 1975

1970 STATISTICS BASED ON THE 1970 CENSUS OF POPULATION AND HOUSING
1975 STATISTICS BASED ON URBAN CHANGE DETECTION FROM LANDSAT IMAGERY

CENSUS TRACT NUMBER	TOTAL ACRES OF TRACT	1970 POPULATION STATISTICS		1970 URBANIZED LAND COVER STATISTICS		1975 URBANIZED LAND COVER STATISTICS		URBANIZED LAND COVER CHANGE BETWEEN 1970 AND 1975		
		NUMBERS OF PEOPLE	DENSITY PER MILE SQUARED	ACRES	PCT	ACRES	PCT	ACRES	PCT	MAJOP
102	ALL TRACT	1141155	0	0	0.0	0	0.0	0	0.0	
66	167.00	89141	2224	0	0.0	6	0.0	0	0.0	
91	217.00	64936	2151	0	0.0	0	0.0	0	0.0	
67	147.00	157958	7379	0	0.0	0	0.0	0	0.0	
71	171.00	76679	3917	0	0.0	1493	0.9	1493	100.0	
96	207.00	21553	1637	0	0.0	2406	3.1	2406	100.0	
89	210.00	11893	963	0	0.0	671	3.1	671	100.0	
79	179.00	30379	3533	0	0.0	684	5.6	684	100.0	
70	176.00	24780	3345	0	0.0	2026	6.7	2026	100.0	
92	213.00	27394	3420	0	0.0	1351	5.5	1351	100.0	
78	178.00	30954	4600	0	0.0	0	0.0	0	0.0	
68	166.00	41116	5369	0	0.0	1694	5.6	1694	100.0	
45	146.00	15705	3373	0	0.0	2864	7.0	2864	100.0	
93	214.00	11880	3919	0	0.0	1278	8.1	1278	100.0	
95	208.00	12496	3889	0	0.0	636	10.5	636	100.0	YES
35	135.00	5125	1717	0	0.0	442	8.6	442	100.0	YES
87	206.00	6369	1461	0	0.0	294	6.8	294	100.0	YES
65	165.00	14725	5823	0	0.0	1377	9.0	1377	100.0	
75	175.00	9319	4067	0	0.0	0	0.0	0	0.0	
69	166.00	7620	3909	0	0.0	687	9.3	687	100.0	
49	149.00	5100	2908	0	0.0	739	12.5	739	100.0	
72	174.00	1749	1097	0	0.0	0	0.0	0	0.0	YES
24	124.00	3578	2610	0	0.0	1260	35.3	1260	100.0	
90	211.00	3565	2365	0	0.0	0	0.0	0	0.0	YES
31	131.00	1503	1259	0	0.0	1048	69.7	1048	100.0	YES
103	221.00	4526	3865	0	0.0	726	16.0	726	100.0	YES
47	147.00	3677	3031	0	0.0	662	19.2	662	100.0	YES
50	150.00	5916	4558	0	0.0	146	2.6	146	100.0	
94	215.00	5227	4943	0	0.0	285	5.4	285	100.0	
101	222.00	5617	5693	0	0.0	480	8.7	480	100.0	
77	177.00	2795	1197	0	0.0	42	2.6	42	100.0	
97	217.00	4775	5621	0	0.0	489	10.4	489	100.0	YES
51	151.00	5975	6331	0	0.0	130	2.6	130	100.0	
51	164.00	1172	7127	0	0.0	493	23.7	493	100.0	YES
60	166.00	3943	5371	0	0.0	1374	36.9	1374	100.0	YES
34	136.00	4247	5901	0	0.0	301	7.1	301	100.0	
41	161.00	2946	4765	24.86	106.2	2484	100.0	2484	100.0	
23	123.00	3629	6444	36.29	103.0	3629	100.0	0	0.0	

Figure 4 Portion of Tabular Report containing indicators of potential urban land area expansion for Orlando SMSA

VERIFICATION OF LAND COVER MAPS FROM LANDSAT DATA

David S. Linden & John Szajgin

(Technical Director - Technicolor
Graphics Services - BLM Operations -
Denver, CO)Introduction

The US Geological Survey's EROS Data Center has pioneered the application of cluster sampling to verifying the accuracy of land cover maps derived from digital Landsat data. This approach was applied by Rohde (Rohde 1976), as part of a pilot project in a 65,000 hectare area in the Denali region of Alaska. Analysis of the pilot study data indicated that cluster sampling was an efficient technique for accuracy assessment. Based on this result, variants of the cluster sampling technique have been used in large scale accuracy assessments for areas in excess of one million hectares in Alaska, Oklahoma and Arizona.

Cluster sampling can be an efficient means of sampling in wildland environments. The largest cost incurred in the field effort is traveling to, and locating, the sample pixels. Data collection procedures on the pixel represent a small proportion of the total cost. For this reason, once a specific pixel is found, it is more efficient to collect data from a number of pixels in close proximity, than to travel to, and locate, widely scattered individual pixels. In this way, more pixels are visited with a corresponding decrease in the sampling cost per pixel.

There is, however, a point of diminishing returns. Sampling adjacent pixels yields less information about the overall population than does sampling the same number of spatially separated pixels. This is because adjacent pixels tend to be similar to each other, and redundant information may exist within a sample cluster. The amount of redundant information is related to the statistical parameter rho known as the intra-cluster correlation coefficient (Sukhatme et al., 1970). Rho is a measure of the homogeneity of the population. Values of rho close to 1.0 indicate very small clusters should be used. Rho has averaged about .3 in the accuracy assessments discussed herein.

There are three types of classification errors which may be of interest, commission, omission and overall error classification. Commission errors for a particular cover type occur when pixels are classified as that cover type but are found to be some other cover type when field checked. Omission errors for a particular cover type occur when pixels, field visited and known to be that cover type, are classified as some other cover type. Overall error is the proportion of pixels incorrectly classified, without regard to omission or commission.

Since the classified image represents the sampling frame, sampling for accuracy assessment is designed to estimate commission error. However, the sample can also provide useful estimates of omission and overall error. The appropriate use of a particular paired observation, Landsat classification and corresponding ground classification, enables one to utilize that observation for each of these estimates.

Alaska

The Alaskan accuracy assessment was conducted during the summer of 1979 as part of a cooperative project between EROS and the US Department of Interior's Bureau of Land Management (BLM). The Landsat classification verified, was a Level IV classification of a one million hectare site in the Denali region. The objective of the accuracy assessment was to estimate the commission error at Level IV for each of six resource class strata with a precision of plus or minus 10% at the 90% confidence level (10/90). Overall error as well as individual stratum omission errors were also to be estimated. However, no precision levels were specified for these estimates.

The original sample was designed as a stratified two phase cluster sample. The first phase consisted of the photointerpretation of all allocated clusters using 9" x 9" true color stereo triplets at a scale of 1:3,000. The second phase was on the ground visitation of a subsample of the clusters where a classification was made for each pixel in the cluster. The clusters were to consist of 25 pixels laid out in 5 x 5 square grid. The cluster size of 5 x 5 was selected as being the largest cluster that a field crew could locate and sample within half a day. In order to obtain the required 10/90 precision for each stratum, an independent allocation was made for each. The entire digital image was first gridded into 5 x 5 clusters. For each stratum, clusters were selected with probability proportional to the number of pixels in the cluster classified as the resource class contained in the stratum under allocation. This sample allocation is called probability proportional to cluster size (referred to as PPCS sampling).

PPCS allocation was used to insure that the clusters selected for a given strata would contain as many pixels as possible from that strata while still being statistically sound. The effectiveness of the PPCS allocation is shown in the table below where the number of pixels expected in a randomly selected cluster as estimated by area proportion is compared to the average number actually obtained in the PPCS sample.

<u>Strata</u>	<u>Expected Pixels In Randomly Selected Cluster</u>	<u>Average Pixels In Actual PPCS Sample Clusters</u>
1	0.5	10.3
2	1.6	13.0
3	2.0	9.0
4	7.4	19.0
5	9.3	17.8
6	4.0	16.8

In determining the sample size required to obtain the required precision, the following assumptions were made —

- 1 The classification accuracy was similar to that of the classification developed by Rohde in 1976 (pers. comm.). Therefore, the sample variation found in the accuracy assessment of the 1976 product could be used to determine the sample size required for the product presently under evaluation.
- 2 Personnel could perform the required photointerpretation with a photo-ground correlation of at least .85.
- 3 Lack of suitable weather conditions during the preferred part of the growing season and monetary constraints would only allow aerial photography to be obtained for approximately 150 clusters.
- 4 The availability of personnel would only allow 72 clusters to be sampled in the field.

Based on these assumptions, a precision level of 10/90 could be achieved for each stratum if 24 clusters were photointerpreted, 12 of which were ground visited. This required a total of 144 photo clusters and 72 ground clusters. To allow for inaccessible clusters and other contingencies, 168 prospective clusters were actually allocated and plotted on 1:63,360 scale quadrangle sheets. Black/white stereo triplets at a scale of 1:6,000 were acquired over all the ground clusters to be sampled. The cluster outlines were then plotted on the photos. These photos were used by the field crews to locate the clusters on the ground. Seventy clusters were actually visited.

All 168 clusters were photographed at 1:3,000 scale using true color film. There were 154 acceptable clusters which were interpreted. Preliminary data analysis indicated that the ground and photointerpretations for individual pixels agreed for only 47% of the pixels. Further investigation indicated that the ground data adequately indicated vegetation

association, but was inadequate in determining percent cover. The photo data adequately indicated percent cover while inadequately determining vegetation association. Based on these findings, it was decided that only those clusters with both photo and ground data could be used in the accuracy assessment. A single classification was made for each pixel in the 70 clusters based on both the photo and ground data. The remaining 98 photo clusters were discarded.

It was decided that Level IV was too detailed a classification to be workable. Ground crews had great difficulty in reaching agreement on Level IV calls. Therefore, it was decided that the accuracy of the individual strata as well as overall accuracy would be evaluated at Level III.

The results of the modified design are presented below. The interested reader may refer to Appendix A for a detailed treatment of the statistical formulae used in the analysis.

Level III

STRATA	COMMISSION		OMISSION	
	Percent Correct	Confidence Interval (90%)	Percent Correct	Confidence Interval (90%)
Tall Shrub	15	+ 12	22	+ 19
Low Shrub	70	+ 7	57	+ 3
Woody Tundra	26	+ 9	57	+ 5
All Other	33	+ 12	11	+ 7

Although the first phase of the original design had to be dropped, the effort still provided useful estimates of classification errors. The objective of estimating commission errors plus/minus 10% at the 90% confidence level was nearly met even though half of the planned sample plots could not be used. The stratified PPCS sampling was proved to be an effective means of controlling the sample allocation. However, the statistical formulae and resulting analysis are quite complicated as a glimpse at Appendix A will show. The authors recommend that PPCS sampling only be used when a statistician is available for all phases of the assessment.

Oklahoma

The Oklahoma accuracy assessment was conducted during the early spring of 1980 as part of a cooperative project between EROS and the US Fish & Wildlife Service. The objective of the project was to identify potential

prairie chicken habitat based on cover type information developed from digital Landsat data. The area mapped consisted of 7 subscenes of approximately 8,300 hectares each. Two representative subscenes were chosen to be verified. The objective of the accuracy assessment was to estimate the overall accuracy of the combined subscenes plus/minus 10% at the 90% confidence level. No estimates of individual class commission or omission errors were required.

The subscenes were relatively small and irregular in shape. If clusters were chosen randomly, there was a high probability that selected sample clusters would cross over the subscene boundaries into areas of image fill and therefore, contain no classification data. PPCS sampling was used to minimize the chance of sampling boundary areas while maintaining the unbiasedness of the estimators. Based on the Alaska experience, the desired precision level, and the available resources, a sample size of 30 - 4 pixel x 4 pixel clusters was used.

The entire project area in Oklahoma was readily accessible by automobile. There was an extensive network of roads and fences throughout. The clusters were plotted on 7.5 minute 1:24,000 scale topographic maps. The field crews were able to locate the clusters on the ground by using these maps along with a staff compass and a tape measure. It was not necessary to acquire any aerial photography of the area.

The overall accuracy of the classification was determined to be 86% plus or minus 4.4% at the 90% confidence level. The appropriate statistical formulae can be found in Appendix B. The specified precision level was easily attained.

The PPCS estimators for overall error are unbiased and relatively simple when compared to the PPCS estimators for individual class commission errors which are slightly biased and very complex. The authors do recommend PPCS sampling for estimating overall error.

Arizona

The Arizona accuracy assessment was conducted during the summer of 1980 as part of a cooperative project between EROS and the BLM (Rohde/Miller 1980). The area classified is comprised of 8 Level II cover types. The objective of the accuracy assessment was to evaluate the commission error of each of the 8 cover types within plus/minus 10% at the 90% confidence level.

The sample design was a stratified two-phase cluster sample with equal probabilities of selection within strata. The strata corresponded to the eight Level II resource cover types represented in the classification. The digital image was gridded into mutually exclusive sample clusters. The cluster size used was 5 pixels by 3 pixels. To control the precision of the estimate for each cover type, and to assure frequent occurrence of the cover type of interest within the corresponding stratum, the image was stratified based upon class plurality within the sample clusters. This will be referred to as stratified plurality sampling (SPS). This established the 8 strata and defined the sampling frame. The effectiveness of the SPS allocation is shown in the table below, where the number of pixels of a given class expected in a randomly selected cluster is compared to the average number obtained in the stratified plurality sample.

Strata	Expected Pixels In Randomly Selected Cluster	Average Pixels In Actual SPS Clusters
1	0.1	8.9
2	0.1	11.8
3	2.6	12.4
4	0.1	7.6
5	2.5	14.0
6	9.2	13.3
7	0.1	9.9
8	0.5	9.3

The sample size was determined based on the desired level of precision and confidence, previous experience with the Alaska and Oklahoma accuracy assessments and available resources. Taking these factors into consideration, a sample size of 160 clusters was chosen. Twenty clusters were allocated to each strata. The sample design called for 20 in each strata to be photointerpreted and a subsample of 10 in each strata to be ground visited.

All clusters were plotted into 7.5 minute and 15 minute USGS topographic maps and orthophoto quads. These were used to plot flightlines for acquiring 1:3,000 scale black/white stereo triplets over all the clusters to be ground sampled. The cluster outlines were then plotted onto the photos. These photos were used by the field crews to locate the clusters on the ground.

Due to unusually poor weather and mechanical problems, completion of the photo acquisition over all sample clusters for the first phase of this design was considerably delayed. The photos were recently delivered but

are not yet interpreted. A preliminary data analysis based on the ground data has been completed, using the statistical formulae described in Appendix C. Based on these preliminary results and an expected photo-ground correlation of .8, the specified precision of the estimates should be met. The SPS sampling appears to be as efficient as the PPCS sampling used in Alaska. The authors strongly recommend the SPS approach over the PPCS approach when estimating commission errors for individuals classes. The SPS estimates are unbiased and far less complex than the PPCS estimates. The SPS approach could be applied by anyone well versed in statistics but not necessarily a statistician.

RANGE & WILDLIFE HABITAT APPLICATIONS (PARALLEL SESSION)

A REMOTE SENSING APPLICATIONS FOR RANGE MANAGEMENT

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Background

Ten years ago, there was a lot of speculation as to what the prospects were for the Earth Resources Technology satellite, scheduled for launch in 1972. A few of us in range science, were excited about the possibility of using this new information source for inventorying and monitoring the earth's most extensive renewable natural resource-rangeland.

Some of us had worked with large scale colored infrared aerial photos. We had seen the U2, Apollo and Gemini photographs, but our imagination was not good enough to dream of the prospect of seeing rangeland over the entire world.

During the past decade, there has been a lot of studies on the use of remote sensing for the management of rangeland. What is the status of this technology now? Where are we today? I am going to explore some of the possibilities and indicate where I think we are.

Before doing that, however, what are some of the things that range people do that make remote sensing important to them? The Range Manager or Rancher needs to know how much and what kind of vegetation is available. Additionally, the rancher has to determine this by eyeballing the pastures as he rides through them. Ranch conservation is a guess too. But he usually validates his estimates with some flipflops. It is usually only the researcher or technician doing a formal inventory that sets up an elaborate sampling scheme to determine in a verifiable way, what kinds and amounts of vegetation are growing on the range.

We say that good range management is based on sound ecological principles. Ecologically, the Manager wants to follow the condition and trims of the resource he is managing. Over the past 40 years, many methods for measuring range condition have emerged. They have one common characteristic - to acquire information over time requires that someone visit these sites repeatedly. Since rangelands are those lands that are too dry, too rocky, too shallow or too steep to support cultivated agriculture, range production levels dictate that rangelands are managed with

minimum capital output. However, that should not minimize their importance. We have nearly a billion acres of rangelands in the US alone. They are a primary source of red meat, they support most of our wild-life herds, and they are a source of water and their vegetation literally holds this old world of ours together.

Thus, it is crucial that these multiple-use lands are managed carefully, and for maximum sustained use. It is obvious that remote sensing can play an important role in improving the management of rangelands and consequently in maintaining their vitality.

I want to concentrate on the use of satellite information for range management today. I want to recognize the increased use of color and infrared photographs. For the most part, it is being used as a sampling mode to reduce the cost of acquisition. It can be useful in monitoring range condition in trim as well as in multiple stage sampling approaches. However, trained personnel are needed to handle the interpretation procedures.

When I was at Texas A&M, we set up a low budget procedure for the University of Texas Lands Department. We used 35 millimeter photography for taking 1:6000 scale over test sites within their leases. The procedures proved to be adequate, but they are not being employed. Why? One reason is, they just do not have the staff to do the amount of photoacquisition and interpretation that would be required to implement the procedures for some of the 130 leases covering more than 2.1 million acres. Most land management agencies, including large ranches, do not like to think about setting up new procedures. Actually, they are seeking a source of information, not procedures for collecting more data. I think this has been a problem with the implementation of Landsat data in the range management process.

Many reports document the usefulness of manual interpretative Landsat imagery for rangeland applications. Generally, they indicate that broad soil vegetation landscapes can be mapped about as well manually as they can through computer processing. We used a hierarchal classification scheme to map land use and cover types over a 250 km area, covered primarily by rangeland. Accuracy assessment indicated 81% correct classification for the 18 vegetation types involved. Similar results were reported for a 21 class vegetation map of a district in Northwestern Arizona.

Classification at this level, whether by manual interpretation or by digital analysis, appears to be necessary if any attempt is to be made

to use MSS digital data for quantitative assessment of vegetation conditions. Studies indicate that Landsat MSS-derived green vegetation indexes accurately measure the amounts of green-standing crops. We found these MSS data products to be sensitive to seasonal changes in vegetation and growth conditions. They provided the measurements taken within a uniform vegetation soil system. Other Researchers found it necessary to sample within the vegetation classes to accurately determine standing crop biomass in the California desert conservation area.

Another approach to the use of Landsat MSS data for range management is change detection. We are looking into the possibility of using greenness change within a growing season for monitoring the dynamics of vegetation production.

Probably the most important concept to emerge from the digital analysis of Landsat data is the use of Landsat as a sampling frame for renewable natural resource inventories. Two researchers reported the concept as applied in the Arizona Vegetation Resource Inventory Project at the Arid Lands Conference in LaPaz, Mexico. The project area was located in Northwestern Arizona and encompassed approximately 2.5 million acres. Vegetation of the area ranged from Mojave Desert shrub to coniferous forest. Landsat MSS data and digital terrain data, were used to develop the classification and a data base for the project area. All of the pixels falling within the area were classified, using both control clustering and unsupervised clustering techniques to derive 76 spectrally separate classes. After the computer process had been aggregated to represent some 9 cover classes, post-classification refinement utilized digital terrain data to improve the classification accuracy. By using terrain data, overall accuracy was increased from 54% - 73%. In addition to a vegetation map of the surveyed area, tabular information was produced describing the vegetation and terrain conditions for each type.

These data are on a geo-based reference base, and they can be analyzed quickly to produce information for the planning process, including one identifying zones for specific management activities, two, for discovering areas where conflicts and management practices may occur and three, where management action may complement one another.

The entire project cost 16 cents an acre. Costs associated with accomplishing the detailed mapping in the project were about 7 cents per acre, including the establishment of the digital data base. The cost of producing application overlays was only about six cents per one hundred acres. We are currently working with the BLM in implementing this technology in their soil and inventory vegetation method. We believe that Landsat vegetation information, when merged with soils and digital terrain data, will define their basic sampling unit.

As an added benefit, the resource unit will add a data base that can be easily manipulated to produce information and maps for planning many aspects of their management program.

Summary

In summary, I think we have really determined over the past 10 years, as to how best to use remote sensing in the field of ranch management. We are not necessarily at a point where we can relax. We do, however, have some approaches that appear to be cost effective, statistically verifiable, and useful for more than mapping vegetation only. The geo-based data files derived from using Landsat data as a sampling framework will provide a readily accessible information source for many range related activities.

B COMBINING LANDSAT MSS, AERIAL PHOTOGRAPHS & GROUND MEASUREMENTS
TO ESTIMATE RANGELAND PRODUCTIVITY

Michael J. Gialdini (Sr Member Technical Staff - ESL Incorporated -
Sunnyvale, CA)

Problem

- 1 Produce a vegetation map over 2.2 million acres with detail down to the plant community level.
- 2 Produce estimates of rangeland productivity (pounds of usable forage per acre for cattle), for a 500,000 acre subset of area with a design goal for accuracy and precision of $\pm 20\%$ at the 80% confidence level.

Approach

- 1 Specification of Data Inputs and their contributions
 - Maps of area (ownerships/allotments/pastures)
 - Control extent of processing
 - Basis for summarization of estimation results
 - Landsat data
 - Spectral classification as a stratification for subsequent sampling
 - Basis for map output
 - Digital terrain data
 - Topographic description of spectral classes
 - Large scale aerial photography
 - Sample of spectral classes, photointerpreted for vegetation composition
 - Stratification for selection of ground plots to measure productivity
 - Ground Plots
 - Estimates and measurements of productivity, related through the aerial photography back to the Landsat data.

Data Collection

- Map entry via digitizing and initial Landsat classification carried on in parallel
- All data registered to a 50 meter UTM grid (Zone 12)
- Survey planning model applied to determine the number of samples required to produce the productivity estimates to the specified accuracy and precision ($\pm 20\%$ at .80 probability)
- Samples allocated and selected from Landsat spectral classification, located on USGS 7-1/2 min, quads of the area
- Samples flown with large scale aerial photography (1:750 nominal scale)
- Large scale photography "bin-sort" interpreted to select plots for ground visit
- Large scale photography interpreted in detail to produce species composition estimates
- Ground plots visited and measured for pounds per unit area of usable, available and palatable species using BLM-SVIM methodology

Data Reductions

- Ground plots provided estimates of pounds per acre of forage for cattle, adjusted for utilization and availability
- Ground plot estimates combined with Landsat classes to produce estimates of pounds per acre of forage by class
- Aerial photography interpretations combined with Landsat classes to produce quantitative descriptions of vegetation by class
- Digital terrain data combined with Landsat classes to produce topographical descriptions by class.

Results

1 Vegetation Map

- Quantitative descriptions of the vegetation by Landsat class used to produce vegetation map to the plant community level based on the BLM Arizona Vegetation Framework

2 Productivity Estimates

- Pounds per acre by class combined with digitized pasture and allotment maps to produce pounds per acre by pasture and allotment

3 Application Example

- Productivity estimates by class combined with new data input, identified water sources, to produce a map of all areas at or above a specified level forage per acre within a specified distance of water

4 Comment

- It is currently felt that the major benefit of the program was the development of a geographically-referenced data base that could be exploited further, even though this data base is a residual of the project, i.e., not the original objective.

C REINDEER RANGES INVENTORY IN WESTERN ALASKA

Thomas H. George (Applications Specialist - Northern Remote Sensing
Laboratory - Geophysical Institute - University
of Alaska - Fairbanks, AK)

Introduction

Range surveys using Landsat data have been in progress on the tundra of Northwest Alaska since 1976. The goal of these projects, sponsored by the Soil Conservation Service (SCS), and the Bureau of Land Management (BLM), is to map the range resource and estimate plant productivity of the Seward Peninsula, an area roughly 6.5 million hectares in size.

Information derived from these surveys is needed by SCS to develop range management plans for reindeer herding and for use by BLM to evaluate potential conflicting use between reindeer and caribou.

Background

Reindeer herding has been practiced in Western Alaska since a small herd was introduced from Siberia in the late 1800s. The industry has enjoyed a colorful history involving a dramatic increase in herd size in the 1930s followed by a crash and slow recovery leading to the present population of approximately 30,000 reindeer.

Recent interest by a regional native corporation to increase herd size for commercial production has resulted in the present inventory projects, to provide information for more intensive management.

The proposed expansion of herd size has raised the possibility of conflicting range use between reindeer and the Western Arctic caribou herd, which overwinters near the east edge of the Seward Peninsula. BLM is examining this potential conflict to determine appropriate management procedures of the range resources.

Inventory Process

The large size and remote location of these ranges, coupled with the lack of surface transportation for conventional range survey, caused SCS to explore the use of new tools for inventory. Consequently, the University of Alaska has participated in the inventory program to develop techniques using remote sensing data, primarily computer analysis of Landsat digital data.

As might be expected of developmental projects, the procedures have evolved through time. A brief description of the approach used during the first project and subsequent modifications should help illustrate the present situation and the problems yet to be solved to use Landsat data as a tool for range inventory on the tundra.

1976 Project

Our first project was to inventory 4 ranges on the Northern Seward Peninsula, covering approximately 1.6 million hectares. An unsupervised classification was performed on portions of three Landsat scenes using ESLs IDIMS system. The unsupervised approach was selected since we had no aerial photography or field reference data for the area. Spectral classes defined during the analysis were grouped into tentative resource categories using a COMTOL display and color products produced where each resource category was represented as a discrete color.

During the summer of 1976, a range survey crew took the color products to the field and used them to select sites for data collection on plant species, productivity and soil type. Field data was collected over a period of 4 weeks, using a helicopter for transportation.

That fall, field data was synthesized into range sites by SCS. A qualitative comparison of range sites to spectral categories led to the following conclusion; promising, but far from perfect. Discrepancies were noted in 3 categories —

- Different resource categories with the same spectral response (Eg., open spruce forest/old tundra burns)
- Terrain aspect problems in areas of moderate relief
- Slight classification discrepancies between the 3 different Landsat images analyzed.

We concluded, that these problems were largely recognizable and could be corrected by hand-mapping the area using the Landsat color product as the base and field reference data, to correct the classification errors. Subsequently, in 1977, a hand-drawn map was produced for the 1.6 million hectare area.

1979 Project

Due to a lapse of funding, 2 years passed before the second inventory project was initiated. The 1979 project involved inventory in two

areas totalling 1.4 million hectares. On the Western Seward Peninsula, some NASA high altitude color infrared aerial photography was available. Using this coverage, we interjected some supervision into the pre-field season computer analysis. During the preliminary aggregation of spectral class into resource categories, areas of confusion between upland and lowland tundra types were noted. As before, color products were produced and taken to the field for allocation of data collection sites.

After a short time in the field, we confirmed our earlier observations that a number of different resource categories were occurring in the same Landsat spectral class.

To deal with this problem, we turned to black/white winter Landsat imagery. Winter Landsat imagery shows the ranges in a snow-covered condition, with a low sun elevation angle which greatly enhances topography. We were able to photointerpret physiographic-terrain units from the winter imagery and use them to stratify the survey area. By referring to a Landsat spectral class within a specific physiographic unit, the confusion between resource categories was greatly reduced.

Following the field season, the physiographic map was digitized, superimposed on to the Landsat digital classification and used to stratify the image. Assemblages of terrain units were displayed on the TV monitor and spectral classes reassigned to resource categories. The image was then reconstructed and a new color product generated. (See Figure 1)

The new product was examined and compared to field reference data. While the product was much improved, terrain aspect differences still caused misclassification. In addition, the legend required to use the product was now in matrix form, which was felt to be too complex for use by resource managers. As a result, once again, a hand generated map was produced which simplified the legend and cleaned up aspect-related classification errors.

1980 Project

Based on the experience gained on the first two projects, some dramatic modifications in approach have been made in the current inventory project.

In Spring 1980, we acquired summer and winter Landsat imagery for the present 1.6 million hectare survey. A physiographic terrain unit map was photointerpreted, dividing the area into 27 regions. NASA high-altitude photographic coverage was acquired and sites selected for field reconnaissance within each physiographic unit.



Figure 1 Classified Landsat Image Section

NOTE This product was generated for the 1979 Range Inventory Project. It shows the Landsat classification results after stratification by physiographic terrain unit (White Lines). The spectral classes have been combined on a unit-by-unit basis, and assigned colors (Shades of Gray), to describe resource categories on the ground. As a measure of scale, the tick marks denote corners of 1:63,360 scale USGS Topographic Map Sheets.

During the summer season, a survey crew spent approximately 2 weeks visiting the preselected sites and collecting reconnaissance data. We are now in the process of performing the computer analysis on the Landsat summer data, using a modified clustering approach. We hope to be able to use the field reference data from last summer to make the best possible image classification, and then utilize our physiographic boundaries to stratify the image as needed to separate resource classes. Our goal is to try and produce a computer generated product which is suitable for use without hand mapping. This would allow us to produce computer generated acreage summaries, more fully realizing the benefits of digital data.

Conclusion

While the results of these projects are being used in an operational context, much still needs to be done to successfully establish the use of Landsat data as a tool for tundra range inventory. Two areas that need additional research and development are —

- 1 Image analysis techniques — We have benefited significantly in hardware/software improvements in recent years that allow us to perform more sophisticated analysis procedures over larger sized images. We hope to experiment with the layered classifier and the use of digital terrain data to improve computer classification results.
- 2 Collection of field reference data — The major expense in our inventory projects is field work. Supporting crews in the field and the use of helicopter transportation is very expensive. We need to examine closely what type and how much field data is needed for computer analysis projects. As the sophistication of analysis techniques increases, we need to know more about the relationship of slope, aspect and elevation to the cover types we are attempting to map. What is the cost of this information and can we afford it?

While progress has been slow and much remains to be done, computer analysis of Landsat data is making a positive contribution to our understanding of the tundra range resources.

D

APPLICATION OF LANDSAT MSS TO ELK HABITAT MANAGEMENT

Dr. Barry J. Schrumph (Director - Environmental Remote Sensing Laboratory (ERSAL) - Oregon State University - Corvallis, OR)

The Oregon Department of Fish & Wildlife (ODFW), has utilized information derived from Landsat MSS data to estimate the impact of proposed timber harvests on potential elk use. These evaluations have been conducted in Northeastern Oregon where several herds of Rocky Mountain elk range in the Blue Mountains. The analysis of Landsat data for elk habitat inventory and mapping and associated field sampling was supported by the ODFW, the Environmental Remote Sensing Applications Laboratory (ERSAL), Oregon State University, the Pacific Northwest Regional Commission and the US Forest Service, Pacific Northwest Forest & Range Experiment Station, Range & Wildlife Habitat Laboratory.

Water, forage and cover, i.e., hiding and thermal cover, are the critical components of elk habitat. The animals seek those areas which provide the necessary combination and arrangement of these critical components.

Timber harvesting, more than any other forest management activity, can have profound impact on the quality and quantity of these essential habitat requirements. Harvesting can have both beneficial and deleterious impacts on elk ranges by increasing forage and reducing cover. Forage areas can be created where little exists. In other areas, where potential elk use is already limited by a shortage of cover, timber removal may eliminate vital patches of cover and further reduce the potential of an area to support elk.

The US Department of Agriculture, Agriculture Handbook 553 entitled "Wildlife Habitats in Managed Forests: the Blue Mountains of Oregon and Washington," provide guides for estimating impacts of timber harvesting when amounts of pre-harvest cover and forage areas can be quantified as well as the cover area that will be converted to forage area by the harvest. The Handbook states the optimum cover-forage relationship for elk in the Blue Mountains is 40% in cover and 60% in forage producing areas of proper size and spacing.

Personnel of ODFW and ERSAL utilized Landsat data to inventory and map cover and forage areas on two of the Blue Mountain elk ranges in 1979 and 1980. Since completion of that project, ODFW has initiated the same procedures for approximately seven million additional acres that provide ranges for numerous other elk herds. The inventory, available

on magnetic tape, is a geographically referenced data base regarding land cover types and habitat components (cover/forage). The wildlife biologist can readily access this data base, pull out data for a specified area in the form of a computer printout, overlay the boundaries of the proposed timber harvest areas, calculate the current cover-forage status of the area and the proposed changes in that status, reference the appropriate elk use response curve in the Agriculture Handbook 553 and estimate the extent to which potential elk use will be increased or diminished by the proposed harvest and habitat modifications. The biologist can also use the printout to estimate the size of forage areas to be created and cover areas that will be left intact and make the critically important evaluations of the size and spacing of these areas in relation to optimum elk habitat.

A

THE PACIFIC NORTHWEST STORY

Kim A. Johnson, Dr. Barry Schrupf, Luke (Ted) Krebs (Speakers)

In February 1978, the Pacific Northwest Regional Commission (PNRC), comprised of the Governors of Idaho, Oregon, Washington and a Federal Co-chairman appointed by the President, approved a 3 year effort entitled the "Landsat Applications Program (LAP)", aimed at establishing operational capabilities in the Pacific Northwest to analyze Landsat digital imagery and apply the results to natural resource management programs.

The Commission, Established in 1972, under Title V of the Public Works & Economic Development Act of 1965 for the purpose of initiating, coordinating and implementing programs designed to improve the region's overall economic well-being, had recognized the importance and potential for utilizing Landsat to aid state and local natural resources decision-makers.

In the fall of 1974, the PNRC established the "Land Resources Inventory Task Force" (later changed to "Technology Transfer Task Force") with the charge of investigating the potential application of Landsat technology to state and local problems. The Task Force, with representatives from Idaho, Oregon, Washington and a Project Director, proposed the establishment of the Land Resources Inventory Demonstration Project (LRIDP). The project was designed to demonstrate to state and local agencies, methods for extracting and using information derived from satellite remote sensing technology. The Task Force proposed that state and local agencies obtain assistance from organizations that had the required technical expertise and analytical capability in the remote sensing field. The Task Force requested and received this assistance from the National Aeronautics & Space Administration (NASA) and the US Geological Survey (EROS/Geography Programs). During the LRIDP, the Task Force and its 2 federal partners assembled 45 state and local agencies as participants in 23 individual demonstration projects. These projects were in the discipline areas of forestry, agriculture, rangeland, urban, coastal zone, noxious weeds and surface mining. The results of the LRIDP encouraged the Commission to embark on the Landsat Application Program in 1978 which had as its stated objective . . . "to establish in-state capability for the use and application of Landsat data by state and local agencies in their decision-making and resource management processes." This objective has been achieved by establishing operational analysis facilities in each of the 3 states. Idaho and Washington have installed Landsat digital analysis systems in Boise and Olympia to augment analysis programs already in place within those states. Oregon, meanwhile, has enhanced existing capabilities at Oregon State University in Corvallis. Currently, a number of agencies are conducting operational application projects utilizing the new data analysis facilities and Landsat derived data is now being used by these agencies in their daily operations.

Idaho

Governor John V. Evans issued Executive Order 80-4 on 11 April 1980, establishing an Idaho Image Analysis Facility (IIAF). The facility is operated by the Idaho Department of Water Resources which has been the state's lead agency during the Landsat Application Program. The executive order was the formalization of a long term effort to establish operational Landsat digital analysis capability in the "Gem State". Governor Evans' order provides a framework for insuring management, coordination, maintenance and technical support of the image analysis facility. The Idaho Image Analysis Facility, while housed and maintained by IDWR, is accessible to other state, federal and local agencies and private interests. IDWR will provide the use of this equipment to agencies in conducting Landsat digital analysis projects. The primary components of the Idaho facility are the VICAR/IBIS image analysis software on the State Auditor's IBM 370/168 and an interactive digital image display device - STC Model 70 Display and System 511 software - which operates on IDWR's PDP 11/34 computer. The facility also maintains interpretation equipment for Landsat imagery and aerial photographs.

The establishment of the IIAF is the first step of operational utilization of Landsat data within the state. Faced with very limited budgets and increasing data requirements for improved planning and decision-making, the resource managers and policymakers in Idaho will be demanding a level of production capability from this technology which will far overshadow the efforts to date.

Oregon

Oregon was the only state with an existing Landsat processing capability. The Environmental Remote Sensing Laboratory at Oregon State University was already established with support from the University Affairs Office of NASA. The state, therefore, elected to enhance these facilities as its approach to developing operational use of Landsat and designated ERSAL as the operational facility for Oregon.

ERSAL is not limited to Landsat, but provides a full range of services including — Sample design for resource inventory and map accuracy assessment. Interpretation of large and small scale aerial photographs, analysis of multi-date imagery and geoscience applications of sidelooking radar imagery.

The Landsat analysis software used in PIXSYS, which started from computer programs developed at Purdue University. This software has been significantly expanded and adapted for Oregon's use over the past 10 years by ERSAL's staff.

Washington

Washington State did not start from an established base. Like Idaho, Washington was concerned with establishing an operational capability to service state users in a cost effective way. An analysis of existing state hardware showed that Washington State University had a computer with sufficient capacity to efficiently process Landsat data covering large areas.

The Washington State University Computing Service Center actively sought to be designated the repository of processing capability. The availability of the AMDAHL V-6 offered a new generation computer capable of rapidly processing large amounts of data. The state agencies felt that the addition of interactive image processing equipment would make it possible to effectively work with Landsat data.

The operational capability in Washington consists of VICAR/IBIS software on the AMDAHL V-6 computer in Pullman and an Interactive Image Processing Laboratory (IIPL) on the Capitol Campus in Olympia. The IIPL operated by WSU/CSC contains (Idaho), the STC Model 70 Display and System 511 earth resources processing software which operates on a PDP 11/34 computer. The AMDAHL V-6 is linked to the IIPL via dedicated telephone lines. Discipline expertise comes from within individual agencies or through cooperative agreements among participating agencies.

Operational capability is achieved by melding the capability of established state expertise and equipment with a modest stimulus of new technology. Together, this combination provides an additional tool to those concerned with natural resource planning and management in Washington State.

Participating State/Local Agencies

1 Idaho

- Department of Water Resources
- Division of Economic & Community Affairs
- Department of Fish & Game
- University of Idaho
- Bureau of Mines & Geology

2 Oregon

- Department of Land Conservation & Development
- Oregon State University

- Department of Fish & Wildlife
- Deschutes County
- Department of Environmental Quality
- Department of Water Resources

3 Washington

- City of Tacoma
- Spokane County
- Department of Game
- University of Washington
- Washington State University
- Department of Ecology
- Planning & Community Affairs
- Department of Revenue
- Department of Natural Resources
- Western Washington University

A

GEOGRAPHIC INFORMATION SYSTEMS

ESRI APPLICATIONS OF GIS TECHNOLOGY - MINERAL RESOURCE DEVELOPMENT

William Derrenbacher - Project Manager GIS - Environmental Systems Research Institute (ESRI)

GIS Applications

During the past 3 years, there has been a rapidly increasing demand for GIS applications for large scale regional assessment related to projected and existing mineral resource development. Interest has ranged from locating resources and identifying candidate sites for related industries and settlements to locating and evaluating candidate sites for waste disposal.

ESRI Technology - Geographic Data Bases

Since 1978, ESRI has participated in the creation of geographic data bases for large land areas in the United States and abroad. Some of the efforts have involved a full transfer of ESRI technology including on-site and off-site training in the following —

- Remote Sensing Techniques
- Data Rectification
- Cross-Comparison
- Compositing & Integration
- Automation
- Land Capability/Suitability Analysis
- Computer Display
- Software Applications

Efforts have been conducted at scales ranging from 1:3,000,000 to 1:25,000. In several instances, broad screening was conducted for large areas at a very general scale with more detailed studies subsequently undertaken in promising areas windowed out of the generalized data base. Increasingly, the systems which are being developed are being structured as the spatial framework for the long-term collection, storage, referencing and retrieval of vast amounts of data about large regions. Typically, the reconnaissance data base for a large region is structured at 1:250,000 scale, data bases for smaller areas being structured at 1:25,000, 1:50,000 or 1:63,360. An integrated data base for the coterminous US was implemented at a scale of 1:3,000,000 for two separate efforts.

Most of the data bases have been used for the purpose of assessing natural opportunities and constraints in a region and for evaluating land capability/suitability for specific uses. In some instances, they have subsequently been used to assess the relative impacts of alternative development plans.

B LANDSAT DEMONSTRATION/APPLICATION & GIS INTEGRATION IN
SOUTH CENTRAL ALASKA

Anthony W. Burns (Senior Planner - Municipality of Anchorage -
Anchorage, AK)
William Derrenbacher (Project Manager GIS - Environmental Systems
Research Institute (ESRI) - Redlands, CA)

Introduction

State and local government agencies in Southcentral Alaska, have been conducting an ASVT demonstration project with the assistance of NASA. INTRISCA, or Integrated Resource Inventory for Southcentral Alaska, has been utilizing Landsat digital data to classify land cover in 22,000 sq. miles of this area. While the primary objective of the demonstration project was classifying land cover using digital analysis techniques on the IDIMS system, training, technology transfer and preparation for an operational capability, were also considered high priorities. As such, several subprojects were undertaken that were agency specific. My comments today will address one of those subprojects - Landsat data integration into an automated geographic information system.

Demonstration Test Sites

Automated Geographic Information Systems (AGIS), were developed for two sites in Southcentral Alaska to serve as tests for both the process of integrating classified LANDSAT data into a comprehensive environmental data base and the process of using automated information in land capability/suitability analysis and environmental planning. The two sites, identified as Big Lake and Anchorage Hillside are illustrated on the following map. The Big Lake test site, located approximately 20 miles north of the City of Anchorage, comprises an area of approximately 150 square miles. The Anchorage Hillside test site, lying approximately 5 miles southeast of the central part of the city, extends over an area of some 25 square miles. Both sites evidence variations in topography, vegetation, soils and land use. The environmental resources of the Big Lake site were inventoried, mapped, automated and analyzed as part of an effort carried out under a cooperative NASA/USDA/ADNR study of the 1,600 square mile Willow Subbasin. (Figure 1)

Methodology

An Automated Geographic Information System was developed and applied toward the evaluation of land capability/suitability in the area. It had a spatial resolution of 2½ acres, areal units smaller in extent not being mapped as discrete units. The Big Lake site was windowed out of

of this data bank for purposes of the present study. A parallel data bank with the same data variables and spatial resolution was developed for the Anchorage Hillside test site as part of the present study. As in the case of the Big Lake site, all data was mapped in a form most closely representing their natural configuration. Areal phenomena such as soil and vegetation types were mapped as polygons. Linear phenomena such as roads and streams, were mapped as lines. Small scale phenomena such as excavation sites were mapped as points. Compatible data variables were composited on the same map at the same time as rescaled boundaries were being rectified and redrawn. Four manually drafted mylar sheets, termed map manuscripts, were drawn for each area. These and the data encompassed within them are outlined below —

Map Manuscript 1 Integrated Terrain Unit Map

Slope
Landform Type
General Geology
Economic Geology
Geologic Hazards
Soil Type
Land Use
Vegetation Type

Map Manuscript 2 Surface Hydrology Map

Stream Courses
Watersheds

Map Manuscript 3 Point & Linear Features Map

Natural Lines
 Escarpments
 Fault Lines

Cultural Lines & Points
 Roads & Trails
 Extractive Sites

Map Manuscript 4 Land Status Map

Townships
Ownership

All of the manuscripts, except the Integrated Terrain Unit Maps, were manually delineated and subsequently automated at a scale of 1:63,360. The Integrated Terrain Unit Maps were delineated and automated at the

larger scale 1:37,000 in order to provide optimal representation of the more detailed data variables composited on them. These manuscripts were created through a process which involved spatial integration as well as compositing. In the preparation of these maps, interrelated data variables were cross compared as well as checked against the imagery and basemaps, and, where appropriate, boundary discrepancies were reconciled. The process resulted in the enhancement of the resolution, accuracy and consistency of the original data. The integrated manuscript maps, like all others, were comprised of a series of consecutively numbered units delineated on a mylar sheet registered to a basemap. These were accompanied by code sheets which expressed the attributes of each area by means of numeric codes. In addition, a coded interpretative matrix was developed and automated as a means of expanding one of the data planes in the system.

The mapped data were automated by a process of x, y coordinate digitizing. The automation procedures provided for the accurate capture of the natural form of the mapped data. The computerized data files, comprised of polygons, line segments and points, were used to create a number of plotter drawn maps of the area, as well as to create a parallel set of data files in a grid format. A uniform 1½ acre (80 meter) grid was laid atop each of the automated x, y coordinate data files for each of the sites, and the data values were transferred into and recorded by individual grid cell. Classified Landsat data were similarly formatted and merged into the grid multi-variable files for each of the sites. This additional data plane, land cover, was created through the unsupervised classification of raw Landsat digital values for 80 meter pixels and the spatial transformation and registration of these data on IDIMS. Initially compiled as grid single variable files, these data were plotted and checked for spatial accuracy and registration before being merged into the grid multi-variable files of other data for each of the sites.

Output Products

The automated data banks for each of the sites were initially used to produce a number of maps illustrating basic environmental conditions in their respective areas. Subsequently, they were used to do the following --

- Assess Environmental Opportunities & Constraints
- Evaluate Land Capability/Land Suitability
- Compare Automated Classified Landsat Land Cover Information & Photointerpreted Vegetation Units

With respect to the latter, a variety of simple discrete statistical procedures were applied to the comparison of the data for each site. Numerous computer maps were produced for the land planning efforts conducted near the Big Lake site area, fewer for the Anchorage Hillside site.

The following maps were generated for both sites —

Polygon Plot Maps 1:25,000 Scale

Land Use & Roads
Watersheds & Streams

Grid Electrostatic Maps 1:25,000 Scale

Vegetation
Land Cover (Landsat)
Geologic Hazards
Average Slope
Specific Soil Slope
Soil Drainage
Soil Limitations for Dwellings
Soil Septic Tank Limitations
Land Capability for Large Lot Residential
Development

Applications

The demonstration project has two important but distinct applications. At the Big Lake site, where land cover has been previously mapped via conventional ground surveys and aerial photographic interpretation, Landsat is being tested for its accuracy in mapping relatively small areas. A successful statistical correlation between the two land cover data sets will mean that the State of Alaska could, with some projected certainty, use Landsat in an operational capacity to classify the remaining 104 million acres it is receiving under the Statehood Acts and for its stateland disposal program (Figure 2).

At the Anchorage Hillside site, another objective is planned. The Municipality of Anchorage is conducting a Hillside Wastewater Disposal Plan to identify on-site and alternative wastewater treatment and disposal techniques. The integration of land cover information derived from Landsat digital data with collateral data (soils, geology, slope, drainage, landform and land use), is being used in a GIS to produce integrated terrain unit maps and models to identify septic tanks suitability/capability. The results of this demonstration will be compared with those of a concurrent study being conducted using manual techniques.

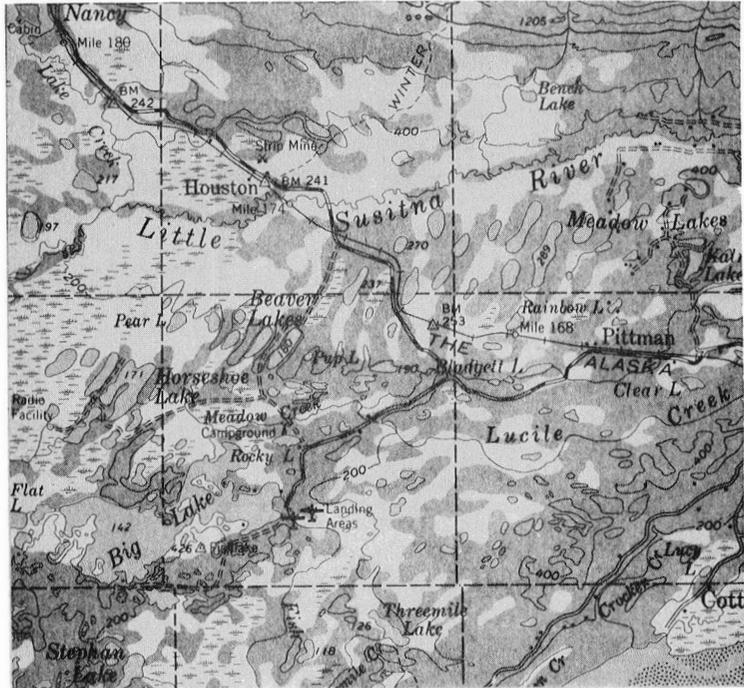


Figure 1 NASA/USDA/ADNR Study of Willow Subbasin

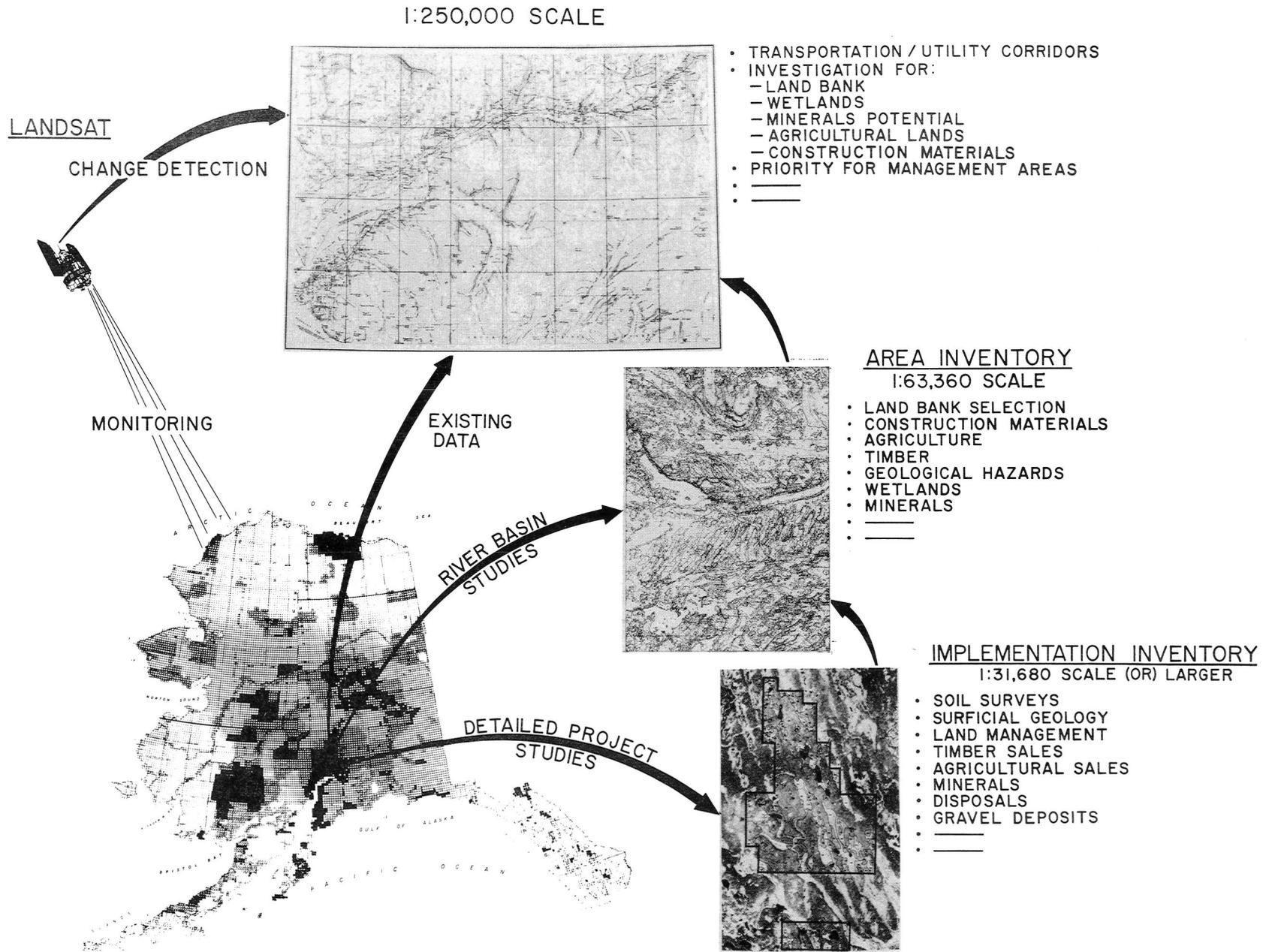


Figure 2 State Land Resource Inventory

D DESIGN & IMPLEMENTATION OF COUNTYWIDE GIS FOR ORANGE
 COUNTY, CALIFORNIA

Thomas Tousignant (Manager - Forecast & Analysis Center - County
 Administrative Office - Orange County -
 Santa Ana, CA)

Two groups within Orange County currently deal with computerized geographic information: the Forecast & Analysis Center (FAC), of the County Administrative Office which uses its system to perform spatial, urban and social research and for planning purposes - the Computer Services Division (CSD) of the Environmental Management Agency which uses its system to support the requirements of engineers and surveyors.

The FAC has built its system over the past 12 years. It has undergone two major reprogramming efforts and currently exists in relatively independent modules on 4 different computers. Different modules support different geographic levels of statistical units and deal primarily with record information and reports. Computer plotting capabilities exist through utilization of a 5th computer and the CSD graphic work station. With increasing frequency, we find that we need to communicate information from one module to another. This is increasing our overhead substantially due to travel time and emulation of tape formats between computers.

The CSD has attempted to develop a parcel level data base for a total of 7 years since they obtained their computer graphics system. They first developed their own software then obtained another system from within public domain and subsequently made major revisions in data formats 3 times. They have currently ceased attempting to create the data base. The hardware is primarily being utilized for graphics.

The FAC and CSD are jointly evaluating geographic information systems at this time. We are soliciting presentations by major GIS vendors for the purpose of stimulating interest among senior level staff and systems analysts. The presentations to date, have been well attended by personnel from many departments and groups which utilize geographic information. These include — assessor, sheriff, fire, registration and elections, facilities planning, recorder, advance planning, environmental services, current planning, building, surveyor, road and flood control, and recreation and open space.

As part of the county administrative office, the FAC has a corporate responsibility to see that the needs of each of these departments and

groups are met. The 7 groups from advance planning through recreation and open space, are a portion of the Environmental Management Agency, and as such, their needs are to be provided for through CSD.

In the past year, Orange County has developed two substantial new GIS data bases: a countywide land cover survey and the Master Environmental Assessment (MEA). The land cover survey was developed in a cooperative effort between Southern California Edison Company and FAC in preparation for the analysis of the 1980 census. The MEA was developed by the Environmental Services Division of the MEA to improve the efficiency and comprehensiveness of the environmental impact analysis process within unincorporated Orange County.

As a deliverable, we have installed the programs required to manipulate and display the data bases with a time sharing computer vendor used in common by FAC and CSD. Both of us have a significant interest in obtaining a GIS that will provide the capabilities of maintenance, update, display and analysis of these data bases in conjunction with other independently developed data bases. The FAC is also looking toward a consolidation of its dispersed modular spatial information systems and data bases.

A needs study is in progress. It will be quickly followed by an RFP and selection of one or potentially more off the shelf GIS to be implemented on County-specified hardware.

SESSION V

1 APRIL

WEDNESDAY (AM)

WESTERN REGIONAL REMOTE SENSING CONFERENCE

SOFTWARE IMPLEMENTATION

A IMAGE DISPLAY SYSTEM 511

Mark Gross (Water Resource Analyst - Department of Water Resources - Remote Sensing Unit - Boise, ID)

If you should venture to Idaho, and find yourself at the Idaho Department of Water Resources (IDWR), Remote Sensing Unit, you stand a good chance of hearing one of our senior management personnel say "you now only have to press the button, and presto, displayed in living color, an image that formerly took weeks to hand color."² This is the current introduction to International Imaging System's (I²S), display device and software that a visitor at our site will receive. It is with pleasure, that I would like to relate to you some of our experiences with bringing System 511 on line at IDWR. Certainly our joys and suffering bear sharing with those who may be considering embarking on a similar endeavor.

Functionally, System 500 is the software package designed to drive I²S's Model 70 digital display device. System 500, according to I²S, is fully supported on 3 minicomputer systems. System 501 is based on the Hewlett-Packard 1000, System 520 on the Data General Eclipse. System 511, to which all further comments shall be addressed, is the I²S version of System 500 designed to run on a Digital Equipment Corporation (DEC) PDP 11 Series minicomputer. It is fully compatible with the DEC operating system as delivered. According to the manufacture's specifications, the minimum system hardware configuration is an 11/34 with a minimum core of 128K word, 10 megabytes of direct access disk and a floating point processor. Required software configuration is RSX 11M V 3.2 operating system with a FORTRAN 4 plus compiler.

The structure of System 511 is a series of hierarchical modular software units. At the highest level, the user has available stand along hardware diagnostic interpreter and file manipulation routines, in addition to the interactive display software, the heart of System 511. The user communicates with the command interpreter, a string processor that interpretes command line syntax, and processes parameter requests. Command interpreter passes control to the application's program, which accomplishes image processing manipulations by utilizing a series of primitives. The primitives use a series of utilities and interface routines to properly set up the Model 70 display device sub-units. At the lowest level, data I/O is handled by device drivers. Both overall program control and data are passed through an 8K resident common block. (Figure 1). Included with the distribution is complete source code for all levels, to enable the user access for system support and maintenance.

The display system hardware/software, configuration settled on was that which was thought to be most amenable to IDWR's current image processing and overall data processing activities, with an eye for minimizing costs and maximizing the use of existing hardware. In committing to System 511, it was recognized that the current version (2.1), contained many deficiencies that would severely limit its application use. I²S indicated that an updated version that would correct many of these deficiencies would be available by the time we were ready to go on line in the spring of 1980. However, Version 2.2 of System 511, was not available until February, 1981, at an update charge of \$ 750. At this time, e.g., this writing, we were operating with Version 2.1 of System 511. It is our understanding that some of the deficiencies discussed in this report, have been corrected in Version 2.2. The extent of the correction is not known.

IDWR operates a DEC PDP 11/34 minicomputer in a multi-user environment, primarily for data entry and as a Remote Job Entry (RJE), station to the state's IBM 370/168. This is the operating environment to which we introduced System 511. The influence of environment on behavior is a consideration that cannot be overlooked when evaluating our experiences. While a well experienced data processing service organization could handle the installation of System 511 in short order, it was IDWR's fate to be without systems programming support at installation time. The installation of System 511 software, due to the forementioned lack of systems programmer support, provided the Remote Sensing Section with an excellent opportunity to become thoroughly familiar with DEC utilities and the operating system. This was our choice because I²S stated that systems installation was straight-forward and required no special training. On site installation by I²S is available for a fee.

Software distribution was in the form of tapes. A master indirect command file queries for system-specific configuration information, then proceeds to build System 511. The installation documentation was limited to the indirect command file which is liberally commented. This approach is straight forward, however, nowhere in the installation, or any other documentation will be found a list of all the DEC utilities required, or the system options that must be enabled via systems generation (a time consuming process in itself), prior to installation of System 511. As a result, it took the Remote Sensing Section, several evenings to sort out the what, where, and how's of the installation. I²S was very supportive at this stage with answers over the telephone.

After System 511 had been contracted, I²S offered a 1 week software training course, I²S recommended that attendees be as familiar as possible with DEC's RSX 11M operating system. The Department's Data Processing Manager and 2 applications programmers attended the course. Due

to personnel turnover, none of these attendees is currently available for direct comment, hence my remarks concerning the training are second-hand, as I did not attend the course. Dissappointment was expressed that the DEC environment was not addressed, as we had been led to believe it would be. A major difficulty with the course was that the full perspective of the hardware/software interaction was not adequately addressed. The course began at the lowest level, examining bit settings. Then the course boot-strapped it's way up through the levels of System 511 to applications design with limited hands on experience. Without a precise foreknowledge of the Model 70's hardware and System 511 software functions, the benefits of this approach were largely lost. The I²S software training course is designed for an attendee who is a programmer experienced in writing image display programs.

As a result of the lack of formal software training, our inhouse System 511 training has been limited to what could be gleaned from the documentation. As a result, we have leaned on it rather heavily. Documentation from I²S consists of a series of brief volumes dealing with the display device hardware and System 511 software. Our perception of the hardware documentation is that it is complete, if not exceptionally readable. The user guide documentation for System 511 and the Diagnostic Interpreter, is adequate, but could certainly be improved. The user guide did have some verification and typographical errors that became apparent during system use. It is the applications programmer who is left holding the bag, the only documentation being the comments in source listing; there is no other. In addition, there is no error documentation.

It becomes readily apparent that I²S fully expects the burden of software support to fall on the user, who is expected to be prepared to provide, or have access to, fully qualified system and applications programming support.

Software support from I²S has been to date, limited by two factors. First, the time factor to access the appropriate person to direct questions to can be days. Once connected though, explicit, intelligent questions get concise, thoughtful answers. No fault there, however, the difficulty in specifically identifying the source of a problem is a limitation imposed by I²S operating under the premise that the user will provide a high level of system-programmer support.

Error situations that occur during the operation of System 511, at IDWR, have fallen in three categories (in order of frequency), user induced, documentational and System 511. System 511 is characterized by error messages that are at the systems-support level, not user oriented. The

combination of poor error reporting and deficient or non-existent documentation complicates the process of determining the source of a problem. A person not familiar with the DEC operating system cannot successfully operate System 511, because of the lack of graceful error recovery and user level error reporting.

With a properly prepared display program, System 511 as delivered, is a very effective sales tool for digital image processing. Presentations on image analysis become more forceful and effective with the capability of rapidly displaying and changing video images, instead of pointing to the tired old hand colored computer printouts. Display capability adds an air of timeliness and a gee-whiz factor that is very effective and compelling.

When System 511 is not being utilized to demonstrate image processing capabilities to department visitors, System 511 does work well as a display system to augment IDWR's image processing capabilities with VICAR/IBIS. When used correctly, System 511 performs the display functions smoothly. However, those functions fall far short of utilizing the full capabilities of the display device. Having worked with other interactive display systems, it is easy to forget the primary display design characteristics of System 511 and expect performance along the line of a larger system. It was our erroneous assumption to expect that when extra hardware features were ordered, you would also get complete software that could utilize the full range of the extended capabilities.

System 511 was not acquired as a "turn-key" system. It is our feeling that many of the short falls of System 511 could be overcome by the presence of a fully experienced, well qualified system programmer, fully knowledgeable on a DEC operating system. It was never explicitly stated, but we feel that I²S expects the System 511 user to provide support at this level, and the burden of application program support and development rests with the user. Should you be prepared to provide this level of support, System 511 contains what appears to be an excellent foundation on which to build a very powerful applications tool.

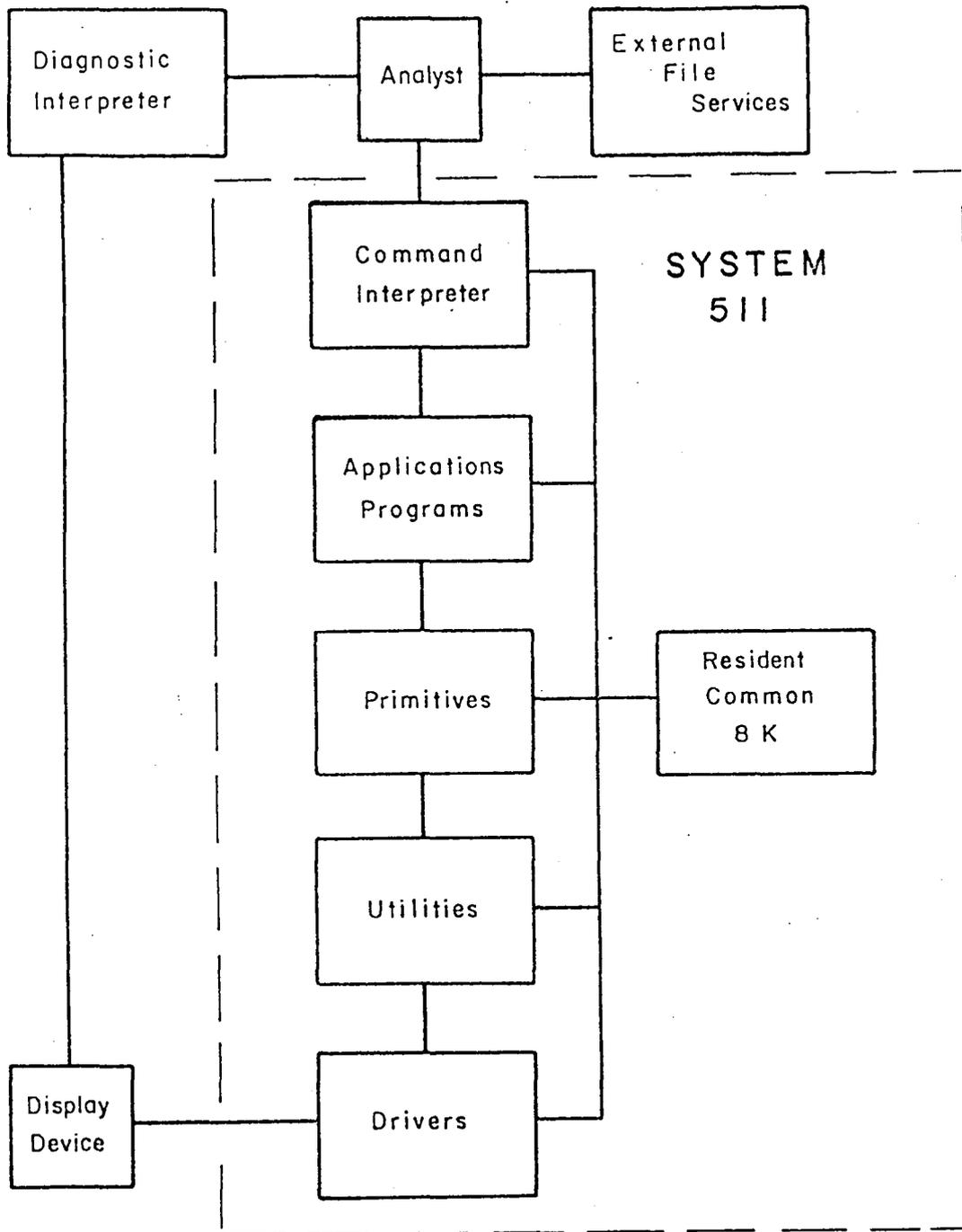


Figure 1 System 511 Software Hierarchy Implemented by IDWR On Digital PDP 11/24

B INTERACTIVE DIGITAL IMAGE MANIPULATION SYSTEM (IDIMS)

Michael D. Fleming (Senior Data Analyst - Systems Manager - US Geological Survey - EROS Field Office - Anchorage, AK)

The purpose of this paper is to address the experiences related to implementing IDIMS and describing some of the capabilities and attributes of the system and vendor support.

An IDIMS (Interactive Digital Image Manipulation System) was installed in the Data Analysis Laboratory (DAL) at the US Geological Survey/Earth Resource Observation System Field Office (EROS), in Anchorage, Alaska, in March 1980. The DAL provides digital image manipulation and analysis capabilities to support training for and operational inventories of Federal, State and local government agencies. IDIMS was selected to provide a variety of capabilities for digital analysis and image enhancements of Landsat Multispectral Scanner (MSS) data, including land cover mapping. However, the system can be and is used to manipulate and analyze all types of gridded data, either singularly or in combinations. IDIMS, using a combination of individual software functions and the flexibility of the Hewlett-Packard (HP) 3000 Series III minicomputer, provides a wide range of system configurations. Data can be input in raster format from computer compatible tapes (CCT's) and from point, line and polygon data which is digitized and converted to raster format on the system. Once into the system, any raster data set can be radiometrically enhanced, spatially enhanced, spectrally and geometrically corrected, rescaled and registered to a map base or another data set. Statistical descriptions can be developed for multispectral processing of the data, this is mainly used to obtain land cover information. Stratification and classification summaries of this information can be produced. Final products are output on a digital display, film recorder, line printer, printer/plotter or CCT.

IDIMS was acquired from Electromagnetic Systems Laboratories, Incorporated (ESL) of Sunnyvale, California, as a complete, stand alone digital image processing system. Purchased by the US Geological Survey for installation in Anchorage, the total cost for hardware, software and installation was slightly over \$ 500,000. This included setting up and testing the hardware in Sunnyvale, shipment to Alaska, installation and testing of the entire system.

The major problem with getting the computer system running was not installing the computer, but preparing the site. Site preparation was planned, computer flooring was built, isolated power supply was installed

and an air conditioning system installed. The components arrived on a Friday, were hand carried up three flights of stairs (no elevator), uncrated and bolted together. Over the weekend, the system was allowed to dry out and adjust to the environment. On Monday morning, the three man installation team started installing the software. On Thursday, the final acceptance tests were completed and the required forms signed. Less than 1 week was required to install and test the entire system.

There were no difficulties encountered during installation, because of the experience of the installation team and ESL's procedure of setting up and testing the system before shipment to the installation site. Since the installation, however, there has been a problem with the disc drive units, caused by radio frequency interference from a concentration of TV and FM stations near the office in downtown Anchorage. This problem was eliminated by shielding the computer room with a wire screen.

ESL provides training for application, support and system users at ESL or on-site. Users, if they meet prerequisites, may also obtain training at government sites - NASA Ames, NASA Goddard, Water & Power Resources Service (WPRS) (formally Bureau of Reclamation), EROS Data Center and EROS Field Office. The courses currently offered by ESL are — IDIMS Introduction (5 days), IDIMS Image Analyst - Reconnaissance (5 Days), IDIMS Image Analyst - Earth Resources (5 days), IDIMS Application Programmer - HP 3000 (5 days), IDIMS Application Programmer - HP 21MX (5 days), IDIMS System Programmer (5 days), IDIMS System Manager (5 days), and IDIMS Advanced System Manager (3 days).

ESL provides IDIMS users with an extensive set of manuals. They include: Users Manuals for IDIMS, Geographic Entry System (GES) and Earth Resources Information (ERIS) System; system management manuals for the overall system and for the Advanced Scientific Array Processor (ASAP), and programming manuals for the system, applications and ASAP. The manuals are updated by ESL as discrepancies are reported and as new releases are available. Currently, many of the manuals are being revised and reprinted.

ESL provides several levels of support for IDIMS. The Alaska EROS Field Office has contracts with HP for support of all HP hardware, HP software and a contract with ESL to provide hardware/software support for ASAP and software support for IDIMS. A minimal amount of hardware support has been needed from both HP and ESL, with a strong willingness from both to correct problems as they occur. ESL provides several types of support for their software system including: fixes, enhancements and upgrades to standard IDIMS software and firmware; assembling, testing and distribution of new software releases; updates and revisions to

documentation and sponsorship of the IDIMS User's Group. Two release tapes of fixes and enhancements with documentation updates have been received since installation, giving improved capabilities.

The major strength of the software is its flexibility. With over 300 functions which can be combined in a variety of ways, almost any digital image processing requirement can be accomplished. However, this requires a well-trained and sophisticated user and in some ways, may be considered a weakness. But a novice, with some preliminary training and reference to the manuals, can accomplish most projects. The flexibility to utilize a variety of peripherals, both in terms of manufacturer and models, is incorporated into much of the software. With a few exceptions, the software functions of the system operate independently of hardware peripherals. These special peripherals are handled as subsystems with special drivers, so if hardware is modified, only the drivers need to be changed.

Summary

IDIMS provides a complete image geoprocessing capabilities for raster-formatted data in a self contained system. ESL can install in a relatively short period of time, both hardware/software and provide a substantial amount of support once the facility is operational. ESL spends a considerable amount of effort to upgrade and fix problems with the software and attempts to keep the system state of the art, both in terms of the hardware and the software.

C VIDEO INFORMATION COMMUNICATION & RETRIEVAL/IMAGE
BASED INFORMATION SYSTEM (VICAR/IBIS)

David B. Wherry (Image Processing Manager - Washington State University - Pullman, WA)

Introduction

Washington State University Computing Service Center (WSUCSC), serves a network of public agency users throughout the State of Washington, the Pacific Northwest region, and other parts of the nation. At the Center, we offer a wide variety of software services to our user community. In 1978, the Computing Service Center became interested in image processing technology and with partial funding from the Pacific Northwest Regional Commission (PNRC), and support from the National Aeronautics & Space Administration (NASA), the VICAR/IBIS digital image processing system was acquired and installed. This paper reports on WSUCSC's experience with acquisition, operation and planning stages of VICAR/IBIS implementation. While we recognize that a service center computing environment is in some respect distinct when compared to the non-user oriented facility, we believe that many of our experiences are applicable in other computing situations where VICAR/IBIS is being considered.

System Overview

The VICAR image processing system has been under development at Jet Propulsion Laboratory (JPL), since the late 1960s. Initially designed as an enhancement tool for data from unmanned interplanetary space missions, the system has since been applied to many diverse aspects of digital image analysis including earth resource and biomedical research. In addition to highly flexible image processing capabilities, VICAR supports a set of geographic information system functions called the Image Based Information System (IBIS). Based on enhanced information retrieval capabilities, the resulting VICAR/IBIS software package is uniquely powerful among other raster processing systems. Although functionally quite strong, serious weaknesses have been identified at the operational levels of system support and maintenance. These shortcomings will be described throughout the paper with references to WSUCSC's responses to problematic experiences and future plans and recommendations.

In overview, the VICAR/IBIS software configuration (Figure 1), supports 4 major components which include —

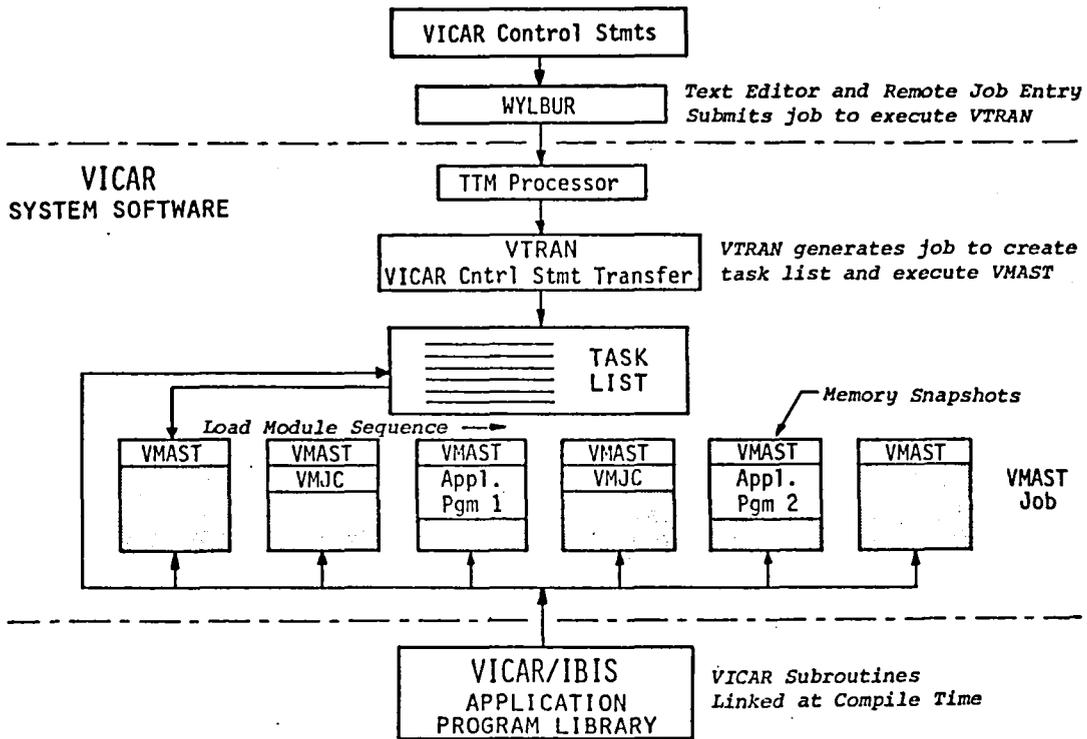


Figure 1 Generalized VICAR/IBIS System Operation

- VICAR System Functions
- TTM Macro Language Library
- 300 Application Program Modules
- Primitive Image Processing Subroutines

VICAR system functions serve as an interface between the user and the operating system relieving the applications person of necessary expertise in Job Control Language. In operation, these programs translate VICAR Control Language, a set of user commands, into appropriate JCL parameters specifying the origin, processing to be performed, and destination of image data sets. Application programs are modular, general purpose functions which are selected, ordered and executed by the user in VICAR Control statements to perform specific processing strategies. The VICAR primitive modules, the subroutines, are called by application programs to perform repetitive image processing operations. The TTM macro language strengthens VICAR/IBIS with a recursive and iterative programming capability.

VICAR/IBIS has been installed as a mainframe, batch oriented image processing system at about 20 installations to date. Current system design characteristics have restricted installation to machines supporting IBM OS operating systems including virtual memory systems (Seidman & Smith, 1978). Although transfer to other computers or operating systems is possible (Lawden & Pearce, 1980), investments required in software modification and reprogramming may prove system transport unfeasible.

Acquisition & Installation

Being developed with public funds by NASA, VICAR/IBIS is normally purchased from COSMIC, the federal government clearinghouse, for about \$ 1,600. System software is transferred on magnetic tape and includes —

- VICAR System Software Modules
- TTM Library
- Source Code for Application/Subroutine Program Modules
- Application/Subroutine Load Modules

Accompanying the tapes are —

- VICAR Image Processing System Guide To System Use
- Individual VICAR/IBIS Application Program/Subroutine Documentation
- Installation Guide (3 Pages)

Like many other image analysis systems, proper installation and use of VICAR/IBIS presupposes knowledge about computing, some basic image analysis concepts, and the system itself. During initial phases of system transfer and installation at WSUCSC, both JPL and NASA/Ames personnel were available to support the project. JPL made two offerings of a week long workshop, the second offering being video taped and made available through NASA/Ames. JPL personnel visited WSUCSC and the Idaho Department of Water Resources in Boise, a second Pacific Northwest VICAR/IBIS installation site, for system and applications debugging and training. In mid 1979, VICAR support personnel involvement shifted from JPL to NASA/Ames where it has continued since that time. Ames personnel presented a 4 day Introductory VICAR Workshop in October, 1980. Each of these training sessions presented topics including —

- The VICAR System Configuration
- Use of VICAR Control Language
- Basic Image Processing Concepts
- Specific Aspects of Earth Resource (Landsat) Applications

Attendees have reported that training handouts have been invaluable reference materials in subsequent use of VICAR/IBIS. None of the workshops addressed specific problems involved in VICAR system installation.

VICAR/IBIS was acquired at WSUCSC in September, 1978. Center personnel had completed the first JPL workshop offering but otherwise were completely inexperienced with image processing technology. Following installation guide directions, one full time programmer versed in IBM utility programs, IBM JCL and FORTRAN successfully installed the system in 14 days. This process was not trouble free. Track size on WSUCSC's IBM 3350 and Braegen Calcomp 4350 disks were too large for VICAR system blocking conventions. Software modification was supplied by NASA/Ames and has now been permanently implemented in VICAR. VICAR tape handling routines require NL or BLP tape label processing parameters which may be regarded in many computer installations as a compromise to tape security. A tape management system utilized at WSUCSC compounded this problem. Tape security policy modifications were necessitated before addressing VICAR/Tape management system incompatibilities. While VICAR was operational without tape system modifications, it was exceedingly cumbersome to use and a resolution of the problem dragged out for nearly a year and required a commitment of about 1 programmer month. Finally, plotting software was not included in the transfer due to its proprietary nature. Although this problem is now nearly solved at WSU, it is foreseen that plotting software implementation will cause unique problems at future VICAR/IBIS installation sites.

Operational Considerations

In the 9 months following installation, WSUCSC personnel used VICAR/IBIS in a Spokane County Landsat project for demonstration and verification of system utility. Throughout the course of this project, Center programmers found time and time again, that when VICAR/IBIS ran, it ran beautifully, but when a program failed, identification of the problem and debugging were nearly impossible. Closer inspection showed that by even the most lax WSUCSC program support standards, VICAR/IBIS was far from being an easily maintainable system. Although support and maintenance guidelines are demanding due to the Center's responsiveness to user satisfaction, WSU programmers believe that the production problems encountered with VICAR/IBIS would cause potential maintenance difficulties at nearly all installations.

Most critical among VICAR/IBIS support problems has been the occurrence of a missing source and/or documentation component from otherwise complete program or subroutine modules. It should be clear that when source code is missing, program debugging, modification and enhancement is impossible. When documentation is absent, the program function must be interpreted from source code (if available), or the program is never used. A more subtle, but nevertheless critical, problem has been that occasionally an application program is found to have functionally uncorrelated load, source and documentation components. In other words, each of the components, when transferred, represented the developing, but operational, algorithm at a different stage of evolution. Several of these uncorrelated occurrences have put serious doubts about the integrity of other VICAR/IBIS programs in the minds of WSUCSC image processing personnel. Lack of available JPL VICAR maintenance documentation and the absence of internal date flags in program modules has made solutions to these problems complex.

Further practical problems with VICAR/IBIS have been identified at WSU. Some of these are as follows —

- Partial Nth generation xerox program documentation - unintelligible
- TTM macro language documentation not transferred
- VICAR abend code documentation is brief and nebulous in places
- Relationship of system abend codes to VICAR jobs is not clearly documented
- Much of the VICAR/IBIS documentation contains outdated information
- Insufficient documentation on program restrictions and timings

- No functional program menu - applications persons must search through all program documents to find appropriate processing function
- Internal software documentation often poor
- Internal software generation and modification dating generally non-existent
- No complete VICAR programmers guide available

While genuine concerns regarding software maintenance and documentation have been generated at the Center, overall impressions and acceptance of the system by WSU staff and Center users has been favorable. Currently running on the Amdahl 470/V 8 under the MVS/VS2 operating system at WSUCSC, staff members and users have become very comfortable with VICAR/IBIS batch job submission via the WYLBUR text editing, remote job entry system. WYLBUR software has been written to reduce VICAR/IBIS job submission and control to a series of user responses to terminal prompts. Several users have made a transition from interactive image processing to the VICAR/IBIS batch environment with differing degrees of comfort. All, however, recognize the advantages of mainframe image processing systems, especially when applied to large amounts of image data and/or complex raster algorithms.

WSUCSC VICAR/IBIS Support Plans

WSUCSC has made a commitment to support VICAR/IBIS as its main digital image analysis capability. To bring the system up to Center support standards, work has begun and is being planned in the area of —

- 1 System software cleanup & enhancement
- 2 Identification/compilation of an easily maintained set of application software
- 3 Redocumentation, reprinting of existing documentation & development of additional documentation
- 4 Organization of VICAR/IBIS users group for interchange of technical information between users & installations
- 5 Development of VICAR/IBIS image processing training for WSUCSC and others

Scheduling and personnel time investments associated with the VICAR/IBIS support effort are presented in Table 1. Each of the support areas will be addressed more specifically in subsequent paragraphs.

System software is one aspect of the VICAR/IBIS package which reflects the long evolutionary development of the system as a whole. Certain commands and options in the VICAR Control Language have not been used

Table 1 Personnel Time Estimates for VICAR/IBIS Installation
& Support

<u>Getting VICAR/IBIS Operational</u>	
WSUCSC Personnel Training	
System Acquisition	
System Installation	
System problems debugging	

Total personnel weeks	18
Accessing VICAR/IBIS Via WYLBUR	2
<u>Program Debugging Due To</u>	
Application Program Bugs	
Inadequate Documentation	

Total personnel weeks	16
<u>Current And Future Efforts To Bring</u>	
<u>VICAR/IBIS To WSUCSC Support Standards</u>	
Software Modification	
Documentation	
Training	

Total Personnel Weeks	120-160

for years due to functional duplication with more recent application programs. Other commands have different names but identical functions. Center staff have identified and removed functionally synonymous command names and functionally outmoded command options leaving a more concise VICAR Control Language set.

In the course of VICAR/IBIS applications and testing at WSU, application programs have failed on occasion. In many cases, program repair was apparent with a little searching by Center staff, in other cases missing or out of date source code prohibited debugging. During this period, NASA/Ames was timely and expert in supplying program fixes when required. Nevertheless, wherever the origin of software modifications, the net effect was like fighting spot fires. As soon as one was extinguished, another was discovered. This type of software maintenance results in an endless effort and does not constitute a supportable system by WSUCSC standards. A decision was therefore made to rebuild the applications software portion of the system from the base up. Center programmers have now begun an effort to recompile all VICAR primitive routines from the latest source code transferred, obtain or rewrite any missing primitives called by a group of application programs designated for support. Recompile that group of application programs from the most recent source code transferred. The completion of this effort will leave WSUCSC with internally maintainable application software from the standpoint of in-house debugging, modification and development of programs.

System support is certainly lacking by any standards without adequate documentation. While solutions to all VICAR/IBIS documentation problems are complex and time consuming, the WSU Computing Center staff have been working on several critical deficiencies and have plans to address others soon. With funding from NASA/Ames, a new version of the VICAR/IBIS Reference Manual is near completion, incorporating the WSU version of VICAR Control Language. Application program documentation is also being reprinted and in some cases redocumented. It is anticipated that through a process of WSUCSC user feedback, VICAR/IBIS documentation can be fine-tuned and expanded for application programs supported by the Center. A VICAR Installation Guide and a VICAR Programmers Guide are planned for in the future.

Throughout the process of VICAR/IBIS transfer, installation and application at WSUCSC, close contacts were established with other installations where the system had been or was being installed. Sharing of technical information and software enhanced the systems and VICAR/IBIS understanding for those involved. As a result, it has become clear that there is not one but many different versions of VICAR/IBIS, and no two are probably the same. To some extent, individual computer system requirements necessitate certain unique system modifications. However, major

distinctions between systems lie in different sets of software and documentation. WSUCSC feels the deficiency of a users group by which information and software could be disseminated. The Center plans to establish such a group in the future and invites all interested parties to contact us.

Finally, essential to successful VICAR/IBIS image processing is good training. With matching funds from PNRG, WSUCSC developed one day overview seminars and 5 day hands-on workshop sessions to aid in the understanding of basic image processing concepts and VICAR/IBIS application. To date, this training has met with much success. The future holds continued offerings of training and course diversification into specific application fields and image processing techniques.

Summary

VICAR/IBIS is functionally a sound system. Operating in an IBM main-frame environment, VICAR/IBIS provides for efficient image processing especially when dealing with large raster data sets. Processing strategies are limited in scope only by applications programmer imagination. Although easily installed and operational within weeks, VICAR has presented WSUCSC with a variety of system support problems. Software and documentation situations at the basis of these problems occur at all sites of VICAR/IBIS installation. To what extent maintenance difficulties will affect computing operation at potential installation sites, depends on highly variable facility characteristics. VICAR/IBIS is in no sense a turn-key system. Those considering VICAR/IBIS installation should be prepared to invest significant personnel time and funds toward system upkeep as a dedicated system maintenance service is not offered at this time.

D EARTH RESOURCES LABORATORY APPLICATIONS SOFTWARE (ELAS)

Dr. Thomas W. Balcerek (Computer Services Manager - Graphic Section -
Computer Services Division - University
of South Carolina - Columbia, SC)

In 1978, it was decided that USC should actively pursue obtaining the hardware/software necessary to do image processing and the classification of Landsat data. At that time, USC computer services was heavily committed to the maintenance and development of its graphics capabilities and it was felt that the landcover data available through Landsat would be a useful compliment to other data (soils, census data, political boundaries, roadways, climate), that was being collected. Some state agencies had contracts, notably with Stanford and ERL, to do specific projects along these lines and it was felt that USC could better meet the needs of the state locally.

A Data General Eclipse Model S/230 mini-computer originally purchased for another purpose was now dedicated to graphics. After suitable modifications, i.e., the additions of a large disk drive, dual density tape drive and an image processing display device, the minimum hardware necessary to do image processing and classification of Landsat data was in place.

Simultaneously, the task of obtaining a suitable software package to do the calculations necessary to this type of work was undertaken. Several systems were originally considered until it was decided that The Earth Resources Laboratory (ERL) software would best fit the needs of USC. Under their technology transfer program, ERL supplied a copy of the software then being used at Slidell, Louisiana as well as the promise of help in setting it up.

Since no new contracts involving the use of these capabilities were pending, it was felt that USC could afford to spend the time setting up the system and tailoring it to fit individual needs. Hardware considerations demanded a FORTRAN based mini-computer system. Shop policy demanded source listings and documentation. Cost involved the manhours and travel necessary to learn and implement the system. The source software was supplied free of charge under the technology transfer program.

Implementation of the system proceeded satisfactorily. In October, 1979, it was semi-operation (i.e., a scene could be reformed, searched, classified and grouped). At this time, in a routine visit to Bay Street -

Mississippi, ELAS was introduced. After judging its merits versus those of the earlier system, it was decided to implement ELAS. A major factor in this was the disclosure that ERL would no longer support the old system once ELAS was totally operational. There was a little difficulty implementing a couple of key modules (namely programs to overlay 2 different scenes and the program to geographically reference a classified scene). It was felt that USC could get ELAS up and implement the overlay and georeference overlays in only a little more time than it would have taken to implement the old modules. (Hindsight shows this judgement correct).

In March, 1980, the image display device arrived and shortly thereafter, USC produced a general landcover map of South Carolina using a hybrid system. The Landsat scenes that made up the map were reformatted, searched and classified under the old modular system but were georeferenced, displayed and grouped into landcover types using ELAS. The individual scenes were then merged into the state data base grid on the universities' mainframe. A tape was subsequently prepared from which the map was produced.

ELAS is now fully operational at USC. The latest project involving the classification of Greenville County in South Carolina was done from Landsat tapes to overlay to final landcover classification on a UTM coordinate grid, entirely by ELAS.

Throughout the implementation procedure, ERL willingly answered questions and supplied, if available, updated programs and documentation when asked. However, the entire task of implementing ELAS was essentially done by USC. This was done partly out of preference, but mostly out of necessity since the Data General Eclipse used by USC is not directly compatible with the Interdata upon which ELAS was developed at ERL.

Hardware differences include the use of 16 bit word versus a 32 Bit word. The smaller addressability results in less space being available for program overlays. This necessitated cutting down some array sizes as used at ERL. The DG Eclipse does not support INTEGER*4 arithmetic which is used extensively throughout the ELAS package. This was rectified by changing all INTERGER*4 variables to REAL and watching for places where floating point arithmetic cannot be used. To date, the resultant loss of significance has not proved to be a problem.

These problems, however, were minor compared to the main task of interfacing the ELAS software to Data General's FORTRAN callable runtime routines. Hence USC had to write its own versions for many of the

subroutines. Notable among them were the subroutines that handle input/output and those that bring in the various overlays.

Every machine handles I/O in its own way. Thus, the packages handling tape I/O, disk I/O, terminal I/O and Comtal I/O had to be developed locally. This is a major but unavoidable undertaking when implementing software on any machine not exactly identical to the machine on which the software was developed. ELAS does however use general I/O subroutines which contain most of the machine dependent calls making this task a little easier. These were totally re-written locally and all the programs linked so that those routines are always resident.

Once the resident section of code was complete, implementation of the individual overlays proceeded fairly easily. However, each overlay did need to be debugged and tested to check for things such as array size and INTEGER*4 arithmetic. The overlay structure of ELAS is such that this can be done without any undo effects on the other overlays. Also, each overlay is linked separately so that the entire ELAS package does not have to be re-linked every time a new overlay is introduced.

There is, however, one time when every overlay does need to be re-linked. That is when a change is made in any of the routines that are always resident. Then every overlay has to be re-linked and re-checked for unforeseen effects. This however, is more prevalent early on when the problems that occur are likely to be those of the resident routines and structure. Once these stabilize, the implementation of any individual overlay is relatively straight forward. At this time, users can write and implement their own overlays without any undue problems.

In general, ELAS is an extremely flexible and workable system for processing Landsat type data. This very flexibility, however, is both its strength and its weakness. In order to make full use of ELAS, the people using it need to have a thorough understanding of it and what they are trying to do. This precludes outside users from working with the system by themselves. Normally, one of our staff works in conjunction with an outside user to produce the product desired.

User documentation is extensive, relatively reliable for such a new system, but takes an understanding of the system in order to use effectively. ELAS is available through NASA's Technology Transfer Program and the version to fit a Data General Computer is available from USC.

ELAS is a good and flexible tool and recommended for any user who can invest time and money for full utilization.

HARDWARE IMPLEMENTATIONS (PARALLEL SESSION)

A THE STATE AGENCY EXPERIENCE (EVALUATION/SELECTION OF HARDWARE FOR AUTOMATED - GEO-BASED INFORMATION SYSTEMS)

Dr. Louis F. Campbell, Jr. (State Cartographer/Chairman -
Colorado Mapping Advisory Committee -
Division of Planning - Colorado Dept
of Local Affairs - Denver, CO)

Introduction

1 General

Recently, there has been a marked increase in the acquisition and utilization of automated, geo-based information systems for the purpose of understanding and rationalizing the land management issues that face state governments. The increasing application of these systems is driven by the fact that the number, variety and complexity of influences on land management decisions have reached the critical point at which conventional or manual geographic information systems are no longer efficient when applied to the generation, encoding, storage, retrieval, manipulation, analysis and display of spatial information. This personal assessment is reinforced by Gates and Heil.

The use of computer technology for the capture and organization of spatial data and the use of computer-based analytical modelling techniques offer the only opportunity whereby present and future demands and expectations regarding land based planning, engineering and management activities can be met.

In the discussion to follow, the descriptors 'geographic' and 'spatial' will be used interchangeably when applied to these information systems and the descriptor 'geographic information system' will be taken to mean an automated geographic information system.

2 Purpose

The purpose of the panel here assembled is to describe, albeit briefly, those procedures by which the hardware components of geographic information systems are evaluated and selected and to a lesser degree, implemented. The panelists are, at once, similar and different. They are similar because each represents any agency

of state government. They differ in the alignment of those agencies within state government —

- 1 Alaska - Research & Development/Department of Natural Resources
- 2 Colorado - Planning - Department of Local Affairs
- 3 Montana - Research & Information Systems - Department of Community Affairs
- 4 Washington - Resource Inventory - Department of Natural Resources

3 Representation Selection

The selection of the states, agencies and systems to be represented on the panel was by design and a restatement of that design follows. Geographically, each state is located within the area defined by the National Aeronautics & Space Administration's Western Regional Applications Program. Institutionally, each agency is a component of the government of the respective state. Technically, and in deference to the fact that this is, after all, a remote sensing conference, each of the systems has or will have the capability of utilizing remote sensor technology in general and digital imagery processing specifically. The importance of this technical consideration is underscored by Knapp.

Despite the problems, Landsat data continues to be regarded as an important data source for interface with automated geographic information systems because of its objectivity, currency, cost effectiveness, availability in digital format, availability for large areas, and potential for temporal and spatial analysis using change detection techniques.

Functionally, the system described herein are automated geographic information systems (GIS), not computer-aided manufacturing systems (CAM), or computer-assisted design and drafting systems (CADDs). With respect to these functional considerations, Orr points out that of the approximately \$ 300,000,000 worth of interactive graphics systems sold during 1979, 60% were acquired for use as CAMs and CADDs. A further constraint on the system described herein is that they are not systems based on analytical plotting machines. The latter are succinctly reviewed by Petrie and that review is recommended to those persons having an interest photogrammetrically derived digital mapping. Personally, each of the panelists has long-term training and experience in conventional or manual geographic information systems.

Panel Format & Constraints

Format

Expediency and convenience of conference format have dictated that this panel on hardware be separated from the preceding panel on software. However, the inseparability of the two is demonstrated by Calkins and Tomlinson.

Hardware and software considerations play a major role in the construction of a computerized geographic information system. These two areas arise from different, but equally valid ways of viewing a digital computer: how it is made and what it does, the physical structure of the computer, hardware represents dormant capability and it can do nothing without programs, the software. However, the software is dormant as well since a program must be executed on a physical machine. The functional capability we refer to as a digital computer is neither the physical hardware nor the invisible software - rather it is the two in combination.

The Calkins and Tomlinson rationale should be extended to include the information data base and the human operators. However, this panel is constrained solely to hardware considerations.

2 Procedures & Approaches for System Selection

While finely drawn, the distinction between procedures for the acquisition of systems and approaches to the acquisition of systems should be noted. In the separate state discussions to follow, the former are explicit while the latter are implicit. Dangermond and Smith have addressed the latter and suggest 5 alternative approaches for acquiring geographic information systems technology.

- User-designed & developed systems
- Acquisition of software for use on existing hardware
- Purchase of turnkey software for use on existing hardware
- Purchase of turnkey software/hardware system
- Purchase of system services

The prudent potential purchaser of a geographic information system should note the differences between the procedures to be discussed and the approaches listed above and then consider the two in concert.

3 Sequence of Presentation

The 4 systems will be presented in alphabetical order by state as follows: Alaska, Colorado, Montana and Washington.

Of more than routine significance, is the fact that each panelist represents a state agency that has either an administrative mandate, executive order responsibility or statutory requirement that includes the spatial analysis of land management data. Each state has varying procurement regulations and budgetary restrictions that affect the acquisition of geographic information systems to carry out these directives. It is hoped that the following discussions of procedural similarities and differences and past successes and mistakes among the 4 states will be of benefit to the conference and will constitute technology transfer of the highest order.

B

THE ALASKA EXPERIENCE

Douglas L. Mutter (Chief - Coordination of Technology Applications-
Alaska Department of Natural Resources -
Anchorage, AK)

Introduction

The Alaska Department of Natural Resources (DNR), is the third largest land management agency in the country and eventually will be directly responsible for 104 million acres of state land - an area about the size of California. DNR manages land, water, forests, grasslands, oil, gas, energy and hardrock minerals, parks, agriculture and related resource development activities. DNR is mandated by the legislature to offer 100,000 acres of state for disposal land. The department selects lands entitled to the state by the Statehood Act. It leases major oil/gas areas such as Prudhoe Bay, maintains surveillance over energy pipeline construction and operation and is developing large new agricultural resources. DNR operates one of the largest state park systems in the nation. DNR's jurisdiction in some areas, such as water resources and land recording, extends over the total 367 million acres of Alaska.

The amount of information it requires to manage these resources and to meet the mandates given DNR by the legislature and public, are significant. For example, there are currently over 200,000 case files, 3,000 active land lease applications, a backlog of 2,000 water use applications, over 10,000 mining case applications per year. Numerous other sales, leases, permits and activities are generating vast amounts of information and data that is required by decision makers and the public on a daily basis. Almost all information handling capabilities are backlogged at DNR at this time and are worsening each day.

In 1978, the Commissioner of DNR established the Alaska Land & Resources System (ALARS). The purpose of this project is to coordinate data processing activities within the department, establish a capital development program for automating information management and to better organize the way in which information is handled. From the beginning, the ALARS project has been as much an effort to provide an efficient and coordinated approach to data management as it has been to provide for the development of programs and the acquisition of computer hardware. Prior to receiving any funding for the project, DNR conducted a user needs survey, produced an analysis of existing systems, developed a conceptual design and established a first year workplan. These activities were completed in June, 1979 at the time the state legislature approved the first year's capital budget of \$ 1.7 million for implementing ALARS. A second year of capital funding at \$ 2.2 million has been secured and a proposal is before the

legislature for a 3rd year at the same funding level. In the meantime, the department has begun to develop a permanent support capability with an operating budget, permanent staff and a statewide terminal network.

The ALARS conceptual design focused implementation efforts into 3 areas of responsibility —

- 1 Land Administration
- 2 Resource Management
- 3 Departmental Management

These areas have been translated into an ALARS approach which includes the development of land activity based application systems, the use of data base management technology, the establishment of network resources and coordinating through the centralized ALARS staff and the acquisition of a geoprocessing capability. We have attempted to include user involvement at key points, to use the state's centralized data processing services and to acquire currently operating systems whenever they meet our needs to save time and money.

The land administration system is being constructed to manage land records, accounting, case tracking, etc., on the state's IBM 370/148. It will be accessible via a statewide telecommunications network. Land status graphics information will be produced and disseminated through microfilm aperture cards. DNR is now looking into the possibility of obtaining an automated drafting system to help speed the drafting of status plates and for producing COM for distribution. The resource information system will be a series of systems each built for specific purposes such as forest inventory, resource inventory, geological inventory, as well as generalized statewide data to be widely available over the terminal network. The ALARS staff will interrelate and integrate these activities as much as possible, while at the same time, meeting specific user needs. The general resource information system will relate computer mapping tabular land records information.

The Geoprocessor Decision

A major component of the resource information system element of ALARS is the geoprocessor (geographic information processor). This was identified through the user needs survey and in the conceptual design as a key system need. As the ALARS project has been unfolding, DNR has continued its efforts of statewide resource planning, regional planning and detailed site planning for land disposals, timber sales, agricultural projects, etc. At the same time, broad statewide policy research activities are being undertaken. All of these efforts could potentially benefit from computer mapping/geographic data manipulation capability.

The ALARS staff undertook extensive review of systems that could meet this geoprocessing need. This effort included visiting operational systems, attending meetings and conferences and reviewing numerous publications that compared systems. Based on the user survey, the ALARS staff review and discussions with system users elsewhere, a set of specific needs was developed which led to the creation of a request for proposals (RFP).

Procurement Process

Early in his administration, Governor Hammond issued an executive order prohibiting the development of numerous state computer data centers. Instead, he wished to develop centralized data processing functions at the two Division of Data Processing data centers in Juneau and Anchorage. The requirement for a geoprocessing capability, however, was considered to be specialized, and since the computer would be dedicated to geographic information analysis, it was approved for acquisition by DNR by the state administration. It is state policy that any contract over \$ 20,000 must be bid upon through competitive process based upon the RFP.

The RFP issued included some background on the project and outlined specific capabilities DNR needed for geoprocessing. Several broad functions were identified for the geoprocessor —

- Data Entry & Storage
- Data Retrieval
- Data Manipulation
- Alternative Testing
- Modeling
- Data Display
- Statistical Analysis
- Numerical Analysis

The specific planning and management uses were identified and included such things as map generation, integration of Landsat data and so forth. Functional requirements were identified including interactive digitizing (1 Station), interactive display and manipulation of a set of 3,000 polygons, polygon overlay and plotting. In order to plan for future integration, it was also a requirement that the geoprocessor be capable of communicating in some manner with the IBM 370 series computers.

Specific vendor proposal instructions were included in the RFP and specific evaluation criteria were listed. Part of the proposal evaluation process was a site survey. This involved a telephone survey of two sites

currently utilizing the proposed system. The sites were to be similar in nature to DNR's activities and situation. The objective of this requirement was to evaluate the performance of the vendor system in an operating environment similar to the one in Alaska.

The evaluation procedure for written proposals concentrated on an analysis of system functions, maintenance, equipment specifications and delivery date as specified in the RFP. Proposals that successfully passed the first review went into the site evaluation phase. Cost was evaluated during the process. Certain point values were allowed for the degree of satisfaction on each of these evaluation criteria. The vendor with the highest score, would be selected.

The list of system functions outlined in the RFP was identified as being mandatory, desirable or optional. The functions were specific in the area of data capture, data editing, data organization, data retrieval and display, software (analytic) capabilities and hardware/operating system features. Maintenance for the CPU, peripherals, and software was a factor that was specifically discussed in the proposal and considered to be an important evaluation criterion. It was required that none of the hardware be modified. The RFP ended with a list of general performance characteristics of the equipment that covered the digitizer, CRT display (graphic/alphanumeric), the central processor and the output systems. The delivery date was to be within 3 months of the award of the contract. A vendor list of some 39 companies was compiled and the RFP was sent to them. DNR received 4 serious responses. A final vendor was selected, that vendor being COMARC Design Systems of San Francisco.

A contract was signed which included specifications for such items as user and technician training at DNR, system installation documentation, hardware, software, maintenance, warranty, pricing, availability of source code, the acceptance test and a request for certain enhancements that were not available as standard components.

It may be apparent from the preceding that DNR was interested in obtaining a "turnkey" system. We asked for an integrated, operational turnkey system, the ability to interface with IBM 370 series computers, a flexible and expandable equipment configuration, interactive display, the ability to build a statewide geocoded data file for natural resource data, and that the system be minicomputer based. The intent was to quickly bring on line, an operational system.

The System

The initially purchased equipment included the following components —

- Talos BL660B backlighted 44 inch x 60 inch digitizer
- Two Tektronix 4014 graphic CRTs
- Tektronix 4631 CRT image hardcopy unit
- Data General Dasher 6053 alphanumeric CRT
- Data General S250 processor with 512K Bytes of memory
- Data General Dasher 6040 system console
- Data General 190 MB disc 6061
- Data General 6062 9 Track magnetic tape drive
- Zeta 3653SX 34 inch plotter
- Data General 4218 line printer
- Data General 34 inch chassis with line multiplexor for Communications
- An AOS RCX 70 IBM 3270 system emulator

Various software components included scaling and coordinate conversion, data manipulation and display for polygons, grids, lines and points, Fortran 5, sort/merge, editor and digitizing software.

Technical and user-oriented training, of approximately 4 weeks duration was provided as part of the contract and was invaluable in assuring a quick start up for operational projects. Subsequently, the system has grown in use and major enhancements have occurred in software development and hardware acquisition. Additional hardware was purchased as follows —

- Another 190 MB Data General 6061 disc
- An additional 36 x 48 inch Talos 648B digitizer
- Two additional alphanumeric Dashers (6108)
- An additional 512KB of memory

The State's Department of Fish & Game has been working with ALARS staff to develop an auxiliary station in its department that will communicate with the centralized geoprocessor. An RJE capability for the IBM is being established. Other divisions within DNR are now being considered for remote data entry and display stations. We are in the process of obtaining additional geoprocessing software to further enhance DNR's geoprocessing capabilities. Major upgrades in the area of attribute handling have occurred and an interface established with USGS IDEMS.

The initial cost of the system including hardware, software, documentation, installation, training, etc., was \$ 300,000. The system was delivered and installed during December, 1979 and January 1980. An additional \$ 80,000 to \$ 100,000 has been spent since that time on enhancements and upgrades. Current staff support for the geoprocessor includes two Systems Analysts, a Programmer, a Data Control Specialist and 4 permanent Digitizers. Additional digitizing support is obtained through a college internship program. Applications and user assistance is the responsibility of three planners.

Considerations

The experience of preparing for, acquiring and operating a geoprocessing system has provided a perspective on several important considerations. Paramount among these, is to examine the current state policy on acquiring such a system and ensure that all procedures are followed and the appropriate officials spoken to in order to facilitate acquiring a computer system. Another consideration of course, is budget. The amount of money available to spend may determine whether or not a system is to be purchased or otherwise phased into operation. In Alaska, a key consideration has been the availability and cost of maintenance service for software and hardware. Without adequate support, one may end up with an expensive dust gatherer. The purchasing agency must have a commitment to continuing an operational system.

The location of the system is important to a state agency as diverse and scattered as is Alaska's DNR. For example, DNR has six different office locations in Anchorage alone. Installation is a factor to be considered. Certainly, part of the contract with the vendor should be to provide for adequate installation and acceptance testing of the system. Initial staff training is crucial. It is important to insure that staff is available to support the system and that they are trained in all aspects of its operation. User training should not be overlooked if the system is to be more than a "toy" for the programmers. Finally, delivery date is an item to consider. The urgency of an agency's need for a system will be an important determinant in the type of system acquired.

Several factors comprise the "untold story" of obtaining a geoprocessing system. Consider the following —

- Security — How will licensed documentation and sensitive data be stored?
- Standards/Procedures — The new geoprocessing center must have standards and procedures for operating the new system, user access, project control, etc.

- Training — Training is a continuing process for both operator and user. For example, DNR has put in more than 45 man weeks on operating staff training and some 900 man weeks of user seminars and training sessions in the past year.
- Environment — Preparing the room with proper power, air conditioning, humidification, static prevention, space, is important.
- Contract Negotiations — There are fine points in negotiating a contract for a GIS which should be discussed by the purchasing staff well before the contract negotiating phase.
- Starter Supplies — Obtaining extra paper, digitizing cursor, plotting pens, ribbon, etc., is something not to be overlooked if you expect to go into immediate operation.
- Support Staff — Being able to create positions and hire staff is sometimes a difficult aspect of state or federal governments. Staff should be hired well in advance of expected system delivery.

Summary

In summary, the events that led to establishment of the geoprocessor at DNR follow. The ALARS mandate was issued and a capital budget request made in the fall of 1978. The conceptual design and work plan was developed and presented in the Spring of 1979. An RFP was prepared and released in the Summer of 1979. The contract was developed and signed with the vendor in the Fall of 1979 and delivery of the system was made in December 1979. The system began operating in January, 1980 and a demonstration to the state legislature was made in February, 1980. There have been approximately 50 projects since that time with several enhancements over the past year. A major upgrade was made during Winter, 1980-1981. Early in 1981, the Department of Fish & Game obtained a remote unit to tie into the system at DNR. We are now considering the acquisition of an automated drafting system and an additional system for handling seismic data - both of which may tie into the geoprocessor.

DNR's geoprocessing system has been a highly successful segment of the ALARS project. No practice demonstration projects were done on the geoprocessor, it was delivered and began producing real management information within 2 months of delivery. It has been used for numerous major and minor projects ranging from site planning, subdivision layout, viewshed analysis, corridor analysis, subsurface analysis, management planning, timber harvest planning, to land status mapping. The system will continue to evolve and grow and become a major tool in the management of Alaska's resources.

C

THE MONTANA EXPERIENCE

Thomas R. Dundas (Administrator - Research & Information Systems
Division - Montana Department of Community
Affairs - Helena, MT)

Introduction

The following is a Montana GeoData System overview to acquaint you with who we are, what we do and how we entered the geographic systems arena.

Our organization was established as a state information system in 1968. We are currently entitled the "Research & Information Systems Division of the Department of Community Affairs. Our responsibilities as defined in the Montana Administrative Code states "That the Research & Information Systems Division is the primary statistical agency of state government and makes demographic, social and economic analysis and research. It's functions include the collection and maintenance of a wide variety of state information data files and documents for the Department, local political and government units, research bodies and general public". The Division provides standard and special tabulations of Census, economic, demographic, social and physical statistics concerning the state and answers requests from within and outside the state for information, advice, evaluation and information sources. We prepare computer-generated maps, population projections, impact analysis, directories and various publications. Basically, we are the primary statistical and research agency in Montana state government.

Our involvement in geographic information systems began in the early 1970's. We initially developed a computer mapping program called GRAMPS or the Gary Rogers Automated Map Program, as Gary was the one who designed most of our geographic systems. This program was used to map by computer, social and economic data in cellular form. I might add that we presently have over 100 separate maps in this series described as Montana Graphic Profiles.

It was about 1972 that we first seriously considered the development of a geographic information system. We had been working with the US Geological Survey and the Helena City County Planning Board and decided to build a statewide system for mapping natural resource information.

We had no special equipment of our own so we were entirely dependent on the state's data processing facility as a consequence whatever we did had to be processed in batch mode. The GeoData System started when we selected the 1:250,000 USGS map base for digitizing. It took approximately

27 maps at this scale to cover the state. As we had no digitizer of our own we contracted with Computer Research, Inc., in Arvada, Colorado and had them ditize the following —

- Township corners
- Administrative areas - counties, cities, Indian Reservations, national forest, wildlife refugees
- Transportation Network-Highways, railroad and airports
- Utility Networks - Pipelines and powerlines

System Expansion

As the years passed, we began to add sizeable computer files. In cooperation with US Geological Survey, we built a central water quality data storage and retrieval system which today houses a large share of Montana's water quality data including files from the state's Water Quality Bureau, the School of Mines & Geology and from the USGS. In cooperation with the Montana School of Mines, we added most of the state's wells in mid 1970's. Land ownership was added by encoding all state-owned land into the system. This was followed by encoding most federal land ownership. We had hoped to do this jointly with the Bureau of Land Management. However, there was little interest at the time but we did obtain the entire 1:120,720 color quadrangles map series from BLM and coded all federal parcels from the surface ownership edition. This was followed by adding the mineral ownership both state and federal in 1976. In 1977, we began working with the Air Quality Bureau of the Department of Health and began to add air quality data to the system.

One of our largest state agencies, the Department of Revenue, became interested in our mapping capabilities in the mid 1970's. They had begun to build a state land appraisal system and without our knowledge had manually digitized under contract all section corners in the state but had no way of knowing whether the corners were accurately located. It was about 1974 when the consultant observed our computer mapping capability and inquired whether we could map several townships as a demonstration. We did this and found that virtually every township in the state, had digitizing errors. Since that time, we have provided 8 - 10,000 computer drawn maps at the township level for the Department of Revenue. Today, we have a section file which is initially clean and accurate for perhaps, 50% of the state.

I mentioned that our Division's computer operation was entirely by batch mode in the early 1970's. The state acquired an IBM 360, Model 40 in 1970, upgraded to a 370-145 in 1973 and the present Model 158 was installed in 1975. We will convert to an IBM 3033 this Fall. Our Division acquired the first terminal, IBM 2741 in 1970 and we are currently utilizing an IBM 3278.

With the development of our graphics system in 1972, we began to feel a need for a graphics terminal. We added a Tektronix 4014, a small Tektronix flat bed plotter and a small microcomputer in 1976. Our graphics equipment is handled in remote batch mode on the 370 and is interactive on the microcomputer. The state recently switched to TSO and we hope to test our graphics equipment in an interactive mode later this year.

State Procurement Procedures

In Montana, we have a central data processing facility which serves all agencies. The agencies have little or no voice in the selection of the state's mainframe computer. However, most do have terminals and the number of these has been growing rapidly in the last 5 years. At present, approximately 400 terminals are tied to the state's mainframe.

Present Applications

The largest ongoing computer mapping application that we have, has been the Department of Revenue township mapping program. In the last 4 or 5 years, we have computer drawn perhaps 8-10,000 maps for the Property Assessment Division of the Department of Revenue. We map by computer at a scale of 1:24,000 all townships and sections on a county-by-county basis. These maps are batched from 2-300 at a time. They are used by the Department of Revenue to correct the section corner master file. This file is, in turn, used as base data for all private parcels in the state. The Department of Revenue is spending a large amount of money to locate accurately, each section in the state and our system is ensuring that accuracy.

A second application is the computer mapping for the US Forest Service of all state-owned lands within selected counties. The maps are produced for the Geometronics Division of the US Forest Service which uses them to identify state ownership for the standard 1:126,720 such maps on a forest-by-forest basis.

A third mapping program has been furnishing water quality interval maps. These maps were developed for the State Department of Health's Water Quality Bureau. Selected water quality perimeters such as iron, phosphates and nitrates are located and plotted at a scale of 1:1,000,000 for the entire state. State and county boundaries are included.

D THE COLORADO EXPERIENCE (EVALUATION & SELECTION OF HARDWARE FOR
AUTOMATED, GEO-BASED INFORMATION SYSTEMS)

David Sonnen (Colorado Department of Local Affairs - Denver, CO)

Introduction

1 General

Following two years of design and development, an automated geo-based information system has been activated in the Colorado Department of Local Affairs. Based on the contracting authority's specifications, the turnkey system was produced by Environmental Systems Research Institute, Redlands, California. It is important to note that operationally the Colorado system is not comprehensive, but dedicated to 1980 census data. Examples of design objectives in that respect include technical assistance to legislative redistricting and State Census Data Affiliate activities. The present arrangement in which the State Cartographer and State Demographer are part of the same organization and share the same geo-based information system is especially fortuitous during a census decennial year.

2 Mandates

The State Demographer and State Cartographer are presently (March, 1981) components of the Division of Planning in the Department of Local Affairs. The former is required by statute to provide estimates and projections of population while the latter is required by Executive Order of the Governor to establish standards and criteria for automated mapping and geo-based data. As a consequence, our system is generally referred to as an automated census mapping system.

System Acquisition

1 Feasibility Study

First among the many convoluted events leading to the acquisition of the Colorado automated census mapping system was a legislatively-mandated feasibility study. Due to the complexity of the task and the extremely short timeline for accomplishing it, the Division elected to have a consultant produce the study and Comarc Design Systems, Inc. of San Francisco, California was selected from among three vendors. The thrust of the study was to determine the best

way to establish standards and criteria for automated, geo-based information systems and one of the conclusions was that standardization would accrue from the establishment of a service facility which would minimize the proliferating number of dedicated systems.

2 System Specifications

The completed feasibility study was delivered to the Joint Budget Committee of the Colorado Legislature which responded by directing the Division to take steps to establish an automated system. Acting on that directive and based on the user needs outlined in the feasibility study, the State Cartographer set about to develop preliminary specifications for the system. These specifications were translated into a request for proposal.

3 Request for Proposal

Colorado procurement regulations permit, among others, three avenues for the acquisition of computerized systems; these are: (1) sole source, in which the device to be acquired can only be made available by a single vendor; (2) invitation for bids, in which the cost factor generally takes precedence over others; and (3) request for proposal, in which the cost factor is but one of several factors to be considered. The latter procedure was elected with an emphasis to be placed on the price/performance ratio of the system proposed.

The request for proposal, while designated to reflect the preliminary specifications, is more than just a simple technical document. Included is a description of the events leading to the decision to acquire the system, the present institutional arrangements affecting the system, the immediate and far-term applications, the procurement requirements of the State of Colorado and an outline of the required format of any proposal submitted in response to the request.

The request for proposal was issued through the Division of Purchasing with the advice and counsel of the Division of Automated Data Processing, both in the Department of Administration. This issue includes a requirement for a letter of intent to submit a proposal and 23 letters were received. After the expiration of the withdrawal period, six vendors had submitted eight proposals. One vendor submitted three proposals and five vendors submitted one proposal each.

4 Vendor Resolution Meeting

A vendor resolution meeting was convened after the eight firm proposals had been received. The purpose of the vendor resolution meeting was to answer all questions about the specifications and system requirements outlined in the request for proposal. Procurement regulations in Colorado require that the answers to questions raised by one vendor be made available to all vendors and the most expedient way to accomplish this was to convene all concerned vendors at one time. The State Cartographer responded to all questions both orally and in writing and copies of the written responses were transmitted to each of the six vendors.

5 Proposal Evaluation

Completion of the adjustments to the proposals on the basis of the vendor resolution meeting marked the end of the period allocated to the receipt of proposals. The next event was the evaluation of the eight acceptable proposals. Accordingly, an evaluation team was assembled and each team member assigned an evaluation element, thus:

- compliance of the proposals with format and content requirements,
- vendor's management philosophy as evidenced by the architecture of the system as proposed,
- vendor's experience as evidenced by prior systems installations in similar institutional settings,
- support delivery including warranties, maintenance, documentation and training,
- hardware configuration, and
- software characteristics.

These evaluation elements were assembled into a matrix and assigned point values for a total not exceeding 1,000. The eight proposed systems were ranked in accordance with total points awarded.

6 Price/Performance Ratio

It is important to note that up until this point, no consideration of price had been included in the evaluation. In fact, Colorado procurement regulations require that pricing information be bound separately in the proposal. When the proposals are received in the

Division of Purchasing, the pricing information is kept from the evaluators until the performance evaluation has been completed. At this point, the pricing information is introduced and a price/performance ratio is developed. On the basis of this ratio, three of the eight proposed systems were selected.

7 Benchmark Tests

A uniform benchmark test was designed in order to rigorously test the three final systems. Since the system was designed as an automated mapping system for use with decennial census data, the test data included the following:

- 1970 census map of Pueblo, Colorado produced on transparent scale-stable material at 1:24,000 scale.
- 1970 topographic map of Pueblo, Colorado produced on transparent scale-stable material at 1:24,000 scale.
- 1970 census data for Pueblo, Colorado on computer-compatible magnetic tape.
- a macro-flowchart of the test procedures to be used which included tasks in three categories (statistical, cartographic and statistical/cartographic merge). The flowchart also included the minimum number of iterations required for each task.

Each of the three vendors was sent a benchmark test package including all of the above data and an on-site test was scheduled. Two-day tests were conducted at each facility. At the conclusion of these tests, the results were summarized and a system accepted from among the three finalists. A notice of intent to buy was sent to the finalist and contract negotiations were initiated.

8 Performance Test

A distinction must be drawn between the previously described benchmark test and the performance test to be described. The former is conducted under controlled circumstances at the vendor's facility. The latter is conducted under uncontrolled circumstances at the contracting authority's facility. Colorado procurement regulations require a 30-day period of performance testing at the end of which the system, if satisfactory, will be accepted. Briefly stated, the benchmark is a pre-installation test, while the performance is a post-installation test. With the completion of the performance test, acceptance of the system and award of contract, the procurement cycle had been completed.

System Architecture

The automated census mapping system is a turnkey system driven by software developed by the Environmental Systems Research Institute and includes the following hardware components:

- central processor — a PRIME 250 minicomputer with 512K memory. The processor includes one dial-up port and an RJE interface with the State of Colorado Sperry Univac 1100/82 for additional flexibility.
- tape drive and disk storage — an integral tape drive and 96MB disk drive.
- digitizing station — one TALOS 848B digitizer having a 36 x 48-inch backlighted surface with 16-button, 4X magnification cursor and .001-inch resolution.
- plotter — Houston Instruments CPS-15 drum plotter having four color pens, 34.5-inch plotting width and 12.7-inch per second diagonal plotting speed.
- graphics terminal — one Princeton 8500M intelligent graphics terminal having 4096 x 3072 programmable density points and full range of gray scales; black-and-white raster scanning admits interactive editing and vector generation.
- line printer — one PRIMENET line printer with 300 lines per minute print rate.
- work stations — four Hazeltine 1510 CRTs.

The access ports are now fully occupied and we plan to add one additional eight-port communications board and one 256K memory board.

System Applications

At present, the State of Colorado Automated Census Mapping System is dedicated to the management and mapping of 1980 census data in order to provide support for the State Census Data Center and assistance to the legislative redistricting and reapportionment process. In addition, a State/Local Government geo-based information pilot project has been initiated. The purpose of the pilot project is to determine the problems to be encountered when applying a State system to local projects. Participants in the pilot project include the R-1 School District, Planning Department, Automated Data Processing Department and Mapping Division, all of Jefferson County, Colorado.

The following projects are in the design stage and will be integrated with the system as soon as feasibility has been demonstrated and present operational requirements have been met:

- in concert with the U.S. Geological Survey, the utilization of digital elevation model and digital terrain model tapes.
- in concert with the U.S. Board on Geographic Names, the utilization of geographic names information system tapes.
- in concert with the NASA Ames Research Center, utilization of Landsat imagery and digital data.
- in concert with the OMB/Colorado A-95 review process, the automated tracking and mapping of grant awards and funding allocations.

It is generally recognized that the integration of these large databases will require additional central processor capacity and the application of a true database management system.

Summary

A brief recapitulation of the preceding information will show that the evaluation and selection events can be sequentially arranged in the following categories: (1) design and development; (2) feasibility studies and preparation of specifications; (3) request for proposal and evaluation of responses thereto; and (4) testing and installation. Having described this sequence of events, albeit briefly, I am compelled to offer the following counsel: (1) the turnkey system which permits one-stop troubleshooting seems generally preferable; (2) the acquisition of a system that includes source codes seems preferable to one that does not, thereby facilitating in-house modification of routines; (3) every reasonable effort should be made to acquire a system that includes a database management subsystem; and (4) the procurement procedure should include a constraint on the cost of future upgrade. The latter should be expressed as a percentage of the cost of the initial system; however, in fairness to the vendor and in consideration of the inflation rate and resultant discount value of the dollar, this constraint should be limited to a mutually agreed upon period of time.

E THE WASHINGTON EXPERIENCE (EVALUATION AND SELECTION OF HARDWARE FOR
AUTOMATED, GEO-BASED INFORMATION SYSTEMS)

Roger A. Harding (Resource Inventory Section - Washington Department
of Natural Resources - Olympia, WA)

Introduction

The Washington experience is still under way and the development of a Washington geographic information system has been evolving for the past 25 years, when the Department of Natural Resources was formed. This system has thrust from two different angles: (1) the proprietary need for information to support the management of five million acres of trust lands by the Department, and (2) the need for data over the entire state because of statewide governmental responsibilities. This dual need has resulted in the development of an inhouse DNR information system to fulfill proprietary needs and the recognition that this system must be expanded into a statewide system to fill governmental needs.

Background

In 1971, the Washington State Legislature assigned to, but did not fund, the DNR direct responsibility for the operation and development of a statewide Land Use Data Bank. This legislation was essential for making a statewide GIS possible, but of equal importance was the experience the DNR had gained in developing a statewide resource inventory program on public lands. This experience had an important influence on both the evolution of DNR's approach to create a statewide geographic information system and conception of the operation of the proposed system with emphasis on the need to make it a cooperative approach.

The 1971 land use legislation directed the department to expand its existing data base to include all information relevant to agricultural, forest, industrial, business and community growth with emphasis on assembling information useful in setting intermediate and long-range goals. At the time of this legislation, DNR was operating a data base that had been evolving over a period of 15 years. The department's remote sensing and geographic data base experience started with the state land inventory and the origin of the aerial photographic procurement program in 1958. The unique aspect of this inventory program at this early stage was the means by which the DNR contracted to collect aerial photography to service the inventory. In order to adequately photograph the extensive scattered state holdings, the DNR realized that it was necessary to collect photography of adjacent private lands and fly these photographic flights cooperatively with other landowners to make the flights economically feasible (9:512-521).

The DNR's original inventory consisted of producing standard forest type maps and has evolved into a computer-based Gridded Resource Inventory Data System (GRIDS). Several years ago, a digital mapping system was acquired to assist in the department's orthophotographic mapping program and to provide a method for displaying soil and forest productivity maps produced by the Private Forest Land Grading Program. More recently, DNR has been investigating the feasibility of developing a statewide GIS using grant funds from the Pacific Northwest Regional Commission (PNRC). This effort has created the framework of a statewide GIS by completing initial design/planning work, expanding the technical capability for processing geographic data in Washington, and demonstrating applications of geo-processing to resource planning/management agencies (5).

Experience gained during the past ten years has led DNR to believe that a statewide information system, if properly designed, is technically feasible and economically viable. This work has led to the drafting of legislation to create a cooperative statewide geographic information system. On January 30, 1981, Senate Bill 3369 was introduced in the Washington State Legislature and calls for the establishment and maintenance of the State Geographic Information Service Center.

The responsibilities of this center include the collection and dissemination of base mapping information, survey information, information contained in the state's Land Use Data Bank, aerial photographs acquired by DNR, names acted upon the State Board of Geographic Names, and geographic information generated by other state agencies, and, if appropriate, federal agencies and private organizations. This service center would operate from a non-appropriated revolving fund, which means the facility would be entirely user-supported. Therefore, unless the system is cost-effective and provides cooperators with required services and products, it will operate successfully. This concept differs from the procedures suggested by Caulkins and Tomlinson, who state that the operators of a GIS be given "direct authority to specify additional data collection programs by other public agencies ... or to modify existing programs of other agencies..." (1:306). Under the Washington concept, the operators of the system and the users of the system would jointly agree to data content, definition and standards. Users would be responsible for data input and update and would be charged for output products/services. In this way, the statewide GIS concept must be cost-effective in the eyes of the user and responsive to the cooperators.

Influence of State Procurement Regulations

In the State of Washington, all purchases of computer equipment including equipment for geo-based information systems, is controlled by, and needs approval from, the State Data Processing Authority. This organization is unique because it reports only to the legislature. The DPA prepares standards and regulations by which computer systems are purchased and operated. The role of the DPA is, at times, controversial, but this authority does insure that computer systems are compatible and are not being installed where they are not needed. Review and scrutiny by the DPA assures a well-planned, designed and operated system.

Feasibility Study

Currently (December 1, 1980 - February 28, 1981), the DNR has a feasibility study under contract. This contract was awarded primarily to investigate the feasibility of developing a new DNR geo-based information system to replace GRIDS, but is being conducted in such a manner as to also take note of the need for a statewide system.

The primary objective of the development work is to investigate the possibility of integrating all existing DNR information systems (GRIDS, TRAX, AIMS) and develop new capabilities for a single, effective management system, thereby allowing the department to be more cost-effective in meeting its goals and objectives. The second objective is to implement a GIS that will also serve needs (not 100%) of other agencies - state, local and federal, and be compatible with similar systems in Oregon and Idaho.

The RFP for this feasibility study calls for a user needs assessment, but this is based on previous studies from two sources: (1) the in-house work done by the Resource Inventory Section staff regarding department needs for a new system done over a period of two years; and (2) Washington State agencies user needs for a statewide system were identified through previously discussed PNRC-funded projects. The feasibility study also will include recommendations for alternative systems which meet minimum DNR requirements in the areas of data base design, analytic capability, input and output capability, and system requirements. Finally, this study includes a cost analysis for each of the alternatives.

System Selection Procedures

DNR selection procedures consist of: (1) careful research into existing system capabilities; (2) user needs surveys within and outside the DNR to match system capabilities and needs; (3) examination of technical operating characteristics of existing systems using a questionnaire sent to vendors; (4) site visits to in-place systems for operational evaluation; (5) review of service record of vendor, and (6) acquisition, service and update costs. This approach allows a thorough examination of system capabilities and design characteristics and their effect on users, a view of the in-place operation of several types of systems, discussions with operating personnel, and a good indication of total long-range costs. The selection process will involve a multi-disciplinary staff composed of personnel with a variety of backgrounds in data processing, geo-processing, resource management, and resource applications of geographic information systems. Presently, two options for operating a GIS exist: (1) use existing hardware at one of several state service centers, or (2) acquire a dedicated computer to operate the system. A decision will be made in the near future.

Summary

DNR has been operating an information system to service proprietary needs for 25 years and is now in the process of developing a new in-house system with the goal of making it expandible into a state system to make common resource data used by all agencies more universally available and compatible. DNR is in the process of conducting a feasibility study to create a geo-based system to serve seven area offices and headquarters personnel. No hardware has been acquired to date, however, two options are being considered. These include the acquisition of a computer or the use of existing service center facilities. In either case, it is envisioned that remote work stations consisting minimally of a CRT, plotter, digitizer and a minicomputer will be tied through a distributed processing network to a main database. Any agency can then tie in and use/add to this state data base.

We make the following general recommendations, but this list is by no means exhaustive:

Administrative --

- obtain approval from executive management/legislature to develop a system.
- transfer the authority to develop the system to technically competent staff personnel.
- seek cooperation from all resource/planning agencies.
- establish system in an environment that allows long-range flexibility, but can meet short-term user project needs.

Technical --

- recognize that your use is unique.
- plan for incorporation of rapidly emerging technologies.
- do not adapt your needs to a rigid system.
- make system easily expandible through rapid cost-effective upgrades to meet changing needs.

ENERGY APPLICATIONS (PARALLEL SESSION)

A OVERVIEW & UTILITIES USE OF REMOTE SENSING

William R. West (Environmental Specialist - Southern California Edison Company - Los Angeles, CA)

Interest in applying remote sensing technology to the solution of our energy problems has increased substantially in recent years. Data obtained through remote sensing is being used to explore alternative energy sources, search for new energy supplies of oil and other fossil fuels, review the environmental impacts of energy projects, forecast energy needs and plan for siting of new energy facilities.

Why is there such interest in using remote sensing in the energy field? Is it due to our interest in a new tool which promises to meet our expanding data needs at ever decreasing cost? Or is it just a new and expensive toy which attracts our attention, but has no real or lasting applications?

Today's panelist will review applications of remote sensing imagery, such as low altitude photography or LANDSAT, in the field of energy exploration and research. As we shall see, remote sensing technology has been tested and proven useful in many applications, but, in other cases, more work and development still is required before it can be considered a useful tool.

I will begin the discussion by reviewing Southern California Edison's involvement in using remote sensing. Then we will review with Ms. Kitcho the use of remote sensing in oil exploration and nuclear siting. Mr. Willis, of the Westinghouse Company, will talk about some new work being undertaken by the Electric Power Research Institute. And lastly, Mr. Harnden, President of Area Information Systems, will talk about using LANDSAT in developing energy related data bases.

B OIL EXPLORATION & NUCLEAR SITING

Catherine A. Kitcho

(Consultant - Woodward - Clyde Consultants -
San Francisco, CA)

The emphasis on energy development in the past few years has caused an upswing in oil exploration, and may soon cause a revival of nuclear power plant siting (rekindled perhaps by the present administration). Remote sensing, more than ever, will become an even more valuable tool in both nuclear and petroleum development. During the past ten years, remote sensing technology has advanced to a point where it is an inexpensive and viable tool for exploration and siting.

The oil industry has experimented with many types of remote sensing imagery (aerial photography, SLAR and LANDSAT), to test its ability to define geologic structure, and therefore to aid in identifying exploration targets. Efforts by private industry and the GEOSAT Committee have produced realistic case studies that showed a high degree of success in using remote sensing as an exploration tool. Research now being conducted may identify ways to combine remote sensing data with subsurface geophysical data to develop an even more accurate exploration approach.

Remote sensing data of various spectral types has been routinely used in nuclear power plant siting, both for geologic and environmental studies, throughout the 1970s. In the last 1970s, the Nuclear Regulatory Commission recommended that LANDSAT imagery be consulted, and that lineament studies should be conducted during geologic investigations of nuclear power sites. During licensing hearings and occasionally after the licensing phase, requests have been made by reviewing agencies or interveners to interpret remote sensing imagery (if it hadn't been done), or to evaluate published lineaments near a power plant site. Renewal of nuclear siting investigations should see a continued or even greater involvement of remote sensing data in siting programs.

Related to nuclear power development are the current nuclear waste management programs. The DOE programs for geologic repositories that have been started during the last three years have utilized remote sensing data for geologic reconnaissance and also ground mapping. These new programs make use of all the state-of-the-art geologic techniques that are currently applicable, and remote sensing interpretation is being included as part of the investigation effort.

C NEW RESEARCH LOAD FORECASTING & PLANNING USING REMOTE SENSING

H. Lee Willis (System Analyst Engineer - Advance System Technology -
Westinghouse Corporation - Pittsburgh, PA)

The effective, comprehensive planning of the power distribution system for a large urban area requires as its foundation a projection of the future electric demand. The electric distribution system is composed of substations, feeders, and other equipment that must be located near the electric load which it serves. Therefore, the projection of future load must be done on a geographic basis with sufficient resolution to plan the locations of such equipment. Such load forecasting is called small area, or spatial, load forecasting, and involves projecting future electric demand on a uniform grid-type basis, typically 160 acres. The most accurate forecast methods have been urban growth simulation models of a land use simulation type. These forecast methods require extensive data on past and present land use type and density on a small area basis. Such data obtained by normal means is often difficult to obtain, expensive, and prone to error. LANDSAT data, through computerized interpretation to land use, seems to offer a better data source.

To summarize, LANDSAT data's advantages for electric utility forecasting are perceived to be:

TABLE I
LANDSAT ADVANTAGES IN LOAD FORECASTING

- 1 More consistent identification of land use from year to year.
- 2 More accurate identification of land use.
- 3 Availability of historical data for the past several years.
- 4 Rapid data update capability.
- 5 Lower cost.

The author agrees with (1) and (3) above, but has seen no proof that LANDSAT data offers more accuracy, quicker update, or significantly lower cost as a source of data for electric utility load forecasting.

TABLE II
LANDSAT-ELECTRIC LOAD FORECASTING RESEARCH PROJECTS

<u>PROJECT</u>	<u>INVESTIGATORS</u>	<u>COMMENTS</u>
EPRI RP-570 1975-1979 Contractor - Westinghouse	V.F. Wilreker (Westinghouse) C.L. Brooks (Westinghouse)	Used 160 acre resolution and MLM identification on Phoenix, Arizona area
Houston Light & Power Co. 1978-1980	H.L. Willis (now with Westinghouse) J. Gregg (now with Boeing Computer) M. Heffler (now with Schlumberger) R.J. Earhart (now with TRW Controls) C. Harlan - Texas A & M University	Used both DIRS and VICAR software and 40 acre basis. Chief conclusion was that LANDSAT data could be accurately overlaid onto a utility data base.
Canadian Electric Assoc. Project 079 D 186 Contractor - Westinghouse	H.L. Willis (Westinghouse) C.L. Brooks (Westinghouse) A.J. Gray - City of Calgary	In progress

There have been to the author's knowledge, only three serious attempts to use LANDSAT data for small area load forecasting, shown in Table II. The author is familiar with all three projects and draws from them the following general conclusion:

- 1 LANDSAT data, interpreted by computer to land use class on a small area basis, normal classification methods, is as accurate statistically as manual interpretation of low altitude photography.
- 2 LANDSAT data is perhaps slightly more accurate in detecting valid, real, land use change than any other method.
- 3 LANDSAT data is much less prone to false change detection.
- 4 In a real world situation, an electric utility faces roughly the same update period (six months) and cost using LANDSAT or aerial photo interpretation.

In addition, LANDSAT does offer one advantage that will perhaps eventually lead to its wide use in electric utility forecasting, its universal availability. Small area load forecast systems of the current state of the art are complex and expensive. The universal availability of LANDSAT means that (at least theoretically), one software system can be developed around LANDSAT data that will be universally applicable. Use of manual interpretation of land use involves a considerable start up cost for each utility, much of which is avoided if a "canned" system using LANDSAT data is substituted. To date, no research project has verified that a single LANDSAT-based system will be universally applicable.

Further research needs to be done in LANDSAT applications to electric utility electric load forecasting:

- 1 Improved land use classification algorithms. Most existing classification methods were developed for agricultural analysis. Different algorithms for urban land use identification may be more accurate.
- 2 Resolution. LANDSAT's advantages over other methods may increase at higher resolutions (small area sizes).
- 3 Universal applicability. Research is needed to confirm that the same LANDSAT identification software will work on different areas.

Budget constraints are often over stressed. If one bases an estimate of the cost of conducting a mapping effort on the use of low altitude air photos , the estimated cost can be staggering; but, in the construction of regional data bases, it is medium to high altitude imagery which is most often applied. The budget for map construction in an automated mode may seem small (a few hours on a computer and then a run on a laser film recorder). The average price per single LANDSAT scene is just under \$10,000 when a classified image is produced. But, when the system development and signature development work is added, this price increases considerably. Most significantly, however, is the fact that each computer run produces a map of a single parameter, while by applying Integrated Terrain Unit Mapping techniques, photo interpretation can produce a map of several parameters at the same time.

Automated classification systems require a more substantial investment in hardware, the use of more highly trained and therefore higher paid personnel, and ultimately deliver a more limited product -- hardly a help to the budget!

In many cases, the absolute size of the study area under consideration is less important than the required mapping resolution, the complexity of data classification, etc. The larger the study area, in fact, the more efficiently it can be mapped because of the normal economies of scale which effect nearly all production efforts. Using no more than 10 or 12 employees per project and averaging three to four projects at one time, AIS has mapped over 300,000,000 acres over the past five years. The same can be said for many other remote sensing firms throughout the United States.

Limitations of LANDSAT

1 Coal Mining and Petroleum Extraction

For both coal mining and petroleum extraction, manual interpretation of LANDSAT, combined with existing mapped information, serves to produce 1:250,000 scale data bases suitable as tools for making yes/no decisions for high/moderate/low rankings. These data bases are also useful for identifying the existence of potential environmental or land use issues which require further in-depth studies.

2 Capability/Suitability Mapping

Site selection for electricity production and distribution facilities requires detailed inventories of a wide variety of information. For example:

● Integrated Terrain Unit Map —

Landform
Surface configuration
Slope
Geology
Soil
Land Use
Vegetation

● Administrative Units —

Counties
Cities
Regional Governments
Water Districts
Sanitation Districts
Air Pollution Control Districts
Utility Districts (Electric)
Land Ownership

● Special Physical Features —

Earthquake Faults
Earthquake Epicenters
Mines
Volcanoes and Cinder Cones
Cliffs and Bluffs

● Infrastructure —

Highways
Railroads
Airports
Navigation Aids
Pipelines
Telephone Lines
Canals and Aqueducts
Energy Transmission Lines
Microwave Stations

- Special Reserved Features —

- Parks
- Reservations
- Campgrounds
- Rest Areas
- Wildlife and Botanical Reserves
- Other
- California Natural Areas Coordinating Council Natural Areas

- Hydrology —

- Stream Course
- Springs and Oases
- Flood prone
- Watersheds
- Groundwater

- Climate

3 Census Tracts

Manual interpretation of LANDSAT scenes together with comparison to published data can produce some improvement in location and delineation of natural features; however, to date, no effort at automated classification of these variables has proven entirely satisfactory.

In these instances, where information must be recorded within \pm a few hundred feet, pixel resolution is not adequate and data sources with better resolution must be relied upon.

4 Energy Load Forecasting

Load forecasting based upon land use inventories and change detection seems to be an area where LANDSAT data can be used in a purely automated mode. Limitations still exist in most land use classification schemes allowing discrepancies or unclassifiable categories to account for 15 to 20 percent of the area classified. In mature, urban settings, this percentage would often equal or exceed the amount of land use change which occurred.

5 Solar Energy Assessment

For solar energy assessment, one technique first tried by JPL and then adopted by AIS involved the statistical sampling of rooftop space available by land use type and then application of the resulting rooftop coefficients to the overall land use inventory of an area. This technique is, of course, subject to the same limitations as is load forecasting based upon land use inventories. It is also difficult to apply accurately using LANDSAT data alone.

Summary

AIS is a firm whose sole function is to construct geographic data bases for use in planning and analysis. To date, our experience in creating such data bases for use in energy-related efforts is that LANDSAT is adequate for general inventories where few data categories are required, where resolution of data to around 150 acres minimum is required, and where no other complete imagery set can be obtained.

APPENDIX A

SPEAKER PROFILES

ALLEN Richard

Mr. Allen is currently Chief, Remote Sensing Branch of the Economics and Statistics Service (ESS) of USDA. In addition to the Remote Sensing activities of ESS, Rich Allen serves as the Manager of the Domestic Crops and Land Cover Project in a multiagency Research program to utilize Remote Sensing for Agriculture and Resource Inventory surveys.

He originally worked in Remote Sensing activities from 1968-1971 and was assigned the major responsibility for the Sample Selection and Data Collection for the 1971 Corn Blight Watch Experiment.

Allen's assignments within ESS since 1971 have included Section Head for Yield Research within the Statistical Research Division; Assistant Statistician-in-Charge of the Illinois State Statistical Office; Head of the Crops, Prices and Labor Group of the Statistical Methods Staff; and Leader, List Frame Project Team. The List Frame Project was a multi-disciplinary effort within ESS to develop and implement methods for improving list sampling frames for State Statistical Offices.

Mr. Allen completed one year of graduate level statistics through a ESS training program before transferring to Washington, D.C. in 1968. He received his degree in Agricultural Economics from Iowa State University. As an undergraduate, he was a member of Gamma Sigma Delta, the honor society of agriculture, and Phi Kappa Phi, scholastic honorary for colleges of science and technology.

ANDERSON James

James Anderson has served in his present position with the Alaska State Department of Natural Resources for two years. He is responsible for providing technical planning advice to the Division Heads and Directors of the Department.

In addition, he operates within the Department as an information transfer specialist. Anderson serves as Principal Alaska Coordinator for the NASA Western Regional Applications Program (WRAP). During the last two years he has worked on the coordination of NASA/DNR high altitude imagery applications in the South Central Demonstration Project involving the Susitna Basin and on the design and implementation of a similar program in the Tanana Basin. He is presently involved in the development of orthophoto coverage for the State.

Before joining the Department, Anderson worked for the following: Boeing Corporation for 18 years; Calista Alaska Native Corporation for 2 years; and the Alaska Federal/State Land Use Planning Commission for 3 years.

Anderson's formal education is in engineering.

BALCEREK Thomas

Thomas W. Balcerek joined the University of South Carolina Computer Services, Graphics Section in January 1977. He is responsible for maintaining and directing the section's computer. Balcerek handles or directs the implementation of all hardware and software to be used with the computer as well as overseeing systems operations.

Prior to joining USC Computer Services, Dr. Balcerek was in the Physics Department at the University of South Carolina working on projects using Mössbauer Spectroscopy.

Dr. Balcerek received his Bachelor's degree from Canisius College and his Phd from the University of South Carolina. Both degrees are in Physics.

BILLINGS Howard

Howard Billings currently serves as EDP Programmer Analyst III for Arizona's Department of Water Resources. His responsibilities include programming in hydrology models, development of systems for staff members on Honeywell 6000 and installation and operation of VICAR/IBIS.

Billings received a BS in Economics from the University of Nebraska at Omaha.

BONNER William Jr.

Since joining the Bureau of Land Management, William Bonner has been responsible for the development and implementation of programs utilizing remote sensing data for inventory applications.

Previously, he was affiliated with the USGS Center of Astrogeology in Flagstaff, Arizona where he developed techniques for extracting lunar planetary slope information from orbital photographs. This data was utilized in the selection of the Apollo landing sites.

Bonner was also associated with the USGS Branch of Regional Geophysics in Denver, CO., and participated in a number of studies utilizing spectral radiometers and multispectral scanners for geophysical applications.

Mr. Bonner received his BS in Physics from St. Mary's University, San Antonio, Texas in 1962. He later received a BS in Mathematics from the same university and earned an MS in Physics at the University of Texas.

BURNS Anthony

Anthony Burns has been Senior Planner for the Municipality of Anchorage for the past five years. His responsibilities include natural resource inventories and data systems development. He has been project manager for the development and implementation of a Coastal Management Program. For a number of years, Burns has served as Instate Project Coordinator for NASA efforts in Alaska. Before coming to the State, he worked for a number of private corporations. Between 1972 and 1974, he was involved in remote sensing and information system design at North American Rockwell Corporation. Subsequently, Burns spent two years as Alaska Regional Manager for the Geoscience Division of GeoSources International. Following this, he served as Executive Vice President of Esca-Tech Corporation.

Burn's formal education is in geography with specialization in remote sensing and land use planning and management.

CAMPBELL, Louis F. Jr.

Lou Campell is a State Cartographer and Chairman, Colorado Mapping Advisory Committee. His cartographic experience has been continuous since 1951 and includes service in the former U.S. Coast and Geodetic Survey, the U.S. Army Map Service Far East in Tokyo, Japan and as a Cartographic Officer in the U.S. Air Force.

Prior to his present appointment, he was an instructor of cartography at the University of Colorado where he also received a Ph.D. with specialization in cartography.

COTTER Daniel

Daniel Cotter is the Acting Director of the Office of User Affairs of NOAA's National Earth Satellite Service.

He has been with the National Earth Satellite Service for the past eight years, working in areas related to system definition, system integration, user applications development, and product development.

Cotter was an Air Force meteorologist for twenty years and taught mathematics at the University of Maryland for a number of years. He holds B.S. and M.S. degrees from the Florida State University in mathematics and meteorology.

DERRENBACHER William

William Derrenbacher has been associated with Environmental Systems Research Institute (ESRI) since 1971. ESRI is a consulting firm specializing in Geographic Information System (GIS) design, development, installation and application. Derrenbacher presently serves as general coordinator of consulting services and overall manager of ESRI contracts for data base development and application. Since coming to ESRI he has been involved in some twenty projects involving GIS design, implementation, and application.

In addition, in 1978, Derrenbacher participated in the development of an environmental impact assessment training program for U.S. HUD and was the lead member of the training team which presented the week-long course for 50 HUD staff members from local and regional offices as well as senior research staff from the Washington headquarters.

During the past year he has managed projects in California, Alaska, Venezuela and Nigeria and has directed two projects involving the application of a nationwide GIS for the United States.

Derrenbacher was on the faculty of the University of California. He held the position of Lecturer in the Department of Earth Sciences at Riverside from 1969 to 1972 and Assistant Professor in the Department of Geography at Davis from 1972 to 1975. While at Davis he was an adviser in the Graduate Program in Ecology.

Derrenbacher's formal education is in Geography, with specializations in ecology and resource management.

DUNDAS Tom

Tom Dundas is Administrator, Research and Information Systems Division, Montana Department of Community Affairs where he directed the development of and maintains a statewide information system. Included in the Division are a State Census Data Center, a National Cartographic Information Center State Affiliate, a statutory information retrieval system and many other large data base systems. The Division also provides economic analyses and population projections and has developed several computerized components for mapping economic social and natural resource data.

Prior to his present appointment Dundas was Director of Program Planning and Control in the Ocean Systems Division of North American Aviation Corporation.

He received a BS in Mechanical Engineering from Montana State University.

EBY James

James Eby is currently a research association at the University of Washington Remote Sensing Applications Laboratory.

Through university service and private consulting, Eby has contributed to remote sensing projects on local, state, and federal levels, concentrating on the areas of land cover mapping and wildlife habitat assessment.

He received a B.S. in Biology from Ursinus College in Pennsylvania and an M.S. in Forest Resources from the University of Washington.

ERB R. Bryan

R. Bryan Erb serves as Manager for the Earth Resources Program Management Office at Lyndon B. Johnson Space Center, Houston, Texas.

He is widely experienced in the field of aerospace technology. Prior to his present position Erb has served in various spacecraft engineering roles in structural, mechanical and thermal systems and as Manager of the Lunar Receiving Laboratory of the Johnson Space Center. He has been awarded the Athlone Fellowship and the MIT Sloan Fellowship and is a member of the American Institute of Aeronautics and the Ontario Profession Engineers.

Erb earned a B.S. Degree and an M.S. Degree from the University of Alberta; an M.S. Degree, Cranfield Institute of Technology, Cranfield, England, and an M.S. Degree in Management, Massachusetts Institute of Technology.

FLEMING Michael

Michael Fleming joined Technicolor Graphic Services (TGS), Inc. at the USGS/EROS Field Office in May 1980. He heads the Data Analysis Laboratory with responsibilities for managing and maintaining IDIMS, providing data analysis assistance to system users and assisting in training courses.

Mr. Fleming was a Research Associate at the Laboratory for Applications of Remote Sensing (LARS) and a Ph.D. candidate in the Department of Forestry and Natural Resources, Purdue University before joining TGS/EROS. His emphasis has been on the design, development and statistical evaluation of computer-aided analysis techniques for applications to natural resource management.

Mr. Fleming received a B.S. in Forestry Management from Northern Arizona University (1973) and a MSF in Forest Remote Sensing from Purdue University in 1977.

FRIEDMAN Steven

Steven Friedman has been a member of the Image Processing Laboratory Staff at the Jet Propulsion Laboratory since 1977. During 1977 to 1980 he was cognizant researcher of the Census-Urbanized Area Project at JPL. Currently, he is managing an IBIS demonstration project for the U.S. Army Engineer Topographic Laboratories.

Mr. Friedman's research has emphasized the development of image processing technology for the mapping of land cover from Landsat and other forms of cartographic data. Other topics of interest are the development and transfer of cartographic theories and technology to image processing and information systems.

He received his Master's degree in Cartography from the University of Wisconsin - Madison in 1979.

GEORGE Tom

Tom George is currently an Applications Specialist at the University of Alaska - Fairbanks Geophysical Institute. His past experience includes participation as a Remote Sensing Consultant with the National Petroleum Reserve Alaska, BLM, in 1977. In addition, during 1979, George taught remote sensing short courses at the University of Alaska.

George received a B.S. in General Science from Oregon State University. He has earned an Oregon Teaching Certificate in Secondary Science, and an Alaska Teaching Certification in Secondary Chemistry.

GIALDINI Michael

Michael Gialdini is a senior member of the technical staff at ESL Incorporated, Sunnyvale, California

GROSS Mark

Mark Gross is a Water Resource Analyst for the Idaho Department of Water Resources. His responsibilities include user training and applications with existing digital image processing software (VICAR/IBIS and System 511), software maintenance and support, and participation in the development of additional image analysis and geographic information system capabilities.

Prior to joining the Department of Water Resources, Mr. Gross worked as a geologist in geothermal exploration and applications.

Mr. Gross received his B.S. in Geology from Boise State University.

HAAS Dr. Robert

Dr. Robert Haas serves as the Principal Applications Scientist - Bioscience Section for the Applications Branch at the EROS Data Center, Sioux Falls, South Dakota.

HARDEN Eric

Eric Harnden is President of Aerial Information Systems (AIS) of Crestline, California. Under his direction AIS has now performed interpretation of remotely sensed imagery for areas of the earth totaling more than 200,000,000 acres (more than 300,000 square miles). AIS has produced both manually drawn maps and manuscripts for subsequent automation and inclusion in automated geographic information systems.

AIS has worked on more than a dozen U.S. and foreign projects related to energy development and distribution. Clients on these projects have included such U.S. organizations as the Lawrence Livermore Laboratory, Pennsylvania Power and Light, Southern California Edison and Pacific Gas and Electric; and such foreign clients as ministries for national development and petroleum development in Nigeria and Venezuela.

HARDING Roger A.

Roger Harding is Manager, Resource Inventory Section, Washington Department of Natural Resources. His present assignment includes responsibilities for the management of the state-owned land resource program and cartography, photogrammetry and remote sensing. Harding is past chairman of the Southeast Washington Chapter and present chairman of the Photogrammetry Working Group of the Society of American Foresters. Additionally, he is Chairman of the Washington Mapping Advisory Committee and a member of the American Congress on Surveying and Mapping and the American Society of Photogrammetry.

He is a graduate of the University of Washington where he received a B.S. in Forest Management.

HEDRICK Wallace

For the past six years Wallace Hedrick has been chairman of the Pacific Northwest Regional Commission's Technology Transfer Task Force and project Director of the Land Resource Inventory Demonstration Project (LRIDP) and the Landsat Application Program (LAP). He is the head of Resources Northwest, Inc. in Boise, Idaho.

Mr. Hedrick holds both a Bachelors and Masters degree in Planning and Management.

HENDERSON Frederick B. III

Frederick B. Henderson III is an exploration geologist and presently serves as the President of The Geosat Committee, Inc. and is a member of its board of directors. The Geosat Committee, Inc. is a non-profit organization supported by about 100 U.S. and non-U.S. oil, gas, mining and engineering companies. The goal of The Geosat Committee is to present to NASA and other applicable governmental bodies the considered professional recommendations of the nation's largest single industrial group of satellite imaging data users regarding future earth resources satellite systems and their application in the solution of critical resources problems.

Henderson worked as a mining, research, and exploration geologist for St. Joe Minerals; Kaiser Aluminum from 1965 to 1971 and as a consulting economic geologist (HENDCO) from 1972 to 1974. In 1974, he joined The Geothermal Group of the Lawrence Berkeley Laboratory, University of California. During this time Henderson was instrumental in the creation of The Geosat Committee, which he joined at its formation in 1976 as President.

Henderson received his BS and MS in Petroleum Geology from Stanford University in 1957 and 1960 respectively. After serving as Communications and Administrative Officer in the U.S. Navy from 1957 to 1959, he received his Ph.D. in Economic Geology from Harvard University in 1966.

JOHNSON Huey

As California's Secretary for Resources, Huey Johnson assists the Governor in establishing objectives of the Administration and in formulating programs and policies governing the State's natural resources. Towards this goal, the Secretary strives to ensure the protection and balanced management of California's natural resources and environment.

Johnson was former Western Regional Director of The Nature Conservancy, responsible for activities in 13 Western states, including land acquisition, management of over 50 holdings, coordination of volunteer memberships and cooperation with agencies including industry and government.

JOHNSON Kim

Kim Johnson is a Principal Resource Analyst for Idaho Department of Water Resources. He has overall responsibility for the applications of various remote sensing data for state water resource management and for the development of an operational digital analysis capability in Idaho.

Currently, Mr. Johnson is responsible for the operation of the Idaho Image Analysis Facility that has been established at the Department of Water Resources. The facility is responsible for redevelopment, support and applications of digital image analysis. The facility is jointly involved in Landsat applications projects with several state, local and federal agencies in Idaho.

Mr. Johnson received his B.A. from the University of Denver and his M.S. in Geography from the University of Idaho.

KITCHO Catherine A.

Catherine Kitcho is currently chairperson of the Industry Advisory Panel for the California Integrated Remote Sensing System (CIRSS) Task Force, and directed publication of a directory of private remote sensing firms in California.

She has worked in private industry as a geologist and remote sensing specialist for eight years. Areas of emphasis have included remote sensing applications for: nuclear power plant siting (domestic and foreign), nuclear waste management projects, corridor studies for pipelines and transmission lines, fault activity and seismicity determinations, fault studies of the Alaska gas pipeline, effluent monitoring through thermal infrared techniques, and water resource evaluation. She has published technical papers on remote sensing applications for structural geology and civil engineering.

Kitcho received a bachelor's degree in Geology from Michigan State University and did graduate work in remote sensing at the University of Southern California.

KREBS Luke

Luke Krebs is currently the Assistant Director of the Washington State University Computing Service Center (WSUCSC). This Center operates as a non-profit corporation providing computing services to more than 85 agencies and institutions throughout the Pacific Northwest. Mr. Krebs has also been the Principal Investigator for five grants on the installation and operation of image processing software and hardware.

Prior to his appointment as Assistant Director, he was the Customer Services manager at WSUCSC. In this capacity Krebs was responsible for developing, pricing, and promoting the majority of the services now offered by WSUCSC. Before working for WSU, he was a project leader in the Research & Technology Directorate of System Development Corporation, Santa Monica, California. While at SDC he worked as a systems programmer on one of the first time-sharing systems in the industry.

Mr. Krebs received a Bachelor of Geological Engineering degree from the University of Kansas in 1957; a Bachelor of Mathematics Education in 1959; and a Master of Mathematics Education in 1963. He has also completed all of the examination and course requirements for a Ph.D. in Higher Education Administration at Washington State University.

LANGLEY Philip G., Ph.D.

Dr. Langley has been working with natural resource survey and management problems since 1950. During this entire period, he has been integrating remote sensing media, beginning with aerial photography, into resource surveys and information management systems. Since 1960, he has been actively engaged in the unification of resource inventory design theory with computer oriented geographic information systems. In 1969, Dr. Langley designed and implemented the first multi-stage forest survey experiment which integrated data obtained from satellite imagery, aerial photography, and ground measurements into a single cohesive sampling plan.

With EarthSat, he has been in charge of major forest and rangeland surveys in the United States and abroad. In Brazil, he participated in specifying the criteria for developing forest inventory plans for Project RADAM in its early stages. Most recently, Dr. Langley directed a forest inventory and mapping project encompassing nearly one million hectares in Honduras, Central America. As Principal Investigator under NASA's ERTS and Skylab programs, he was in charge of determining the potential of utilizing satellite acquired data in multistage forest inventory methods which he pioneered.

Dr. Langley holds a B.S. in Forestry, an M.A. in Statistics, and a Ph.D. in Wildland Resource Science from the University of California, Berkeley.

LINDEN David

David Linden is Technical Director with Technicolor Graphic Services, Inc., Bureau of Land Management Operations, Denver, Colorado. In the past he served as Resource Assessment Specialist with Technicolor at the EROS Data Center in Sioux Falls, South Dakota.

Linden received his B.A. in Mathematics from Cornell University and his Master's degree in Forest Biometrics from the University of New Hampshire.

LITTLE Gene

Gene Little is Deputy Supervisor - Services for the Washington State Department of Natural Resources. He has been affiliated with the department for more than 20 years, having served as Assistant Division Supervisor - Inventory and Division Supervisor of Technical Services.

He received a Bachelor's degree from the University of Washington, Seattle, and later earned his BSF from the same university.

MASCY Alfred

Mr. Masy has been associated with NASA Ames Research Center for the past 19 years, during which time he has authored more than 30 publications in the area of air and ground transportation systems; alternative energy sources, spacecraft rocket propulsion, space mission analysis, manpower, facility and budget assessments. Mr. Masy was appointed as Assistant to the Executive Secretary of the National Aeronautics & Space Council, in Washington, D.C. in 1971 where he remained until 1973.

Currently, Mr. Masy is Manager of Information Systems & Services for the Western Regional Applications Program (WRAP), at NASA Ames Research Center. His highly developed and specialized expertise includes transferring timely information concerning NASA developed technologies and methodology to the general public.

Mr. Masy is a graduate of Drexel University, Philadelphia, with a Bachelor of Science degree in Mechanical Engineering. He received his Master of Science degree from Stanford University in both Aeronautical and Astronautical Engineering in 1967.

McCORMICK Michael

Mike McCormick is currently with the Local Government Services Division of the Washington State Planning and Community Affairs Agency. Prior to last January 1st, he was on loan to the NASA Ames Research Center where he served as Liaison Officer for the Technology Applications Branch and worked directly with the 14 western states in developing programs to test and implement Landsat/remote sensing techniques within state governments. McCormick has also served as Washington State's representative on the Land Resource Inventory Demonstration Project and the Technology Application Program. He directed state programs dealing land use, environment, housing and the administration of federal planning grant funds. He has worked as a planner for Fresno County, California, San Francisco, and the University of California.

McCormick received a Bachelor's Degree in Geography from Fresno State College and a Masters of City Planning from the University of California, Berkeley.

MOOR Jay

Dr. Moor is a policy specialist with the Division of Policy Development and Planning in the Governor's office, Juneau, Alaska. He is currently the remote sensing coordinator for Alaska's state agencies and, in the past, has participated in the Pacific Northwest Landsat Applications Program while working as a policy advisor for the Washington State Governor's office.

Moor has doctorate and master's degrees in urban planning from the University of Washington and has worked as a city and regional planner in Yugoslavia, Idaho and Korea.

MOUAT Dr. Davis A.

David Mouat is presently a research scientist at NASA's Ames Research Center. He was formerly the director of the University of Arizona's Applied Remote Sensing Program and also served as an assistant professor of air lands and geography.

Dr. Mouat has been involved in a wide variety of remote sensing activities and has taught university remote sensing courses and workshops in this country and overseas.

He completed graduate work in geomorphology and geocology and received his Ph.D. at Oregon State University in 1974.

MUTTER Douglas

Doug Mutter is Chief of Coordination and Technology Applications for the Alaska Department of Natural Resources where he also directs the Alaska Land and Resources System. His experience includes service as a planner and director of natural resource activities and technology applications efforts in remote sensing and computer mapping for the Federal of Rocky Mountain States. Prior to his present appointment he helped establish, then direct the natural resources activities of the Western Governor's Policy Office.

He is a graduate of Colorado State University and received a B.S. in Forestry and M.S. in Resource Planning.

NORMAN Susan

Susan Norman is the current Assistant Branch Chief of the Technology Applications Branch, and Operations Manager of the Western Regional Applications Program.

She received a B.S. in Mathematics from the University of Michigan in 1965. In 1969, she received an M.S. in Computer Science from Stanford University.

Norman joined the Mission Analysis Division at NASA Ames in 1965. In 1974 she was selected to participate in the President's Executive Interchange Program and assigned to Sikorsky Helicopters in Connecticut for a year. She returned to NASA in 1977 to join the staff of the Technology Applications Branch which oversees the Western Regional Applications Program (WRAP).

Her professional interests include fostering the development of Landsat Analysis techniques so that Landsat users can concentrate on use of the data rather than on digital analysis. Norman is married and resides in Cupertino, California.

PARKER Ivan

Ivan Parker is currently a regional ecologist for the U.S. Forest Service, Pacific Southwest Region.

His responsibilities include development of a comprehensive classification system and inventory methodology for coordinated land management planning and implementation for all National Forests within California.

In addition, Parker served as primary author on the CALVEG system, a classification of California vegetation.

He received a B.S. in Forest Management from Humboldt State University and a Master's from U.C. Davis.

PETTEYS Edwin

Ed Petteys has been affiliated with the Hawaii Division of Forestry since 1967.

As a Resource Inventory Forester, his responsibilities involve resource inventories, mapping and remote sensing activities within the Division.

Mr. Petteys received his Forestry degree from Oregon State University, Corvallis, Oregon.

PLOTT Bruce

Bruce Plott serves as a Systems Specialist for the Utah Geological and Mineral Survey, Salt Lake City, Utah.

POULTON Dr. Charles

Poulton joined NASA Ames in 1978 as a Training Officer with Airview Specialists Corporation in support of the Western Regional Applications Program (WRAP). He is also involved as an independent consultant in rangeland management and ecological resource analysis for the development and management of natural resources.

Poulton was Head of the Range Management Program at Oregon State University from 1949 to 1971. In 1972 he served as Director of the Environmental Remote Sensing Applications Laboratory (ERSAL), established under NASA.

Since 1966, Poulton has been involved in research, development and consulting in the use of remote sensing as a tool in resource development and management. He was a Principal Investigator through the Apollo, ERTS and Skylab programs with particular attention to range and land use applications.

Poulton received a B.S. in Forestry and Range Management from the University of Idaho. He received an M.S. from the same university in 1948 majoring in Range/Animal Nutrition and his doctorate from Washington State University in 1955 in Ecology and Soils.

RANEY Dr. William

Dr. William P. Raney became NASA's Assistant Associate Administrator for Space and Terrestrial Applications (Programs) in 1978. His area of responsibility is NASA's program to advance practical applications of space technology to other fields.

After serving as an assistant professor at Harvard and an associate professor at the University of Minnesota, Minneapolis, Raney began his government service in 1962. Until 1964, he was Executive Secretary for the Committee on Undersea Warfare with the National Academy of Sciences/National Research Council.

From 1964 to 1972 he was Special Assistant to the Assistant Secretary of the Navy for Research and Development. He served as Deputy and Chief Scientist at the Office of Naval Research from 1972 to 1977. From 1977 until joining NASA, Raney was Senior Policy Analyst with the White House Office of Science and Technology Policy.

Raney received his bachelor of arts degree (cum laude) from Harvard University, Cambridge, Massachusetts in 1949. He went on to earn his master of science and doctoral degrees in physics from Brown University, Providence, Rhode Island in 1953 and 1955 respectively.

Raney was awarded the Navy Distinguished Civilian Service Award in 1972 and an honorary doctor of science degree from Lawrence University, Appleton, Wisconsin, in 1977.

He is a member of the Society of the Sigma Xi, the American Physical Society, the Washington Academy of Science and is a Fellow of the Acoustical Society of America.

SALOMONSON Vincent

Dr. Vincent Salomonson is the Chief of the Earth Survey Applications Division at Goddard Space Flight Center and the Project Scientist for Landsat-D. Prior to this present position, he served as the Head of the Hydrological Sciences Branch in the Laboratory for Atmospheric Sciences from 1974-1980. Since coming to Goddard in 1968 he has been engaged in studies seeking to assess the applications of space technology to meteorology and water resources management.

Before coming to Goddard he spent three years as a Weather Officer in the United States Air Force (1959-62).

His academic training includes a B.S. degree in Meteorology from the University of Utah (1960) an M.S. degree in Agricultural Engineering from Cornell University (1964), and a Ph.D. in Atmospheric Sciences from Colorado State University (1968). His publication record shows approximately 70 publications in scientific journals, conference proceedings, and NASA reports.

SAWYER Glenn

Glenn Sawyer serves as Chief of the Water Conservation and Use Section, Division of Planning, California Department of Water Resources. He is responsible for statewide land use and water use data collection programs and is a member of an interdisciplinary team which guides studies to derive estimates of future land use and related water management needs in California.

SCHRUMPF Barry

Barry Schruppf is Director of the Environmental Remote Sensing Applications Laboratory (ERSAL) at Oregon State University.

Schrumpf served as an ERTS-1 (Landsat 1) investigator from 1972-1975 and has directed ERSAL since 1974. He has participated actively in NASA's University Program which has brought remote sensing techniques to bear on resource management problems in Oregon, and in the Pacific Northwest Regional Commission's programs: Land Resource Inventory Demonstration Project and Landsat Applications Program. Dr. Schruppf and the ERSAL staff have regularly provided university courses, seminars, workshops and popular presentations regarding remote sensing throughout Oregon, and nationally and internationally as well.

SHADBOLT Lawrence

Lawrence Shadbolt has served as a consultant and project coordinator for a variety of community planning and resource management projects. He is currently on contract with the Pacific Northwest and Southwest Innovation Groups to identify local government information needs and to assess the application of LANDSAT data systems at the sub-state level. Recently Mr. Shadbolt served as Assistant to the Major, City of Portland, responsible for coordination of the final review, amendment and adoption of the comprehensive plan.

Mr. Shadbolt studied program planning in the International Health Department, School of Public Health University of Hawaii (1979). He was a Lasker Fellow at the University of California (Berkeley) where he received a M.C.P. in City and Regional Planning (1968) and a B.S. in Economics and Sociology at the University of Oregon (1964). Mr. Shadbolt was on the faculty of the Urban Studies Center, Portland State University (1972-75) and University of Oregon, Bureau of Governmental Research and Service (1969-71).

SHINN Dr. R. Duane

Professor Shinn is currently associated with the Department of Urban Planning at the University of Washington in Seattle. He is a Co-director of the Remote Sensing Applications Laboratory at UW.

Dr. Shinn has contributed to remote sensing applications in teaching, research and university service with state, local and federal agencies. His expertise and specialization involve urban land use, regional land cover, and reconnaissance of terrain for facility siting.

He has served as Chairman of the University Advisory Committee for the Pacific Northwest Region's Landsat project, acted as consultant for the Federal Power Commission use of remote sensing in routing and siting Alaska natural gas facilities and co-authored Remote Sensing for Planner (Rutgers, 1979).

SLOSKY Leonard

Leonard Slosky serves as Assistant to the Governor of Colorado for Space and Technology. In addition, he is Staff Director of the Natural Resources and Environment Task Force for the Intergovernmental Science, Engineering and Technology Advisory Panel, Executive Office of the President.

Slosky received a B.A. in Environmental Technology Assessment from the University of Colorado in 1975.

SONNEN Dave

Dave Sonnen is Staff Forester (Resources) in the Colorado State Forest Service and Chairman of the Colorado Geographic Information Systems Work Group.

His prior experience includes forestry and ten years in automated data processing. He received a B.A. degree in Forestry from the University of Georgia and is presently engaged in an M.A. program in ADP Management at Colorado State University.

SUNDIE Dennis

Dennis Sundie is an economist with the Arizona Department of Water Resources. His experience within DWR includes responsibility for agency environmental activities and development of a remote sensing program.

Sundie received a B.A. in Economics from Duquesne University in Pennsylvania and an M.S. in Agricultural Economics from the University of Arizona.

SYVERTSON Clarence

Clarence Syvertson is the Director of NASA's Ames Research Center near Mountain View, California. He has held this position since April 1978.

Prior to his appointment as Director, Syvertson was Deputy Director of Ames Research Center. In 1970-71, he served a year-long detail with the Department of Transportation in Washington where he was Executive Director of the Joint DOT-NASA Civil Aviation Research and Development (CARD) Policy Study. In 1971, he received the NASA Exceptional Service Medal for his leadership of the CARD Policy Study. Earlier awards include the Lawrence Sperry Award of the American Institute of Aeronautics and Astronautics and the Space Act Invention Award (shared with three others). He was named a Fellow of the American Institute of Aeronautics and Astronautics in 1976, and a Fellow of the American Astronautical Society in 1978. Recently he was elected to the National Academy of Engineering.

Syvertson earned a Bachelor of Aeronautical Engineering degree from the University of Minnesota in 1946, and an M.S. degree from that school in 1948. He is also a 1977 graduate of the Advanced Management Program of the Harvard Business School.

TESSAR Paul

Paul Tessar is currently Senior Project Manager of the National Conference of State Legislature's Natural Resource Information Systems Project. He is responsible for providing technical assistance to state legislators on remote sensing and natural resource information systems, and for representing state interests on these topics to the Federal government.

Previously, Tessar was the Director of the South Dakota Planning Information Service where he was responsible for the design, development and management of the South Dakota Land Resource Information System. The system includes operational capabilities for Landsat and other remote sensing analysis and applications, for analyzing natural resource data such as soil surveys and digital terrain data, and for synthesizing interpreted remote sensing and natural resource data into composite maps. The Planning Information Service worked extensively with state and local agencies in South Dakota on various planning, management and monitoring projects requiring data on land resources.

Tessar received a Master's Degree in Regional Planning from the University of Illinois at Urbana in 1974. Major areas of study and research included quantitative methods, automated resource information systems and remote sensing techniques and applications.

THORNHILL Ronan

Mr. Thornhill, Forester & Resource Planner for the Nevada Division of Forestry, is responsible for the statewide Forest Inventory Program which is being conducted in conjunction with the U.S. Forest Service and the Bureau of Land Management (BLM). In addition, he is responsible for the Pilot Forest Inventory using the techniques of Landsat imagery and high altitude aerial photographs. He is Coordinator for the division's program planning effort between the state office and three area offices.

Mr. Thornhill is a graduate forester from the University of Nevada, Reno, with a minor in Recreation & Military Science (Commissioned 21st U.S. Army).

TOSTA-MILLER Nancy

Nancy Tosta-Miller joined the California Department of Forestry as a soil scientist in 1976 and later moved into the Forest Resources Assessment Program (FRAP) to conduct remote sensing and soils work. She is currently project manager for CDF's contract with NASA Ames to carry out Landsat projects.

She received a B.S. and M.S. from the University of California at Berkeley in Soil Science and Plant Nutrition.

TOUSIGNANT Thomas

Thomas Tousignant has held the position of Manager of the Forecast and Analysis Center for six years. He is responsible for the development, operation and maintenance of the CAO spatial information system for urban and social research. This system provides on-going data support to the County Development Monitoring Program, the County Housing and Community Development Program, and the County Transportation Planning Program, among others.

Tousignant is also responsible for coordinating all efforts of all County departments and agencies related to the 1980 census and will be responsible for performing all analyses carried out by the County on the 1980 census data.

Before assuming his present position, Tousignant was with the County Road Department for 11 years. During that time, he held the position of County Traffic Engineer and County Transportation Planning Engineer. His formal education is in engineering and business administration. He is a registered civil engineer and traffic engineer.

TUYAHOV Alex

Alex Tuyahov is Chief of the Space Applications Branch at NASA Headquarters and is responsible for applications development and transfer of remote sensing to the public and private sectors.

Before coming to NASA, Tuyahov was responsible for project management and marketing at Earth Satellite Corporation and was Natural Resources Coordinator in the Governor's Office of the State of Texas. His additional experience was as Director of System Analysis at Texas Instruments in the design and development of data acquisition and intelligence extraction systems and as a Captain in Air Force Intelligence.

Mr. Tuyahov received a Bachelor's Degree from Rutgers University and a Master's Degree from the University of Texas in Physical Science, and a Masters of Science Administration from George Washington University.

Tuyahov has 17 years of experience in remote sensing and information systems developments both in the civil and defense sectors.

VANDENAKKER Jack

Jack Vandenaeker is currently a remote sensing specialist with Standard Oil. He has been affiliated with the company since 1954, and served as a photogrammatist until 1976.

In addition, Vandenaeker was a geological assistant with Shell Oil Co. from 1946 to 1953.

He was born and educated in the Netherlands.

WEST William

William West has been active in the field of remote sensing since joining Southern California Edison in 1977. He has directed the company's involvement in regional growth studies and automated land use information systems utilizing remote sensing. His interests include using land use data obtained through remote sensing to improve energy load forecasting and distribution planning. In addition, he is involved in studying the environmental and siting problems of alternative energy sources such as geothermal and wind power.

West has worked closely with government agencies in Southern California, consulting with them on how to improve their information systems and assisting them in the development of automated land use data systems. He is currently working jointly with NASA and the Environmental Systems Research Institute to familiarize the electric utility industry with land use data and remote sensing techniques.

West has a Master's degree in Economics from San Diego State University and completed advanced work in Urban Planning from the University of California, Irvine. He taught at the University of San Diego from 1972 to 1973.

WHERRY David

Wherry currently manages development and application of digital image processing at Washington State University Computing Service Center. Since his arrival in Washington last year, Wherry's major efforts have included direction of redocumentation of the VICAR/IBIS image processing system and preparation of training courses in system use.

Trained as a geographer, he has worked the past six years in geo-information retrieval and processing research and applications. Gaining a broad base of photo interpretation and information mapping skills at the California Department of Water Resources, Wherry moved to a systems analyst position at the Image Processing Laboratory of the Jet Propulsion Laboratory (JPL). There he worked closely with image based information system applications addressing resource and land use assessment problems. Now in Washington, Wherry feels that his emphasis has shifted to the development of a broader range of image processing applications.

WILLIS H. L.

Mr. Willis joined Westinghouse Advanced Systems Technology in 1980 working in the Distribution Planning Group. His main activity centers around distribution planning studies and development of improved special load forecast methods. Currently his work includes developing urban modeling procedures for spatial load forecasting. He recently developed a successful method applying two dimensional signal theory to the evaluation of power system load forecast error design sensitivity.

Mr. Willis was associated with Houston Lighting and Power Company where he initially worked on a variety of power engineering problems, including SCADA, field construction, protection criteria, substation design and system planning. While at HL&P he became involved in small area load forecasting, providing some of the initial research in that area while supervising HLSP's Load Analysis group. Mr. Willis also supervised their Generation Analysis group in loss of load probability and generation performance analysis.

From 1975 to 1979 Mr. Willis was also an advisor to EPRI on load forecasting for distribution planning. He was 1979 Chairman of the Texas Interconnected System's Installed Reserve Criteria Task Force and co-chairman of the ERCOT-Southwest Power Pool Interconnection Requirements Committee.

Mr. Willis has published extensively on the subjects of small area load forecasting and power system planning.

WILSON Paul

Paul Wilson is President of GEOGROUP Corporation, based in Berkeley. GEOGROUP's activities focus on the application of computer techniques to urban and regional planning. A major current project is the ongoing management of BASIS (The Bay Area Spatial Information System) for the Association of Bay Area Governments. Mr. Wilson managed the development of BASIS while on the staff of ABAG from 1974 to 1978.

Other significant projects include work on vertical data integration for the CIRSS Task Force and a survey of resource information systems for the California Environmental Data Center.

Mr. Wilson received a B.A. in Political Science from Vanderbilt University and a Master of Urban and Regional Planning degree from the University of Mississippi. He is a member of the American Institute of Certified Planners.

APPENDIX B

LIST OF ATTENDEES

LIST OF ATTENDEES
WESTERN REGIONAL REMOTE SENSING CONFERENCE
MONTEREY, CALIFORNIA

30 MARCH - 2 APRIL 1981

ALASKA

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