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A REGIONAL LAND USE SURVEY BASED ON REMOTE SENSING AND OTHER DATA

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16. Abstract

During this second quarter of the 18-month project, the six participating states completed selection of four target quadrangles of characteristic land use and vegetation within each state and within the inter-state test areas. They also completed the field and office work on land use training sites, providing maps and records for each of the 19 land use classes, including seasonal crop and fallow cycles wherever relevant. The technical subcontractor, Colorado State University, selected and acquired the best cloud-free Landsat CCT's; streamlined the computer programs for geometric corrections and thematic interpretation; and substantially completed the processing of one target quadrangle in each state. The Federation convened four state work sessions on this project, and under a separate but related project completed the preparation of the computer cellular mapping program, CMS-II, and a Users' Draft Manual for distribution to the states. Some of the member states are prepared to begin compiling a multi-source land use information system in cellular form, and then incorporate the Landsat and other remote sensing as the project delivers it.

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PREFACE

Objectives: To test and apply Landsat, other remote sensing and ground data, in an optimum mix for seasonal land use survey, for portions of six states in the region (Montana, Wyoming, Colorado, New Mexico, Utah, Arizona).

Scope of Work: This Quarter's work (July 10 to October 10) is following the Work Plan of January, 1975. The Schedule and Time Sequence following Page 14 of that work plan is here used as reference. The states of Montana, Wyoming, Colorado, New Mexico, Arizona, and Utah have appointed official lead agencies, and they in turn have interagency contacts. With the assistance of the Federation and its subcontractor, these groups are moving toward establishing state land use information systems to utilize satellite, other remote sensing and conventional data. This project is adopting a good detailed working scale of 1:24,000, and a grid cell size of 1.15 acres which is exactly in conformance with the Landsat picture elements and the USGS 7½-minute quadrangle mapping system. In addition to the Landsat source, other data from imagery and ground surveys will be utilized in the test quadrangles, for demonstrating multi-variance map compositing and associated quantitative analysis.

Conclusions: This is the second quarterly report, offering only a preliminary view of the feasibility and problems of this procedure.

The problems of securing interagency coordination within states are beginning to appear and need for more review meetings and interagency work participation within each state. The first four such state-Federation meetings proved salutory in speeding up the coordination work.

On the technical side, the project is getting into peculiar problems of an extensive data system, with twenty-four target quadrangles and hundreds of ground truth sites, to be mapped through several seasons. One indicated needed improvement is a uniform "Manual for Training Site Specification." Another is the condensation of procedure for correcting and converting CCT data into maps. These technical needs will be followed through in the evaluation phase of this project, looking at the feasibility of a widespread regional, state, or interstate land use information operations.

INTRODUCTION

This is the second quarterly report in the 18-month scheduled project.

The project scope is complex and must be described in parallel roles of six state lead agencies, a technical contractor for extracting land use information from Landsat digital tapes, and the Federation as coordinator and demonstrator of multi-source and multi-purpose information procedure.

In summary, by reference to Appendix A (Work Schedule and Calendar):

Task II.A - Field analysis of training sites for signature calibration--substantially completed.

Task II.B - Check the states' selected training sites, relative to land use categories and the problems of signature analysis--substantially completed.

Task II.C - Analyze effects of extraneous local variables on the interpretation of land use classes--underway.

Task II.D - This task changed to bilateral conferences between FRMS, subcontractor, and individual states--held in four out of six states.

Task II.E - Determination of final cell size--completed.

Task II.F - Selection of socio-economic and resource topics for combination with Landsat data--underway.

Task II.G - Identify anomolous portions of training sites and correct--underway.

Task II.H - Correct the signatures for selected training sites--underway.

Task III.B - Aggregate pixels into larger cellular mapping units--not yet considered.

Task III.C - Los Alamos Scientific Laboratory cooperation on cell aggregation procedures--not yet undertaken.

Task III.D - Second field surveys, as needed, for training data--ongoing.

Only two states are lagging behind schedule for training site analysis; these are expected to be completed before snow season. All needed EROS products are in hand--selected seasonal imagery CCT's, prints, and microfilm. Some EROS materials which were supplied by the original standing request (9x9 prints Landsat scenes) were discontinued, to shift the material budget into other EROS requirements, essentially for retrospective selection of various seasonal images.

During the second quarter, the six states finalized selection of the twenty-four target areas. There are four per state; standard USGS map quadrangles in the 7½-minute series, fifty square miles each, approximately, distributed over characteristic resources and landforms.

They accomplished most of the required training site field work, identifying "pure types" of each basic land use category. Each training site contains thirty acres or more. In some cases of difficult signature analysis, such as urban, residential and/or certain crops, training site information included information on proportions of different elements, by season. Also, a seasonal history of crops was recorded. An annual crop history might include approximate date of ground preparations, peak growth, and harvest. This involved checking back for the 1974 and 1973 uses of the field--since the investigation was conducted during 1975. Landsat imagery by seasons is distributed mainly in the calendar year 1974.

DATES OF SELECTED SEASONAL IMAGERY

1974 Landsat CCT's Selected for Seasonal Coverage and Minimum Clouds:

Arizona (four seasons)
- February 14, 1974
- May 15, 1974
- August 31, 1974
- November 29, 1974

Colorado (three seasons)
- May 30, 1974
- August 10, 1974
- November 26, 1974

New Mexico (three seasons)
- May 17, 1974
- August 10, 1974
- November 26, 1974

Montana (four seasons)
- June 1, 1974
- July 25, 1974
- September 17, 1974
- November 10, 1974

Wyoming (same dates as Montana)

Utah (three seasons)
- June 22, 1974
- August 15, 1974
- October 8, 1974

The reasons for this retrospective schedule are to provide optimal imagery for known field conditions by seasons; and to have the entire cycle of imagery in hand for machine processing.

A major decision was to adopt the 1.15 acre cell size (instead of the 2.5 cell size in the first Quarterly Report. The subcontractor, Colorado State University, is able to perform thematic analysis at this cell size, using its pattern recognition routines (RECOG). This cell size, when printed out by the standard line printer matches the 1:24,000 USGS map quadrangles, and opens up many useful combinations.

Progress in Processing of Computer Compatible Tapes

One test quadrangle (USGS 7½-minute quad at scale 1:24,000) is now being processed in each state with the Landsat CCT data by the subcontractor, Colorado State University.

Of special importance is the streamlining of the computer program for CCT conversion into land use maps. The CSU remote sensing scientists have resolved a number of problems inherent in their original pattern recognition program. That program, called RECOG, had been derived from the Purdue and Michigan programs, but required seven separate phases of processing Landsat digital data, through geometric and filter corrections into final signature analysis of given land use and cover categories and correct registration with base maps. Now they have compressed these steps into four steps and a new Production Version of the Landsat Recognition Mapping System. This is a substantial improvement, particularly adapted to wide area user applications in data banking, in place of the earlier research type CCT conversions programs for limited areas. Flow charts and technical documentation for this improvement will be contained in the final report.

The cost effectiveness of this new process is indicated, for example, by saving in computer time for the same results--from a previous 800 seconds of CPU time for processing a Landsat scene to 30 seconds in the new program.

The present status of the processing is described in terms of the four new steps:

Step 1 - Processing CCT data into corrected mapping form. The new process above is being applied to first test quadrangle in each state.

Step 2 - Compressing the seasonal data series of images, plus any ancillary data overlays into a single complex record for each 1.15 acre mapping cell. Being applied to the first test quadrangle in each state. This step combines the three or four seasonal images into a multi-spectral, multi-date single record for a target quadrangle. It does this for a selected part of a total Landsat scene without going through the process for the entire scene. At this

point, any ancillary data on the target area can be added to the record, such as soils, elevation, slope, aspect, or previous verified land use. This set of information is keyed to each cell and used for identifying the land uses and cover. This combination of information is important to increase the accuracy of the land use and cover identification process. This combination approach was originally proposed to be done in a later process--cellular map compositing--but some definitive information such as slope, elevation and soils is better combined with the multispectral data for each cell, at the beginning.

Step 3 - Compute statistical signature of each land use or cover material to be mapped. This process is now designed, but its implementation is not yet due.

Step 4 - Produce cellular maps of the target quadrangles with complete land-use classifications. The programming for this step is 75 percent complete, using the original PECOG and making about 25 percent change in the mapping process. This step is not yet due.

Progress of the Computer Mapping and Compositing System

The computer mapping system (CMS-II) being developed and distributed by FRMS is capable of storing and manipulating the cell values in various mathematical, statistical, and logical subroutines, and aggregating any cells into larger cells for scale changing to 1:50,000 or other common scale.

The following define the scope of the possible information system. Each potential user or functional area, agriculture, natural resources, etc., needs its own particular classification of land uses and conditions. The problem of a multi-purpose land use system is to contain many "elementary indicators," which are mixable into any complex description. Remote sensing can "see" only elementary indicators of certain kinds. The following categories are to be identified by Landsat CCT's in this project:

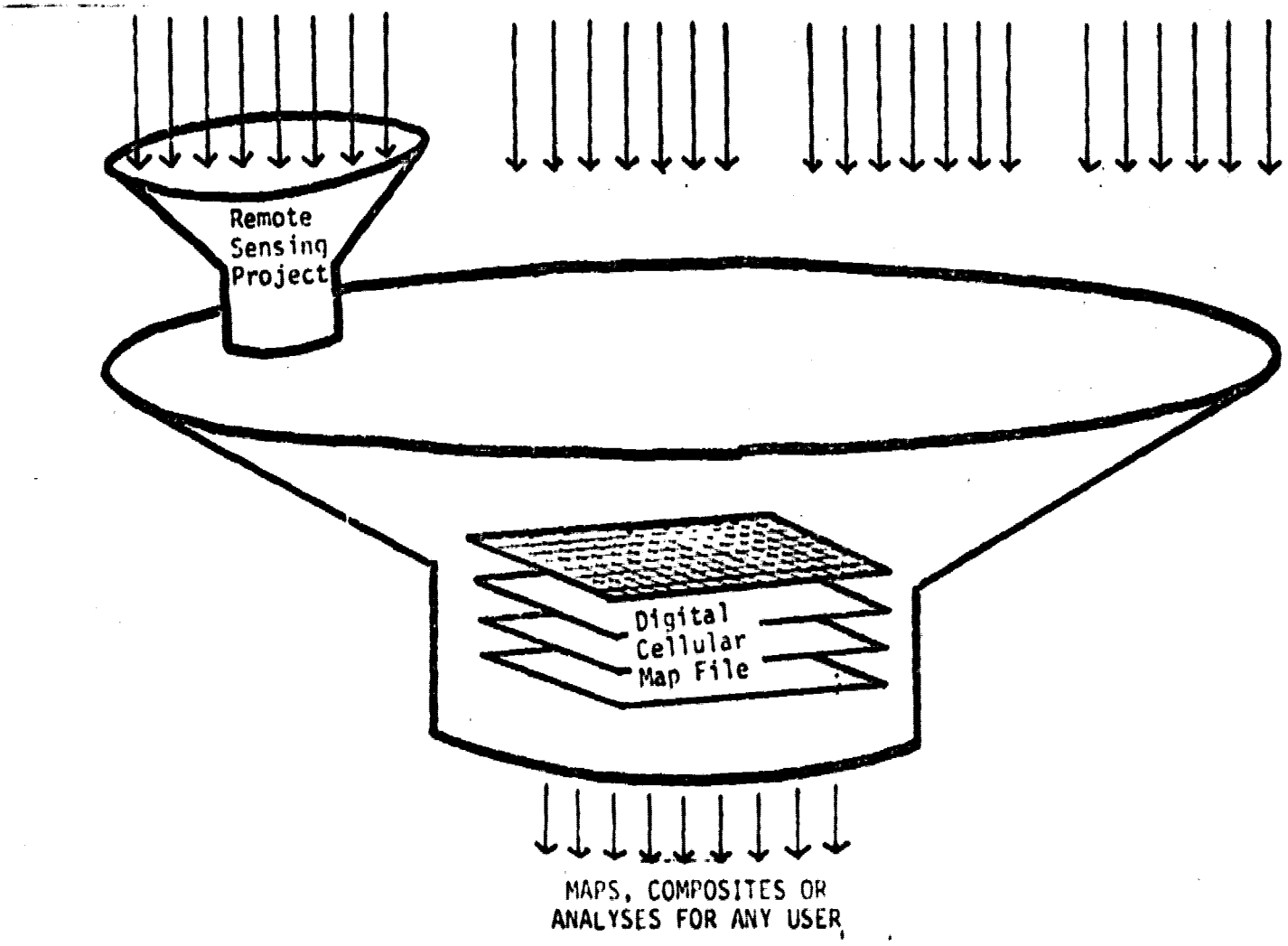
- Residential
- Industrial - Commercial
- Deciduous Forest
- Evergreen Forest
- Mixed Forest (with decision rule)
- Grassland - Irrigated
- Grassland - Non-irrigated
- Cropland - Irrigated
- Cropland - Non-irrigated
- Water - Lakes, Reservoirs, Streams
- Water - Shallow Surface Water
- Marshlands
- Brushlands
- Snow Fields
- Bare Lands
  - Salt Flats
  - Bare Soil
  - Bare Rock
  - Sand Areas
- Unclassified

It is equally important to use aerial photography, geological data, water data, industrial and urban data, etc. All these indicators may be mapped in digital cells which may be combined into functional or activity maps of various kinds; for example "Forest Grazing Area," "Open Pit and Strip Mining," "Parks and Recreation Areas," "Timber and Recreation" descriptions. In urbanizing areas, the categories are even more complex--"large lot subdivisions and open farming or flood zones," or "industrial park and airport approaches."

The project attempts both (1) the efficient application of satellite sensing and (2) its efficient manipulation with other data, running through a cellular compositing hopper.

SCOPE OF REGIONAL INFORMATION SYSTEM

Landsat Demonstr. List	Other Basic Physical Surveys	Socio-Economic Area Data	Local Spot Information
Residential	Soils, Capability	Population	Area Zoning
Comm-Indust.	Precipitation	Growth	Subdiv. Filings
Forest Types	Groundwater	Composition	Dist. Boundaries
Grassland Types	Crop Production	Employment	Service Zones of Utilities
Cropland Types	Grazing Levels	Occupation	Service Zones of Schools, Hospitals, Etc.
Marshland	Forest Surveys	Income	Highway Corridors, Capacities, Loads
Two Water Areas	Geological,Mineral	Vital Stats.	Planned Areas for All Above
Brushland	Levels of Mining Activity	School Stats.	
Snow Fields	Fish & Game	Recreation Stats.	
Bare Lands	Land Assessments	Sales Stats.	
Etc.	Etc.	Etc.	



Each state will apply multi-topic mapping (compositing) in one or several quadrangles for an appropriate demonstration of planning and management solutions.

The project is attempting to resolve the problem of computer mapping programs being restricted to one or another type of hardware, making it difficult to interchange data tapes among states or agencies. The Federation's first version of a Composite Mapping System (CMS-I) was one such program, useable only on UNIVAC and CDC equipment. Since the Economic Development Administration granted the Federation assistance for converting it to CMS-II, it will now operate on IBM hardware as well as UNIVAC. The basic features of the new CMS-II cellular mapping program are:

1. Small memory core requirements to reduce operating costs.

2. Compatible with the Landsat cellular output format.

3. Compatible with any other cellular mapping program, such as SYMAP, for receiving smoothly interpolated cell maps based upon random field data samples.

4. Will accept both digitized polygonal input from other digitized mapping tapes, or any conventional maps or tabular data.

5. Internal storage of maps (map-filing).

6. Instant symbol conversion from one data scale to another.

7. Inter-map arithmetic compositing through addition, subtraction, multiplication or division point-to-point, map-to-map.

8. Inter-map logical compositing using logic functions.

9. Scaling and mapping of census data from tabular files.

10. Frequency distribution or histogram output.

11. Compatability with correlation or Multiple Regression programs, which may manipulate the cellular map file.

12. Aggregation of small cells into larger, for statistical or scale changing purposes.

New Mexico Workshop of July 14:

Scope: Review of procedure on multi-spectral signature training on selected land use and ground cover. Examples of training sites work in other states to reveal the tricky problems of agricultural field signatures changing in various stages of planting, growth, harvesting; similar problems of signature mixture in Urban Residential, having various proportions of roofed area, open space, paved roads, dirt roads, amounts of vegetation, etc. The workshop reviewed examples of multi-data compositing in the cellular mapping procedure, to be used with Landsat and other information in the selected quadrangles. Committee members from federal, state, and local agencies discussed possible applications of this multi-data procedure in several of the quadrangles:

Santa Fe Quadrangle. Simulation of "urban developable and non-developable zones," through composite mapping of such maps as remotely sensed existing land uses and other data on flood plains, utility service zones, transportation accessibility, new and projected employment and residential areas, soil and foundation conditions, etc. The Santa Fe Planning Director indicated particular interest in working with the committee on such composite demonstration.

Rural Questa Quadrangle. Possibility of compositing data from numerous existing sources to simulate "optimum land uses." This quadrangle ranges from riverine vegetation to irrigated agriculture, dry farming, grazing, and forest. The BLM representative was particularly interested in the common problem of multi-purpose land use planning.

Representatives present:

Michael Inglis, Technology Applications Center, State Lead Representative
Gordon Page, State Planning Office
Wayne M. Kuhn, DURA Land Management, New Mexico Office
Lorie Byrd, State Highway Department, New Mexico
Phil Freeman, New Mexico Department of Game and Fish
Harry Moul, Planning Director, City of Santa Fe, New Mexico
David Tabet, New Mexico Bureau of Mines
Sandy Feldman, Technology Applications Center, University of New Mexico
Dr. Eugene Maxwell, Contractor, Colorado State University
George Nez, Principal Investigator

Colorado Workshop July 28:

Scope: The meeting reviewed the organization of the Colorado portion of the project, with Lead Agency working responsibility assigned to the Colorado Energy Research Institute at the Colorado School of Mines, Golden. The Division of Planning of the Colorado Department of Local Affairs maintains sponsorship and ultimate potential user ship of the process in the state mapping program. A technical review covered the multi-spectral mapping process, the cellular compositing process, and the ongoing training site work. Further discussion added a second region, Northwest Colorado, to the first region in South Central Colorado, but the second region would be surveyed and planned separately from this NAS522338 project. Its objectives are oil shale, coal, gas development simulation, area impacts on water requirements, general environment and locations of worker housing. The technical experience on the South Central project would be immediately transferred to the Northwest.

Representatives present:

Thomas J. Vogenthaler, Director, Colorado Energy Research Institute
Albert G. Melcher, Deputy Director for Operations, CERL, and State Lead Agency Representative for the Landsat Project
Dr. Keith Turner, Professor of Geology, Colorado School of Mines, Chairman of the Land Use Committee of the Federation of Rocky Mountain States (overseeing the Landsat Project)
George Nez, Principal Investigator

Utah Workshop September 11:

Scope: Reviewed with member agencies: (1) training site selection and description; (2) agency interests and programs related to the project, particularly the selected quadrangles; (3) example cases of using remote sensing and composite mapping; (4) discussion of the individual quadrangle analysis with multi-source data:

Metropolitan Salt Lake, simulating likely pattern of urban growth in relation to several new planned circumferential highways, interchanges, water and sewer serviceability, flood reservations, foundation conditions, existing land use and zoning, land valuation, and process of land uses.

State Highway alternative route analysis extending through two quadrangles in the Wasatch Front, requiring a combination of data on land use, foundation and engineering possibilities, environmental factors, etc.

Great Salt Lake. Analyzing the changing lake levels and effects on vegetation, habitats for wildlife species, etc.

Representatives present:

Professor Merrill Ridd, State Laiason Representative
Professor Csung-Myun Lee, Department of Geography, University of Utah
Professor Betsy Burris, Department of Geography, University of Utah
C. G. Powers, Utah State Planning Office
Clayne J. Ricks, Salt Lake County Planning Commission
James Harvey, State Soil Conservation Commission
James Cochran, U. S. Forest Service
Sheldon McConkie, Utah Department of Sanitation
Elbert Regenthal, Utah Water Life Resources
Roger McCoy, Department of Geography, Utah University
Reynold Willie, Department of Geography, Utah University
Professor E. L. Maxwell, Remote Sensing, Subcontractor, Colorado State University
Professor Keith Turner, Principal Investigator, Geology, Colorado School of Mines
George Nez, Principal Investigator

Wyoming workshop October 5:

Scope: Reviewed with state member agencies: (1) training site work, remaining problems of site selection and correct description of land uses for multi-spectral calibration; (2) relevant examples of Landsat and conventional data compositing for sharper description of seasonal and mixed uses; (3) possible map compositing demonstrations in quadrangles for practical problems such as applying coal strip mining criteria, and/or simulating urban area growth propensity; (4) reviewed detailed aerial photo plans of the BLM state office.

Representatives present:

Professor Lawrence Ostresh, State Lead Agency Representative
Bruce Keating, Wyoming BLM Office
Roy Breckinridge, Geological Survey of Wyoming
Michael Stone, Wyoming Game and Fish Department
Henry Miller, Wyoming Highway Department
James Vandel, Wyoming Highways
Lenore Diem, State Planning Coordination Office
Professor Eugene Maxwell, Remote Sensing Subcontractor, Colorado State University
George Nez, Principal Investigator

FINAL SELECTED MAPPING QUADRANGLES IN EACH STATE

Within the large interstate test sites of the project, selected 7½-minute quadrangles for full mapping of land uses and land cover have now been finally established, as shown below. These involve only a few shifts from the quadrangles shown in the previous Quarterly Report.

COLORADO TEST SITE AND QUADRANGLES

1. Alamosa W. Urban, irrigated agriculture, pasture, recreation.
2. Manassa. Irrigated, range, recreation.
3. Fox Creek. Forest, grass, range, recreation.
4. Zapata Ranch. Forest, grasslands, range, sand dunes.

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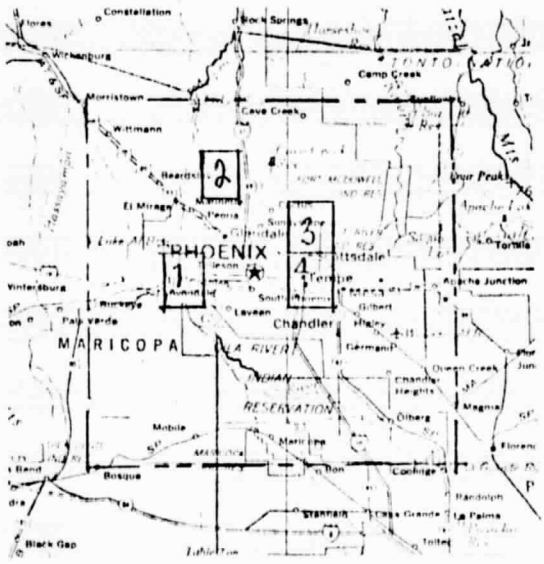
1. Questa. Mining, grass, range, forest.
2. Taos. Urban, irrigated, agriculture, grass, range.
3. Espanola. Mixed type agriculture.
4. Santa Fe. Urban, range, recreation.

NEW MEXICO TEST SITE AND QUADRANGLES

UTAH
TEST AREA AND QUADRANGLES

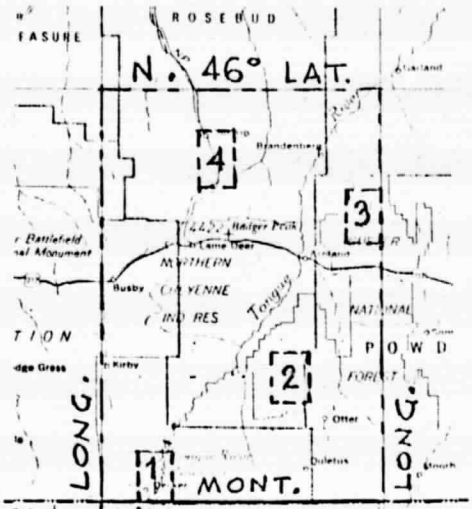
1. Dromedary Peak. High mountains, forest types, bare soil, rock, streams and ponds.
2. Farmington. Urban, range, farming, fluctuating water.
3. Tremonton Quad. Agriculture types.
4. Salt Lake City S. Urban, agriculture.



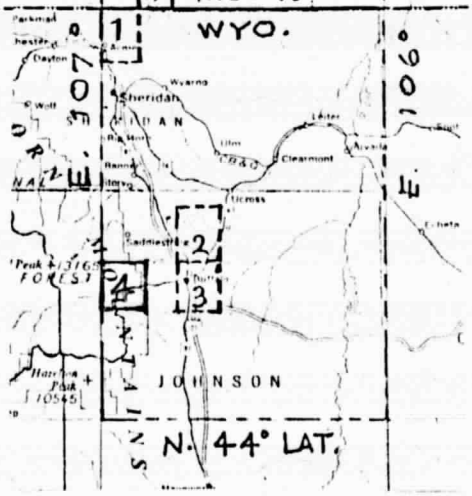
1. Tolleson quad. Urban, irrigated agriculture, range.
2. Hedgepeth Hills. Irrigated agriculture, range, subdivision.
3. Paradise Valley. Urban, irrigated agriculture, range, recreation.
4. Tempe. Urban, irrigated agriculture, range.

ARIZONA TEST AREA AND QUADRANGLES

MONTANA TEST SITE AND QUADRANGLES



1. Decker quad. Dry grass, coal stripping.
2. Poker Jim Butte. Forest service, grass and ponderosa development.
3. Beaver Creek School. Agriculture, grass, ponderosa.
4. Colstrip. Coal stripping, sub-irrigated agriculture, rangeland.



1. Acme quad. Coal stripping, grassland, range, urban.
2. Lake de Smet. Coal, grassland, range.
3. Buffalo. Coal, grassland, range.
4. Hunter Mesa. Timber and grazing.

WYOMING TEST SITE AND QUADRANGLES

Intra-state Project Coordination Problems

Our project management continues to work on problems named in the previous Quarterly Report of July 2, paragraphs A and B under Conclusions, page 11. It is necessary to tighten up on agency coordination within states. Although numerous state agencies originally recognized the relevance of the project when it was first formulated by an interstate Federation committee and circulated by each Governor's office or the State Planning Office, this resulted in giving responsibility to one Lead Agency in each state. Thereafter, the participation tended to narrow down to on-call response to that agency's requests for assistance in field work. The Workshops have had a salutary effect in featuring the innovative work of the state Lead Agency in the correct identification of the many training sites for Landsat signature calibration. The workshops also opened the door on the application possibilities for a land use information system and the next project step of defining meaningful area analysis and planning problems in each quadrangle. In the next general meeting of all state Lead Agency representatives with the Federation management and the technical subcontractors, the subject of offering demonstrations and securing agency participation in each state will be aired.

Budget Adjustments Made to Meet the Needed Landsat and Aircraft Products

As described in the beginning of this main text, the Landsat imagery requirements fell entirely in the calendar year of 1974 for a complete cycle of three or four seasons per state. This retrospective coverage eliminated the need for current 1975 Landsat inspection prints and 70mm negatives. In order to save this unnecessary expense to the project, the Principal Investigator requested discontinuance of this particular Standing Request under Account G22550. This had originally been projected as an expected normal requirement by NASA. The two other requirements and accounts were: (2) CCT Account GB2550 and (3) U-2 Account GW2550. The project developed a need for microfilm to assist in the retrospective selection of minimum-cloud images for 1974 seasons, which could be met by savings from Landsat Print Account G22550.

After discussing this with the Project Monitor in Goddard, the rebudgeting was initiated. Subsequently, it was found that the discontinuance of the standing request for the Landsat prints required some three months to work its way through the administrative chain to the EROS laboratory, while unneeded Landsat prints and 70mm film continued to come through the supply line. This change has now been effected.

During this quarter, much work has been done by Colorado State University, the technical subcontractor, in streamlining the processing of computer compatible tapes. While the original pattern recognition program, RECOG, was based on the Larsys and Erim programs, it required too many separate phases of processing for a "production program" in extensive and repeated surveys, under Western circumstances. Therefore, the subcontractor has re-programmed RECOG into a condensed process, resulting in approximately 90 percent saving in computer time for converting the raw CCT data into land use mapping form. This is also referred to on pages 4 and 5 of this report under "Progress in Processing of Computer Compatible Tapes."

Another change from the previous quarter is the change of the mapping cell size from the original 2.5 acres to 1.15 acres, for the following reasons:

(1) to preserve all the available detail from the Landsat picture elements, and
(2) to achieve a good common denominator cell size which corresponds with 1:24,000 map scale when printed out by a standard line printer. This matches with the popular 7½-minute USGS quadrangle map series.

In the background, Los Alamos Scientific Labs, participating with this project, are investigating the use of micro-densitometers and high-speed scanning equipment to produce cell maps, which would provide a very efficient procedure to handle any ancillary map and photo sources in operational land use information systems. I.e., it would greatly speed up the data convertability, interpretability, and scale conversion.

PROGRAM OF NEXT REPORTING INTERVAL

By reference to the Work Schedule and Calendar, from the original work plan of January, 1975:

(a) The technical subcontractor, Colorado State University, will complete thematic interpretation for all of the training sites given by the states, and may substantially cover all the target quadrangles. In this process, he will interleave the seasonal data series for each pixel and add any state-desired ancillary data, to form a single complex record for each 1.15 acre mapping cell, as described in Step 2 on page 4.

(b) All state Lead Agency Representatives will meet in a six-state workshop, with the technical subcontractor and Principal Investigator, to (1) identify the selected land uses, (2) project any needed following field work, and (3) formulate typical quadrangle data compositing problems for utilizing Landsat plus ancillary data in analyzing/planning resource management.

Longer term schedule:

During this winter and the spring of 1976, the lead agencies will specify with their state user groups typical area planning problems to use cellular compositing to bring in sources other than satellite data, including agricultural and forestry production data, hydrology data, recreation data, economic factors, ownership and land assessment information, etc. By this time the CMS II cellular mapping program will be available to fit any state computer installation. Also, Los Alamos will have compatible and efficient high-speed scanning procedures for conventional map and non-satellite remote sensing. This phase will demonstrate to potential users the versatility of a state information system for land use and related data.

CONCLUSIONS

A. The interstate and intrastate potentials of this project require much administrative work by the project management of the Federation and each state Lead Agency. The two problem areas in inter-agency coordination within each state are (1) getting agency cooperation in ground truth work, and (2) lining up agencies for meaningful composite mapping demonstrations in the quadrangles. The Federation management will convene another general interstate meeting on this problem, and assist the state Lead Agencies to secure adequate inter-agency participation, by moving the project forward from strictly scientific work (calibrating multi-spectral imagery and mapping out land uses in first quadrangles) to making use of the remote sensing in composite mapping projects addressed to practical problems of resource management and area planning as may be defined by the member agencies.

B. Federal agencies such as BLM, Bureau of Reclamation, Forest Service, Agriculture could become members in areas of high federal land proportion and management. Generally, federal agencies are better stocked with data, and inclined to systematic improvements in survey procedure.

C. It has become apparent in the field work in the training sites that a thorough "Manual for Training Site Specification" is needed, particularly for extensive area applications of Landsat data. This should cover such topics as: land cover reflectance interpretation, seasonal and mixed cover description, appropriate map and tabular data, forms, evaluation of the signature accuracy and follow-up ground work.

RECOMMENDATIONS

A. Referring to paragraph A of Conclusions, one recommendation is that State Lead Agencies augment the participation of other state agencies. The Lead Agencies have completed the "measurement work" of specification and ground truth for Landsat calibration - but the next phase will be much more in the nature of "applications". The various agencies of the state would logically carry much more project responsibility in such steps as defining and conducting composite mapping analyses and solutions to resource problems in the quadrangles, or ultimately joining in a state mapping bank and incorporating the Landsat project technology. This is all becoming timely, and should be featured in the next regional meeting, during this quarter. Further, Lead Agencies in each state should be assembling an inter-agency project group made up of individuals with interest in this new process.

B. Referring to paragraph B of Conclusions, there are various federal agency observers in the present state groups, and their agency concerns for regional analysis and resource use planning appear to be relevant and timely to this project. In each state, target quadrangles contain federal lands, and admixtures of federal, state and private lands. Therefor, the time for bringing these interested federal agencies into the project is now, and the route is via the management problems in the target quadrangles. Strip mining, shale processing, pipelining, related water development, approaching town development problems - all typify subjects of federal-state joint concern in some target quadrangles. There are similar urgent problems in transportation, recreation, agriculture, and long-term water engineering.

C. A Manual for the selection and survey of training sites for Landsat image calibration should be developed - including forms, procedures for handling mixed and ambiguous land use categories, and cross-references to the Data Users' Handbook. This is apparant in an extensive geographic project, and particularly when attempting to cover seasonal changes in crops and land cover. An outline of the Manual might be included in final reporting on the present project, together with problems and solutions from this experience.

APPENDIX A

ORIGINAL PROJECT WORK SCHEDULE AND CALENDAR

State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
		D A T A P R O C U R E M E N T A N D D A T A P R E P A R A T I O N			
		(I.A) Convene all participants for review & training sessions. Throughout the project: - provide quarterly reports to NASA, states - review progress - fiscal control - coordinate makeup plans - state, CSU and LASL coordination in technical work - technical assistance to states in establishing wider survey system	(I.A) Review and training (I.B) Define the preferred land use classification system in 1st & 2nd order, adapt to test areas & the state planning & analytic purposes of a data system	(I.A) Participate in the initial training session	(I.A) Preside and participate in the first general review meeting. (Throughout the project provide review and advice for scientific and policy matters.)

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(I.C) Procure maps, air photos, high altitude data for test sites					
	(I.D) Procure remote sensing imagery of test sites for series of dates				
	(I.E) Determine map control points for sites for geometric rectification of remote sensing imagery				
	(I.F) Rectify appropriate portions of each original ERTS-computer compatible tape (CCT) to conform to I.E				
(I.G) Select land use identification sites (jointly)			(I.G) Select most significant land use classes for training sites, for computer image processing		

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				(I.H) Consultation and assistance on rectification procedures	
	(I.I) Combine rectified ERTS-CCT onto a single tape for each site: 1. continuous segments of each site from rectified images 2. each spectral band from each date will be interleaved				
		(I.J) Work with CSU and LASL to integrate cellular system for wider scope data files & compositing analysis		(I.J) Work with FRMS & CSU to set up a demonstration of a cellular interchangeable mapping system for a wider scope of information, accepting any raw data form	(I.J) Advise on purposes & characteristics of a regional cellular mapping system

ate Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
LAND USE CLASS IDENTIFICATION PROCEDURES					
I.A) Provide available information on geology, soil, topography, etc., for study of effects on land use identification by remote sensing, for II.C	(II.B) Statisically analyze & characterize land use readings, in order to: 1. recognize erroneous data in the training fields 2. determine clear separations between classes	(II.D) Convene all participants for stage agreements	(II.E) Determine most practical cell sizes for the several purposes of the project & future system applications, develop the LASL approach to multi-factor mapping	(II.F) Determine scope of socio-economic or resource topics for analytic mapping, beyond the ERTS land use range. Determine best sources & needed state inputs.	(II.D) Review meeting #2
I.G) Field or photo-check anomalous portions of training sites whose statistically inconsistent with CSU analysis (task II.B & II.C)	(II.C) Analyze effects of extraneous variables (i.e., geology, soils, slope, etc.,) on interpretation of land use classes (II.H.) Analyze & correct the remote sensing readings for new modified land use classes		(II.I. Modify training sites & land use classes as needed before final review of land use identification		

State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
		LAND USE MAPPING IN THE TARGET QUADRANGLES			
(III.A) Select four 7 1/2 minute quadrangle map areas within the test sites in each state for detailed ERTS mapping (III.D) Collect additional needed and/or desired data for the quadrangles for verification & analysis purposes as well as cost/time information on data preparation (III.G) Evaluate the accuracy of the land use overlays prepared from the ERTS source	(III.B) Aggregate the ERTS picture elements into larger cell sizes (i.e., 10 or 40 acres) as jointly determined (III.E) Identify land uses in all cells in the selected map quadrangle areas (III.F) Prepare transparent computer land use classification overlays of the selected quadrangles	(III.H) Convene all participants for stage agreements	(III.H) Review output products	(III.C) Consultation and assistance on cell aggregation procedures, appropriate for the test data file extending beyond ERTS land use classes. (III.I) Obtain ERTS land use outputs and other state inputs for demonstration of "mixed" data analysis & composite mapping for states' selected planning objectives	(III.H) Review meeting #3

State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
TECHNOLOGICAL ASSESSMENT OF RESULTS, AND COMPARATIVE EFFICIENCY AND COSTS					
(IV.A) Provide further analysis requirements	(IV.B) Examination and assessment of classification errors (IV.D Comparison of ERTS land use classifications with other methods (IV.E) Provide cost/information tradeoff analysis (IV.G) Identify needed R & D and future capabilities of ERTS land use information	(IV.C) Aid states and LASL in further analysis possibilities	(IV.H) Evaluate ERTS land use survey system and its contribution to general area analysis relative to the LASL demonstration	(IV.F) Produce composite mapping simulations & analysis as per state guidelines	(IV.H) Evaluate ERTS land use survey system and its contribution to general area analysis relative to the LASL demonstration

State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Los Alamos Scientific Laboratory (LASL)	Los Alamos Scientific Laboratory (LASL)	NM Institutes of Water Resources Technology Applications
PREPARATION OF FINAL PRODUCTS					
(V.A) Prepare any additional input for final report	(V.B) Prepare final forms of computer images and printed overlays. Draft Technical Report & Users Report on ERTS applications			(V.C) Prepare final output & contribute to the general report on techniques and results	
		(V.D) Convene participants in a final evaluation and procedure workshop	(V.D) Review and evaluate products & results - review draft of final report - determine further efforts		(V.D) Preside over review meeting and workshop
(V.E) Participate in general report	(V.E) Participate in General Report	(V.E) Coordinate the preparation of the General Report on both ERTS & larger scope data system including the socio-economic and resource mapping of LASL			

Fig. 5. TIME SEQUENCE - page 1 of 3

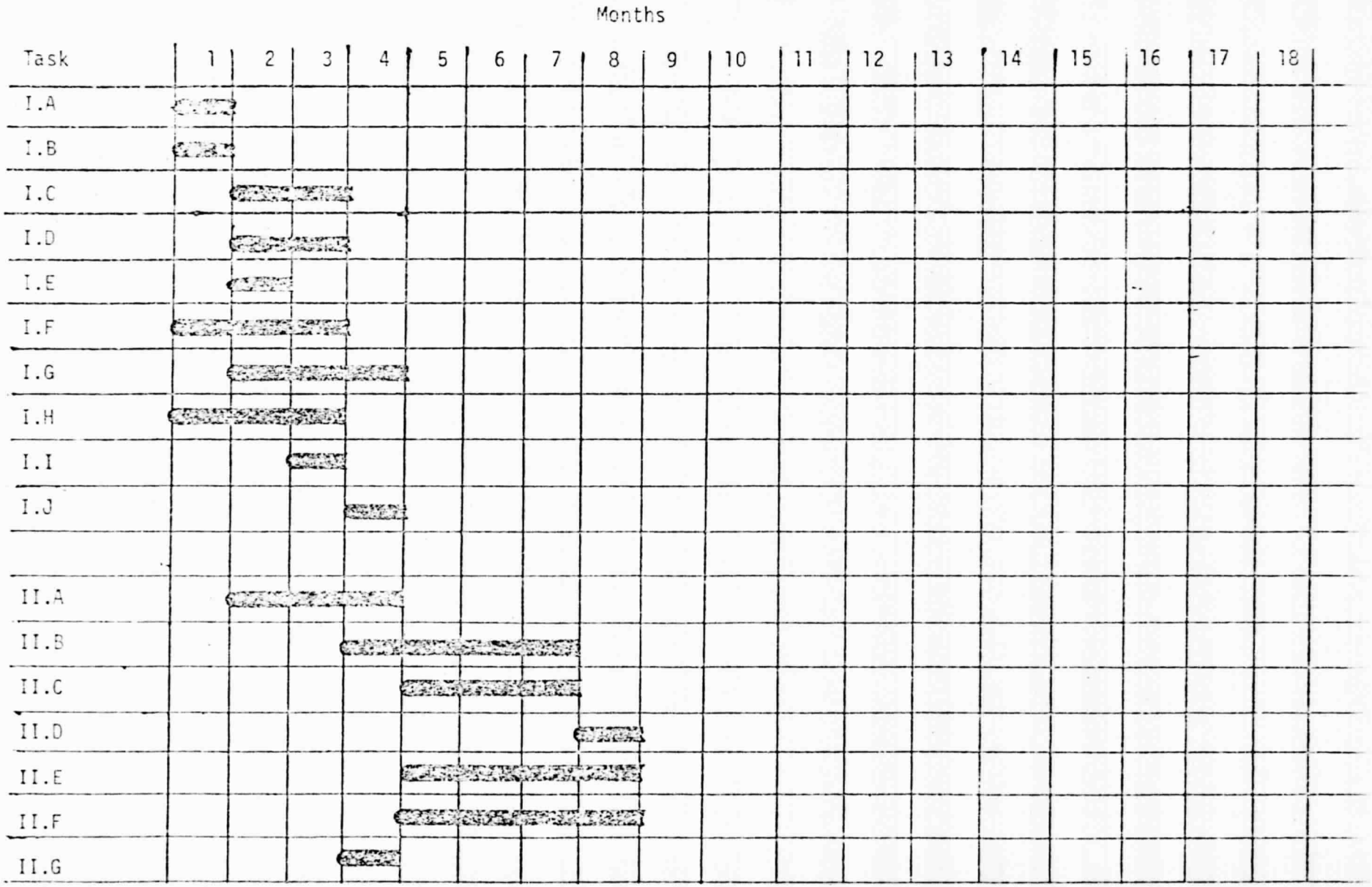
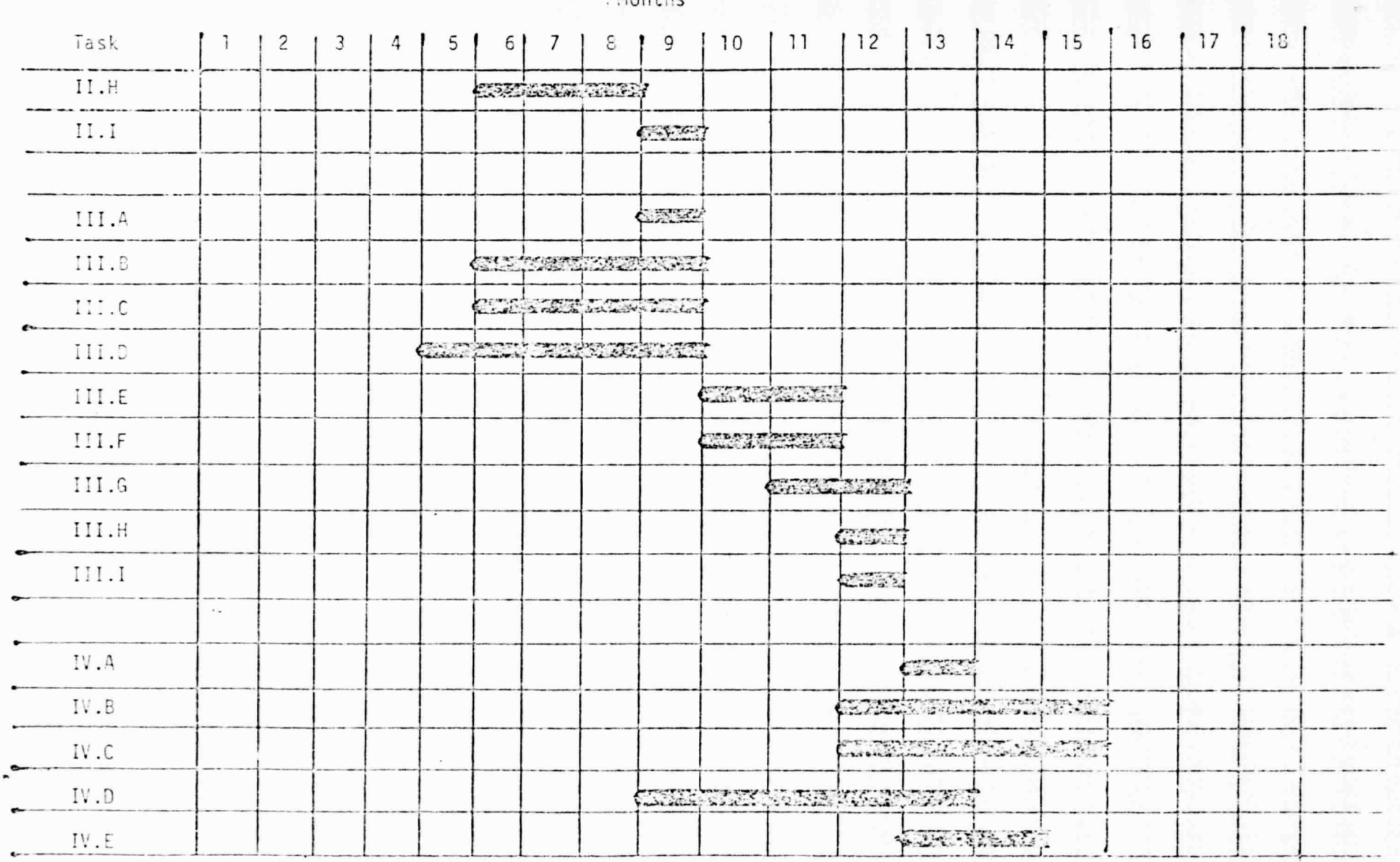
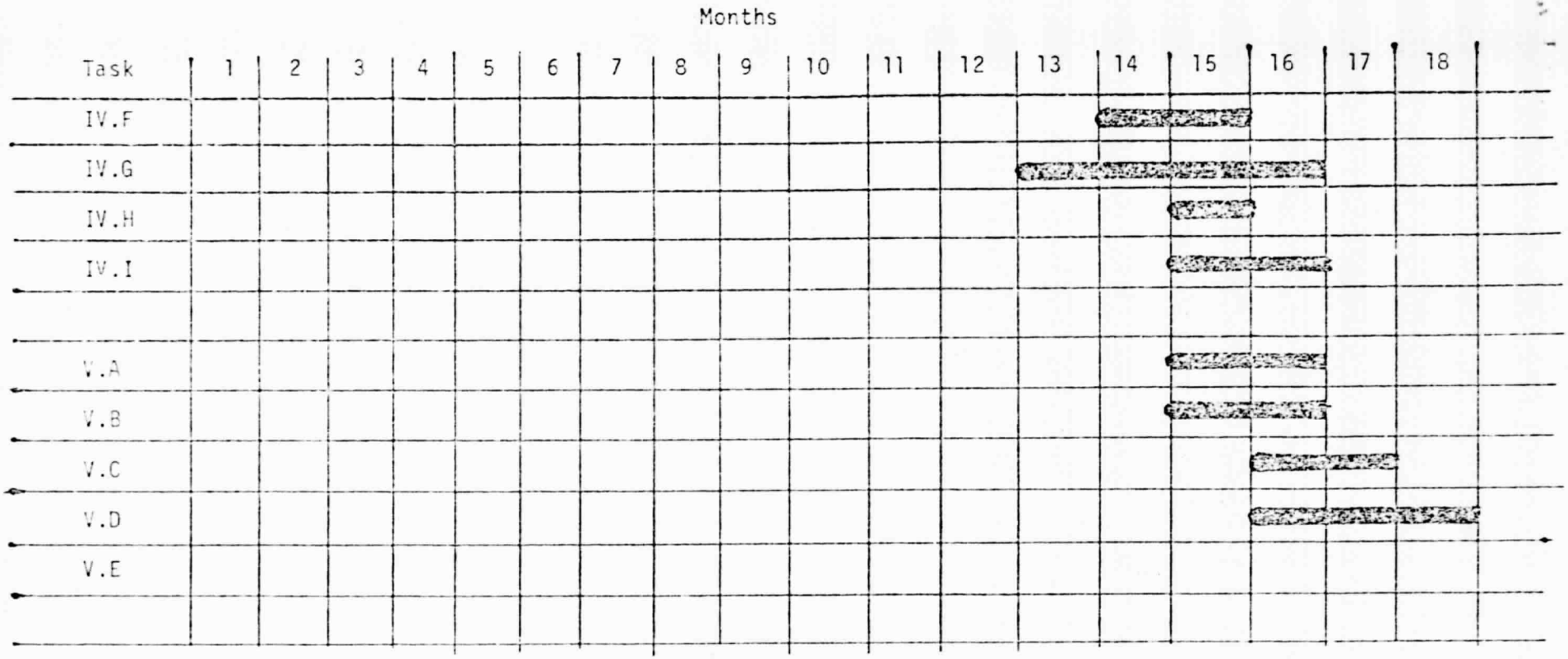


Fig. 3. Time Scale




Months
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