CHAPTER 3

SEASAT LAND EXPERIMENTS

Active Microwave Users Working Group

Seasat Land Experiments Panel:

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INTRODUCTION

The basic objectives of the Seasat Land Experiments Panel were as follows.

1. To review documents concerning the potential roles for active microwave imaging systems on board satellites, with particular emphasis on the Seasat SAR

2. To make recommendations concerning the types of experiments that could most profitably be conducted over land with the Seasat SAR system capabilities available

Primary emphasis during the 3-day Houston workshop was on the second of these tasks.

The Seasat Land Experiments Panel was composed of representatives from private industry, the academic community, and the Federal Government. A basic criterion for member selection was land-applications expertise. In advance of the workshop initiation, the selected participants were provided background material on the Seasat program in general, the Seasat SAR system in particular, the basic panel objectives, a suggested list of types and/or classes of questions to be addressed, and a tentative schedule of activities for the 3-day meeting in Houston. In addition to the aforementioned background material, during the first morning session of the workshop on August 10, 1976, panel members were provided with additional written background material and briefed on potential applications of a space program imaging radar by members of the Active Microwave Task Force.

OVERVIEW

An overview of the Seasat land experiments program is presented in the following subsections.

Seasat Mission

On the afternoon of August 10, 1976, Seasat representatives discussed the project - its organizational structure, sensor complement, satellite system, mission design, data acquisition and distribution plans, and experiment team activities. J. A. Dunne, Seasat-A Ocean Experiments Manager, provided an overview of the Seasat-A program with particular emphasis on the proof-of-concept nature of the experiment and the science/user advisory apparatus that has been operating since the initiation of the project (see the organization chart, fig. 3-1). The subsystems, together with the associated responsible agencies, were itemized as follows.

Satellite: Jet Propulsion Laboratory (JPL)/Lockheed Missiles and Space Corporation

Tracking and data acquisition: GSFC/Spaceflight Tracking and Data Network (STDN)

Mission operations and control: GSFC

Project data processing: JPL

SAR data processing: JPL

Operational data processing: Fleet Numerical Weather Central (FNWC)

Experiment teams: Various

User data distribution: NOAA, FNWC, USGS/EROS[2] Data Center

Mission planning: JPL

He pointed out that, because they represent user interest in the formulation of plans for aircraft test experiments and surface-truth-activities experiments to be conducted with the use of satellite data, the Science Steering Group (SSG) and the experiment teams are important elements in achievement of the project objectives, which include the demonstration of techniques for global monitoring of oceanographic phenomena and features, the provision of oceanographic data for both application and scientific users, and the determination of key features of an operational ocean dynamics monitoring system. Further, they will provide an objective assessment of the geophysical performance of the microwave instrument complement. (Table 3-1 lists the sensors, and the organizations represented on the respective experiment teams.) With regard to interactions between the broad user communities, as

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[2]Earth resources observation system.

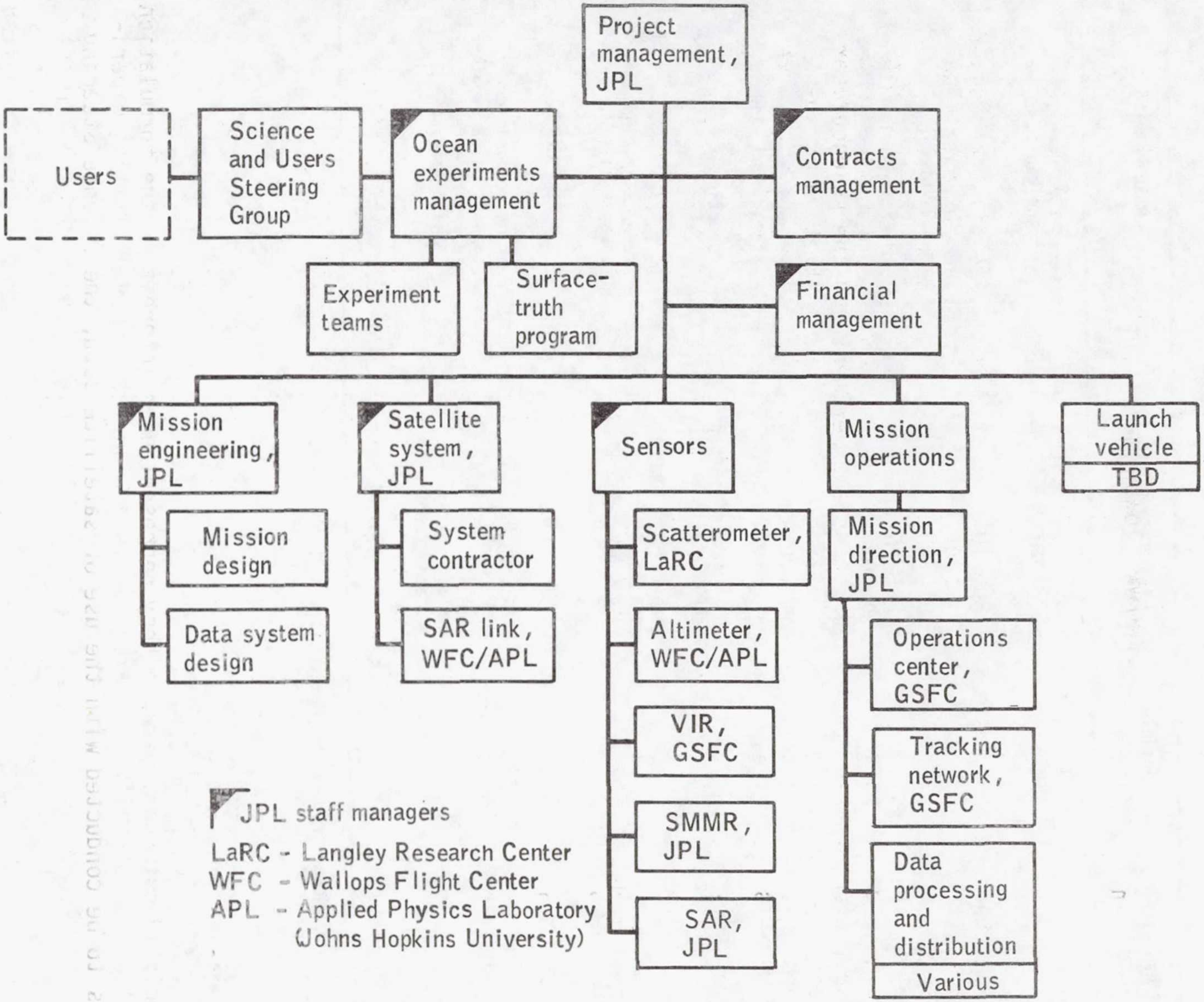

Figure 3-1.- Seasat-A functional organization.

TABLE 3-1.- SEASAT-A SENSORS

Sensor	Responsible organization	Team representation	Measurements
Altimeter	WFC	NOAA (AOML,[a] NOS,[b] HQ[c]) DOD[d] (NSWC,[e] NRL, NOO[f]) NASA (WFC, JPL) Smithsonian Astrophysical Observatory	Ocean topography, marine geoid, sea state
Synthetic aperture radar (SAR)	JPL	NOAA (NESS,[g] AOML[a]) USGS Scripps Institute of Oceanography ERIM[h] NASA (JPL)	Coastal interactions, wave directional spectra, ice studies
Windfield scatterometer	LaRC	NOAA (NOS,[b] HQ[c]) NASA (LaRC, JPL) CUNY[i] University of Kansas Penn State University	Windspeed (surface stress) and wind magnitude and direction
Scanning multichannel microwave radiometer (SMMR)	JPL	NOAA (NESS,[g] AOML[a]) USGS NASA (LaRC, JPL, WFC, GSFC) DOD[d] (NRL) CUNY[i]	Sea surface temperature, high-windspeed measurements
Visible and infrared radiometer (VIR)	GSFC	NOAA (NESS[g]) DOD[d] (NOO[f]) NASA (GSFC) Scripps Institute of Oceanography Research Triangle Institute	Feature recognition support, clear-weather sea surface temperature, cloud temperature

[a]Atlantic Oceanographic and Meteorological Laboratory.
[b]National Ocean Survey.
[c]Headquarters.
[d]Department of Defense.
[e]Naval Surface Weapons Center.
[f]Naval Oceanographic Office.
[g]National Environmental Satellite Service.
[h]Environmental Research Institute of Michigan.
[i]City University of New York.

represented by this panel, for example, Dunne stated that access to the project is provided through the SSG and the experiment teams. Figures 3-2 through 3-4 provide information on the Seasat-A orbit, data system, and SAR station coverage. The telemetry system has two radiofrequency (rf) data links, as follows.

1. Unified S-band: 2287.5-MHz downlink, 2106.4-MHz uplink

a. Real-time low-rate telemetry (T/M) from altimeter, scatterometer, SMMR, VIR, and satellite engineering/attitude data; data rate = 25 to 32 kbps

b. Playback T/M, consisting of recorded real-time low-rate T/M; data rate = 640 to 800 kbps

c. Command; 1 to 2 kbps

d. Tone ranging, transponded Doppler range-rate

2. S-band real-time SAR link: 2265.5-MHz downlink, 18-MHz analog modulation, raw data from the SAR sensor

The data acquisition capability may be summarized as follows.

1. The STDN sites at Alaska, Goldstone, Rosman, Madrid, and Orroral will be utilized for low-rate data acquisition. Playback data will be source of data records. Real-time data will be used for monitoring and control.

2. Alaska, Goldstone, and Rosman probably will be equipped to receive/record SAR data. Signal film/tape will be shipped to JPL for processing.

3. Low-rate data (real-time and playback) will be returned to GSFC by means of 56-kbps wide-band lines (NASA ground communications system).

4. Near-real-time data link from Alaska only to FNWC/Monterey will relay playback data.

This capability is important to those interested in SAR data, which can be acquired only through a suitably equipped tracking station.

Charles Elachi, leader of the JPL Radar Applications Group, provided a detailed discussion of the Seasat SAR (figs. 3-5 and 3-6). The system characteristics were summarized as follows.

Frequency - 1275 MHz

Look angle - 20° from nadir (not variable)

Altitude - 794 km

Resolution - 25 m in range and azimuth

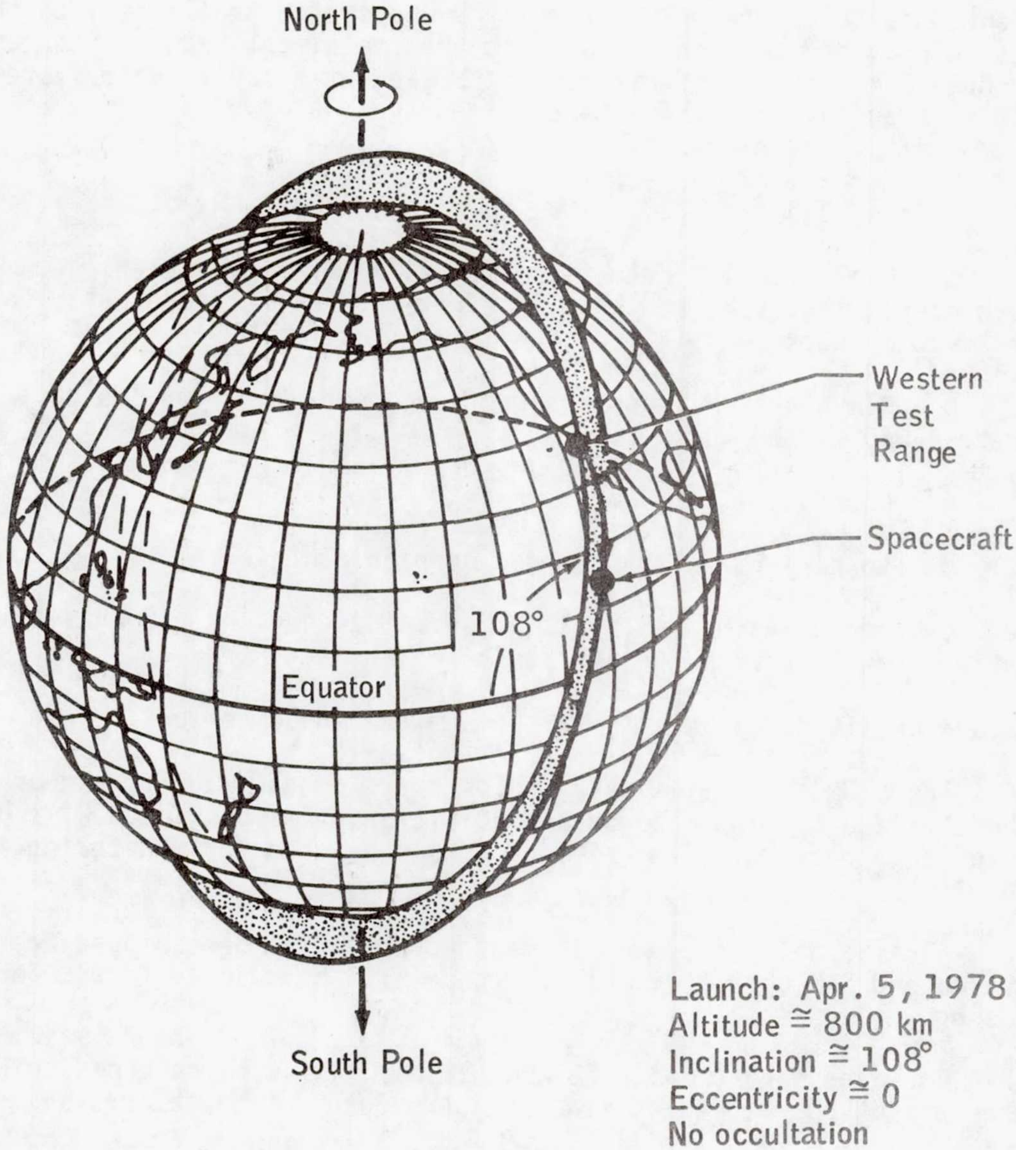

Figure 3-2.- Seasat-A orbit geometry.

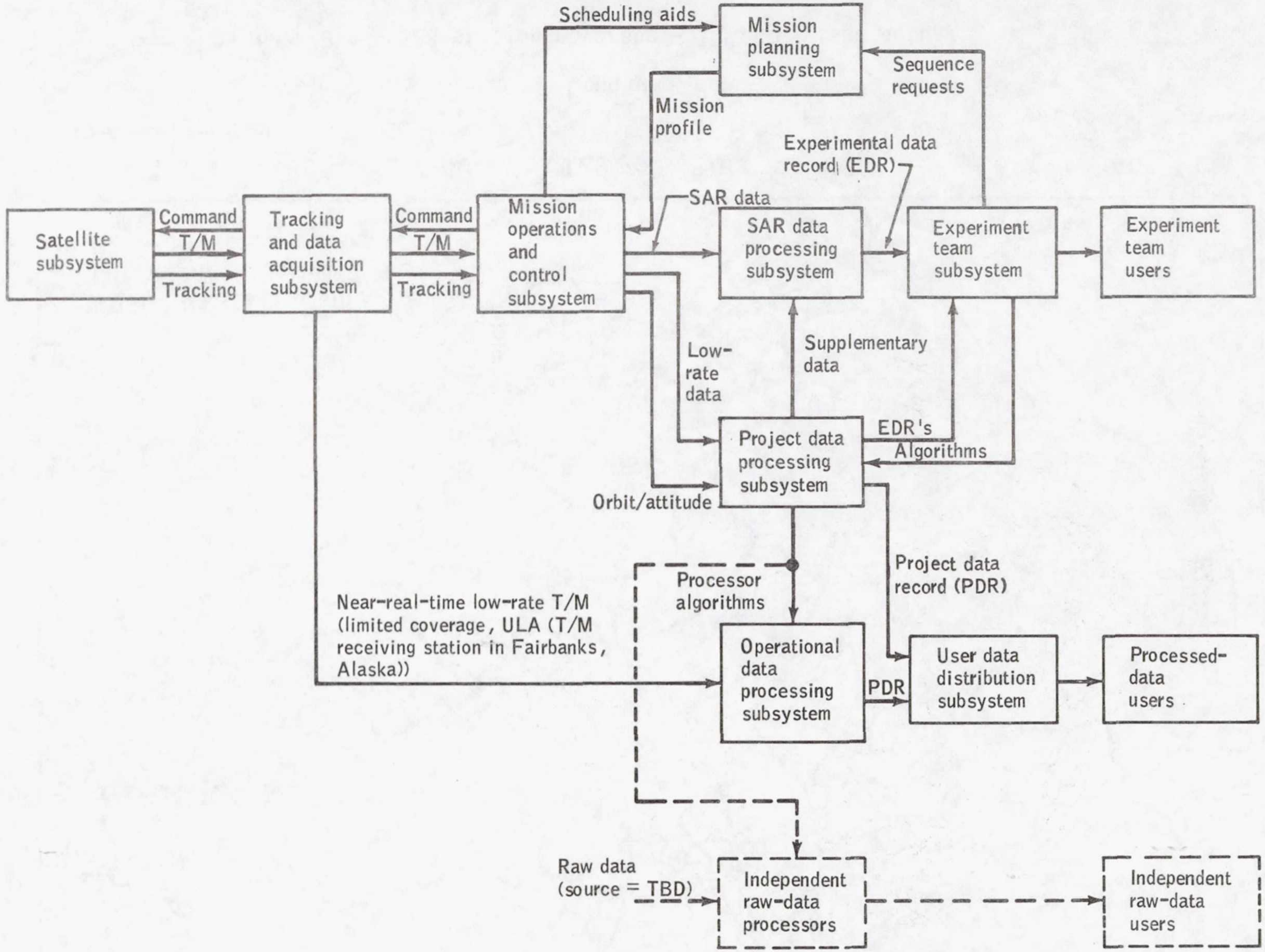

Figure 3-3.- Elements of the Seasat-A end-to-end data system.

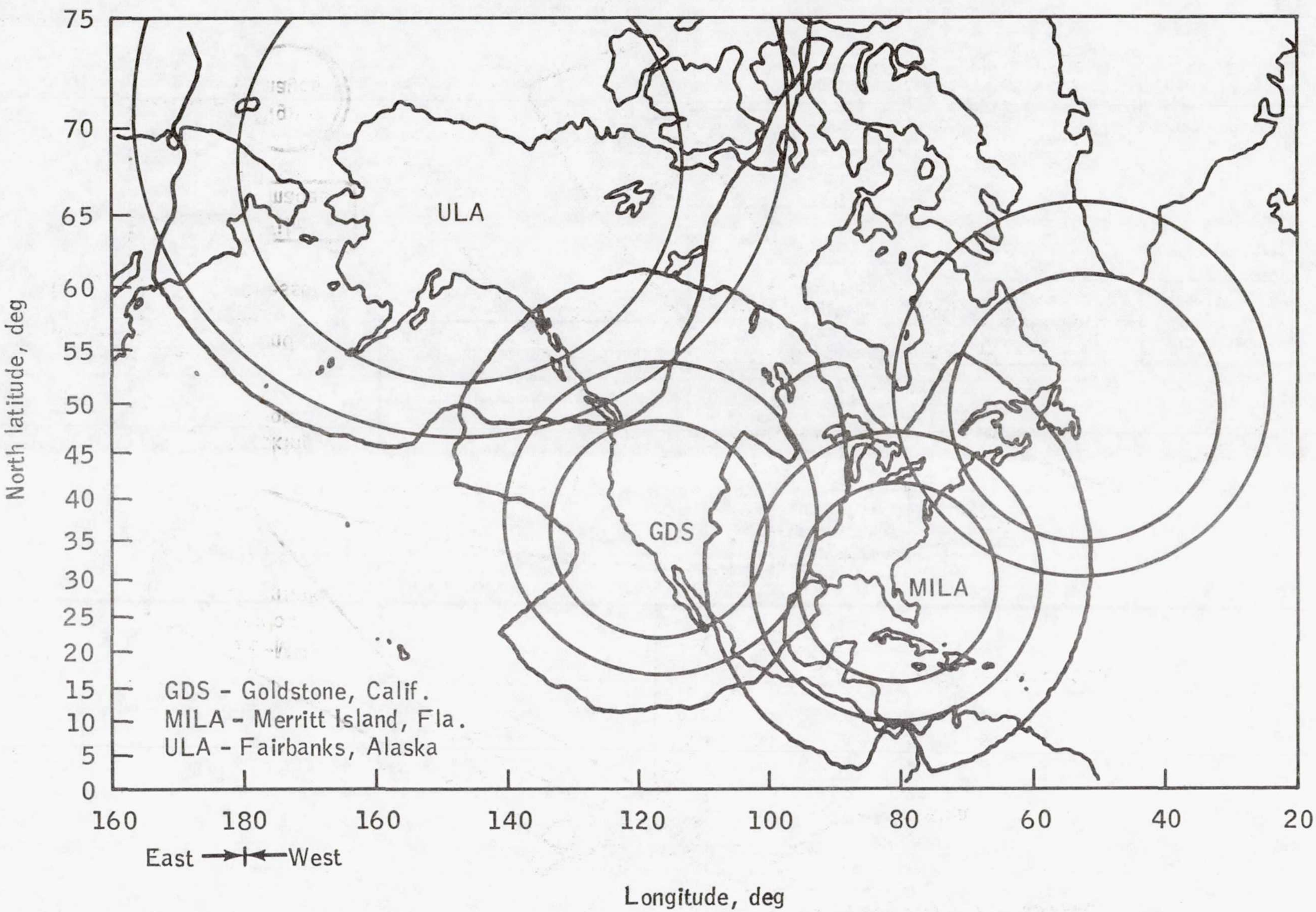

Figure 3-4.- SAR station coverage - 10°, 20°, and actual.

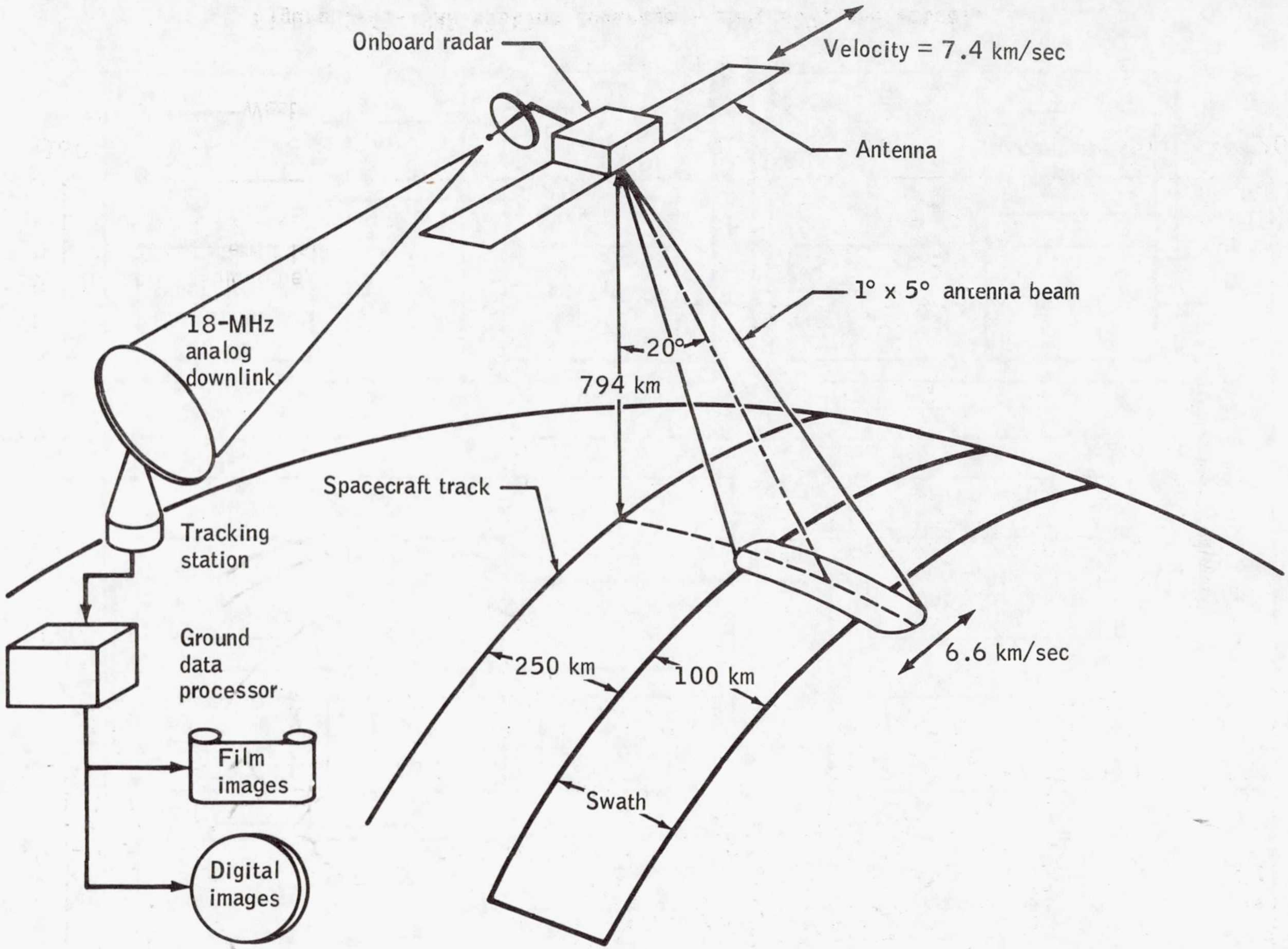

Figure 3-5.- Seasat-A SAR.

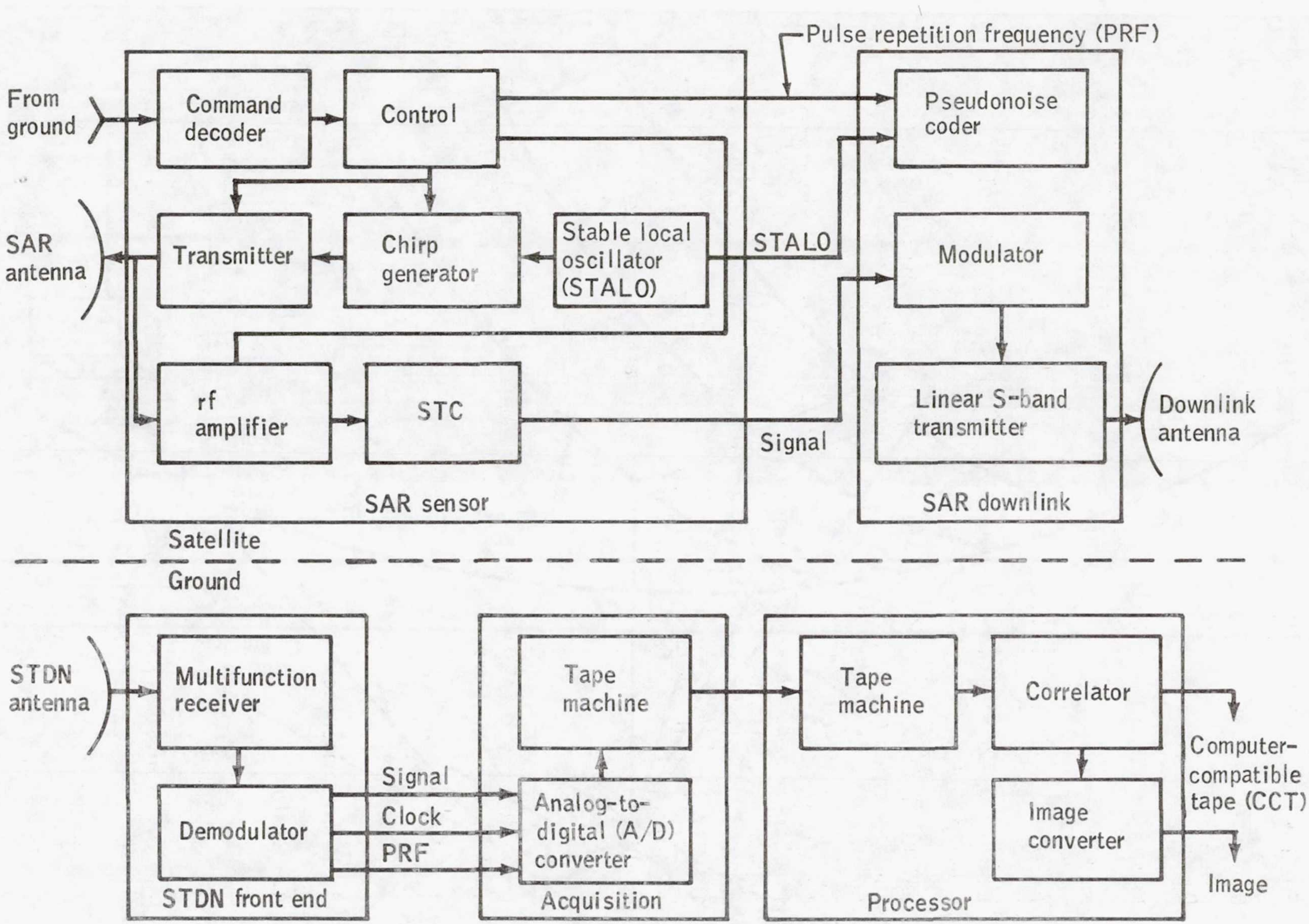

Figure 3-6.- Functional diagram: Seasat-A SAR system.

Swath width - 90 to 105 km as defined in the experiment plan

Number of looks - 4.0

Recording-pass length - 4600 km

Number of passes recorded - 400

Number of passes processed - 260

Dynamic range - up to 20 dB for uniform-scattering regions

Sensor flexibility - automatic or commandable gain control and commandable sensitivity time control (STC)

Paul Teleki, USGS, Seasat SAR Experiment Team Leader, discussed the elements of the experiment plan under development by that group, with particular emphasis on land applications (table 3-2). Teleki pointed out that satellite system constraints will limit total SAR data collection time to approximately 15 000 min/yr. The data that will be processed into final form will correspond to a collection time of approximately 3000 minutes, a limitation imposed primarily because of processing costs. Of the processed data, approximately 30 percent has been identified by the SAR Team as being required for land-application studies, corresponding to an areal coverage of approximately 40 Mm^2. Teleki emphasized that plans for utilization of the SAR are still in the formative stages and that the team would welcome suggestions for well-coordinated experiments.

Panel Structure

Following the briefing by members of the Seasat program, four land-applications subpanels were formed to address the following topics.

1. Mapping and land-cover analysis

2. Food and fiber

3. Water resources

4. Geology

Although individual panel members were assigned to specific subpanels, members contributed to more than one applications area.

The following criteria were used by panel members during the proposal and evaluation of land-applications experiments.

1. Scientific merit

2. Potential for successful achievement of proposed goals

3. Established need for the data that the experiment is designed to produce within the user community

TABLE 3-2.- PROJECTED USES OF SEASAT-A SAR TO EARTH RESOURCES AND ENVIRONMENTAL ASSESSMENTS

Application area	Assumed uses and benefits	Evaluation[a]/ priority[b]	Frequency of coverage, days	Resolution exceeding 25 by 25 m	Comments
		Mineral resources and geologic features			
Land-form identification and terrain analysis	Mapping of uncharted land surfaces		Multiple passes (more than two) required within a month; two different seasons	No	For best resolvability, at minimum, one ascending and one descending orbit are needed to rectify relief (inaccuracy of point on ground not to exceed 50 m); coverage from overlapping orbits is also desirable
In regions of perennial cloud cover		A1			
With foliage penetration		B1			
Detection of geologic features related to mineral location and exploration	Regional geological mapping for resource identification		At least two passes; time of year not specified	No	Same as above
Stratigraphic and structural traps	Hydrocarbons	B1			
Linears, dikes, and intrusive bodies	Metallic minerals	C1			
	Nonmetallic minerals	B1			
Seismicity/tectonics					
Lineaments related to earthquake epicenters	Seismic zonation	B1	At least two passes within 6 mo	No	

[a]Application evaluation key:
- A - demonstrated
- B - highly probable, partially demonstrated
- C - speculative, further research needed
- D - inapplicable
- E - untested concept

[b]Application priority key:
- 1 - high
- 2 - moderate
- 3 - low

TABLE 3-2.- Continued

Application area	Assumed uses and benefits	Evaluation[a]/ priority[b]	Frequency of coverage, days	Resolution exceeding 25 by 25 m	Comments
		Mineral resources and geologic features (cont'd.)			
Seismicity/tectonics (cont'd.)					
Illuminated targets on faults for dilatancy measurements	Crustal motion detection	E2			Special application requiring aircraft underflight
Engineering geology					
Site evaluation and selection	Construction sites	A1	At least two passes within 6 mo under identical environmental conditions	No	
Material differentiation	Construction material location	C1		No	Differentiating for gravels is demonstrated
Fracture tones, faults, and volcanic activity		A1		No	Carbonates and igneous rocks not tested with L-band (only X-band)
		Water resources			
Surface water					
Watershed delineation	Water runoff prediction	A1	At least two passes, preferably in summer	No	Catchment basin/drainage pattern analysis (proven by Landsat)
Wetlands delineation	Wetlands inventories	B1	Two passes per season	No	
Flood detection, mapping, and monitoring	For forecasting purposes	B1	Bracketing occurrence of event	Preferred: 10 by 10 m	Need for imagery before, during, and after event

[a]Application evaluation key:
- A - demonstrated
- B - highly probable, partially demonstrated
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- D - inapplicable
- E - untested concept

[b]Application priority key:
- 1 - high
- 2 - moderate
- 3 - low

TABLE 3-2.- Continued

Application area	Assumed uses and benefits	Evaluation[a]/ priority[b]	Frequency of coverage, days	Resolution exceeding 25 by 25 m	Comments
Water resources (cont'd.)					
Ground water		D			
Snow and ice					
Permafrost	Inventory and engineering purposes	E2	Two passes within 6-mo interval	No	
Frostline detection	Agricultural use; freeze/thaw line	E2 C2	As often as possible in the spring season	No	Differences between dielectric constants of frozen and unfrozen soils should be measurable
Snow cover	Runoff estimation	C1	As often as possible in the winter season	No	Data base is lacking
Mapping glaciers and glacier surges	Information for iceberg season (calving rate)	A1	Once at beginning and once at end of Seasat period	No	
Glacial sounding	Measuring rate of migration	A2	At every opportunity for selected glacier	No	Detection of ice structures below surface of glacier
Extent of freshwater ice (lakes and rivers)	Mapping to aid navigation	A1	Every pass	No	
Thickness and type of freshwater ice		C1	Every pass	No	
Water quality	Detecting pollutants	D			

[a]Application evaluation key:
A - demonstrated
B - highly probable, partially demonstrated
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D - inapplicable
E - untested concept

[b]Application priority key:
1 - high
2 - moderate
3 - low

TABLE 3-2.- Continued

Application area	Assumed uses and benefits	Evaluation[a]/ priority[b]	Frequency of coverage, days	Resolution exceeding 25 by 25 m	Comments
		Agriculture and forestry			
Crops, forest and range			At least once each season; one pass per month in growing season at selected test sites		If L-band does not penetrate
Imaging cultivated areas	Crop identification, extent of cover, and yield prediction	C1		No	
Imaging rangelands	Range identification	B2		No	
Differentiating rangeland conditions	Differences in grazing conditions	D		No	
Soil mapping					
Types of soils		D			
Soil properties		D			
Soil moisture	Watershed management and crop yields	B1	Every pass at selected test sites	No	Data have been collected, have not been analyzed

[a]Application evaluation key:
A - demonstrated
B - highly probable, partially demonstrated
C - speculative, further research needed
D - inapplicable
E - untested concept

[b]Application priority key:
1 - high
2 - moderate
3 - low

TABLE 3-2.- Continued

Application area	Assumed uses and benefits	Evaluation[a]/ priority[b]	Frequency of coverage, days	Resolution exceeding 25 by 25 m	Comments
		Land use and hazards			
Disaster monitoring	Cooling and peatbog fire detection	B2	Event related	No	Change in backscatter
Fire	Rangeland and timber management	A2	Event related	No	Change in backscatter
Earthquake, landslide, avalanche, and wind damage	Delineation of disaster areas	C2	Event related	No	Proven in concept only
Land-use monitoring					
Marshlands, wetlands, and swamps	Coastal zone resource management	B2	One pass each season	No	Data available for St. Johns River, Fla.
Irrigation networks and reservoirs	Agriculture	A1	Every opportunity	No	
Transportation networks	Delineation of new pipelines, powerlines, highways, and railroads	A2	Two passes per year	No	
Regulatory monitoring					
Oil spills on land	Environmental assessment	C1	Every target of opportunity	No	Detection of pipe break; effect of heated oil on Arctic environment

[a]Application evaluation key:
A - demonstrated
B - highly probable, partially demonstrated
C - speculative, further research needed
D - inapplicable
E - untested concept

[b]Application priority key:
1 - high
2 - moderate
3 - low

TABLE 3-2.- Concluded

Application area	Assumed uses and benefits	Evaluation[a]/ priority[b]	Frequency of coverage, days	Resolution exceeding 25 by 25 m	Comments
		Land use and hazards (cont'd.)			
Regulatory monitoring (cont'd.)					
Strip mining	Change detection	B1	Monthly	No	
Disposal of subsurface mine wastes		C2	Twice yearly, two passes each	No	Radar imagery superimposed on Landsat MSS imagery
Forest logging		A1	Monthly	No	
Cartography	Planimetric mapping	A1	Temporal coverage	No	Required accuracy
Radar imagery mosaics	Topographic mapping	E1	Multiple passes	No	Vertical, 100 m; horizontal, 50 m

[a]Application evaluation key:
A - demonstrated
B - highly probable, partially demonstrated
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4. Potential economic benefit to the user community should such data become available

5. Impact of the experiment on the design and development of future microwave space systems and missions

The aforementioned criteria are not listed in rank order, and panel members tended to consider each of them equally during the evaluation of individual experiments.

In the following subsection, the experiments proposed by the subpanels have been ranked as high-, medium-, and low-priority experiments. All experiments discussed herein are considered important. Indeed, because of the difficulty in assigning relative priorities to individual application areas, the uncertainties in the dates of specific test site overflights, and the consensus of the panel that a wide range of applications should be demonstrated, no attempt has been made to rank experiments other than within each of the four topic areas. The priority ranking was performed at the request of the workshop sponsors.

As panel members proposed and assessed potential experiments, they were careful to examine each from the following standpoints.

1. What is the basic objective of the experiment?

2. What sensors on board Seasat-A would be employed?

3. What potential test sites could be employed?

4. What volume of data would be required to successfully complete the experiment?

5. What supporting remote sensor or in situ data would be required?

6. Who would be the potential users of the data?

7. What is the overall significance of the proposed experiment?

Experiments

The proposed experiments are understood to be in a preliminary outline form. In addition, it is recognized that the orbital parameters and system capabilities specific to the Seasat SAR may not be optimum for all experiments. However, because of the level of significance attached to such experiments by panel members, they have been included because they deserve thorough evaluation. The need for more specific documentation is fully recognized, but the material presented is adequate for initial evaluation.

A specific assignment of considerable importance in the conduct of this panel was to aid NASA in assessing both the data type and volume requirements for a Seasat land experiments program. These data requirements have been included for each experiment. Figure 3-7 is a map illustrating the test sites for the proposed experiments. Table 3-3 provides an overview of

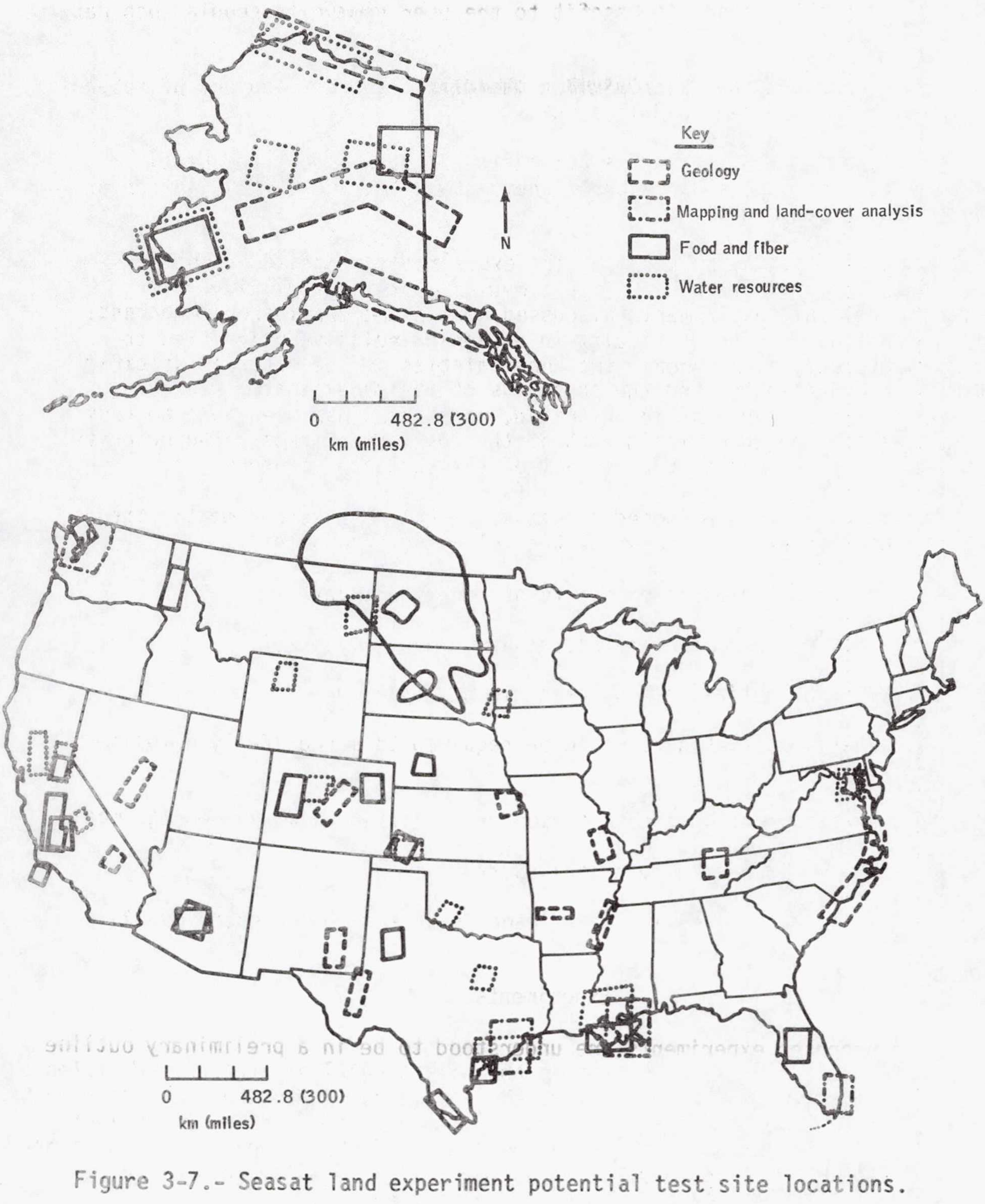

Figure 3-7.- Seasat land experiment potential test site locations.

TABLE 3-3.- OVERVIEW OF EXPERIMENTS PROPOSED BY THE SEASAT LAND EXPERIMENTS PANEL

Experiment title	Priority[a]	Potential test site locations	No. of Seasat passes required	Flightline length required, km	Time spent to accumulate Seasat SAR data, sec/yr[b]
Mapping and land-cover analysis					
Planimetric Mapping	H	Washington, D.C.; Garden City, Kans.; and vicinity of Whittier, Alaska	2/site	100/site	78
Metropolitan Land Cover Mapping	H	Puget Sound, Wash.; New Orleans, La.; Houston-Galveston, Tex.; and Miami-Dade County, Fla.	2/site	200/site	208
		Subtotals:	14	1100	286
Food and fiber					
Forest Fuels Assessment	H	Idaho Panhandle	2/yr	100	26
Forest and Range Biomass	H	Colo.	2/yr	100	26
Wild-Land Renewable Resource Evaluation	H	Salmon, Alaska	2/yr	100	26
Soil Moisture/Crop Yield	H	N. Dak., S. Dak., Kans., Calif., Ariz., Colo., Nebr., and Tex.	3/season/site	100/site	312
Saline Seep/Soil Salinity Detection and Mapping	H	Mont., N. Dak., and S. Dak. (four sites)	2/yr/site	150 (av)/site	156
Crop Discrimination and Stress Evaluation	M	Maricopa City, Ariz.; the lower Rio Grande Valley, Tex.; central Fla.; Bakersfield, Calif.; and the Tex. High Plains	1/growing season/site	100/site	65
Vegetative Cover Mapping for Wildlife Habitat	M	Yukon-Kuskokwim Delta, Alaska	Every June pass (5 assumed)	200/pass	130
Aquatic Vegetation	M	Calif., Tex., La., Fla., Wash., and the Sargasso Sea	2/3 mo/site	100/site	624
		Subtotals:	168	3800	1365

[a]Priorities listed here are relative. All experiments listed are considered significant and have been listed as high (H), medium (M), and low (L) upon request. The judgements were made on the basis of members' experience and took into account the scientific merit, the potential for successful achievement of proposed goals, the established need for data, and the potential economic benefit.

[b]Potential maximum.

TABLE 3-3.- Continued

Experiment title	Priority[a]	Potential test site locations	No. of Seasat passes required	Flightline length required, km	Time spent to accumulate Seasat SAR data, sec/yr[b]
		Water resources			
Watershed Runoff	H	The Kern River, Calif.; Chickasha, Okla.; Waco-Refugio, Tex.; and the Patuxent River, Md.	3 to 4/yr/site	100/site	416
Surface Water/Flood Mapping	H	Targets of opportunity and the rice-growing areas in south-central La., the vicinity of Houston, Tex., and the Sacramento Valley, Calif.	3/yr/nationwide; 2 to 3/growing season/site	100/site	39 117
Snow Mapping	M	The central Sierra Nevada Mts., Calif.; Steamboat Springs, Colo.; the Wind River Mts., Wyo.; Luverne, Minn.; the upper Missouri River; and the Sangre de Cristo Mts., Colo.-N. Mex.	4/site/yr	100/site	260
Alaskan Lakes Mapping	M	The Arctic coast; the Bethel, Alaska, region; the Koyukuk, Alaska, region; and the Mackenzie River Delta, N.W.T., Canada	2/site/yr	100/site	78
		Subtotals:	57	1700	910
		Geology			
Placer Gold Belt Mapping	H	The central Yukon River area, Yukon Terr., Canada	2 to 4/yr	1150	600
Assessment of Glacial Ice Dynamics	H	Skagway to Palmer, Alaska	1 to 2/yr	850	222
Mineral and Petroleum Exploration	H	Central Ark.	4/yr	200	104

[a]Priorities listed here are relative. All experiments listed are considered significant and have been listed as high (H), medium (M), and low (L) upon request. The judgements were made on the basis of members' experience and took into account the scientific merit, the potential for successful achievement of proposed goals, the established need for data, and the potential economic benefit.

[b]Potential maximum.

TABLE 3-3.- Concluded

Experiment title	Priority[a]	Potential test site locations	No. of Seasat passes required	Flightline length required, km	Time spent to accumulate Seasat SAR data, sec/yr[b]
		Geology (cont'd.)			
Geomorphic Mapping in Coastal Wetlands and Marshes	H	La.	4/yr	100	52
Land Subsidence	H	Carlsbad, N. Mex., area	2/yr	100	26
Discrimination of Construction Materials	H	Goldfield, Nev.	2	100	26
Discrimination of Terrain	H	Memphis, Tenn., vicinity	2	100	26
Roughness and Texture	H	Death Valley, Calif.	4	100	52
Discrimination of Geologic Structure in Areas of Low Relief	M	Northern S.C. to Va.	2/yr	400	104
Evaluation of Arctic Coastal Ice Structure and Dynamics	M	Arctic coastline of Alaska	2 to 4/yr	800	416
Evaluation of High-Relief Terrain	M	Colo. mineral belt	1	200	26
Linear Assessment	L	Northeast Kans.	1	100	13
Midcontinent Base Metals Exploration	L	North-central Tenn. to south-central Ky., southeast Mo.	2/yr/site	150/site	78
Sulphur Deposit Exploration	L	Orla-Van Horn, Tex.	2	100	26
		Subtotals:	38	4600	1771

[a]Priorities listed here are relative. All experiments listed are considered significant and have been listed as high (H), medium (M), and low (L) upon request. The judgements were made on the basis of members' experience and took into account the scientific merit, the potential for successful achievement of proposed goals, the established need for data, and the potential economic benefit.

[b]Potential maximum.

the range of experiments proposed by the panel. Table 3-4 presents a summary of the total aerial coverage and volume of data required for the experiments listed in the four land-applications subareas.

Data Requirements

The land applications found in table 3-3 tend to indicate that implementation of all suggested experiments would not result in a particularly heavy data-processing load, even if the maximum amount of data were acquired for each experiment. The table summarizes the experiments proposed for each application area, specific site locations, the number of Seasat passes, and the flightline lengths required. The final column translates number of passes per year per site length into real-time seconds of accumulated Seasat SAR data per year per experiment.

A number of experiments proposed require seasonal data, some annual data; a few require data only once, whereas several are event dependent. The right-hand column (table 3-4), therefore, represents a maximum data requirement that may be expected in a single year from the Seasat land experiments; however, it is highly probable that the total would actually be less than the cumulative amounts shown. In addition, no attempt has been made to reduce the total requirement that would result from concurrent data acquisition for two or more sites - i.e., overlap of sites between experiments.

The total precision-processed-SAR-data requirement for all experiments, if potential savings resulting from concurrent acquisition are disregarded, is estimated to be approximately 4400 sec/yr, or approximately 73.5 minutes. This figure equals one-half of 1 percent of the total annual unprocessed data acquisition capability of the Seasat SAR sensor system. In terms of processed data, this figure represents only a modest portion of both the total projected processed data and the total processed data projected for allocation to land experiment programs.

EXPERIMENT DESCRIPTION

The proposed Seasat land experiments are described in the following subsections.

Mapping and Land-Cover-Analysis Experiments

For all anticipated land applications, the comparison of SAR imagery with existing maps and ground-truth data will be required. For many applications, the digital interfacing of Seasat SAR and Landsat digital imagery for a variety of computer analysis procedures (i.e., supervised and unsupervised classification, modeling, and geographic information systems) is anticipated. Both types of applications require the geometric rectification of raw data to ground coordinate systems. The experiments proposed under this subsection will result in the following accomplishments.

TABLE 3-4.- SUMMARY: SEASAT SAR LAND APPLICATIONS DATA REQUIREMENTS

Category	No. of Seasat passes required	Flightline length required, km	Time spent to accumulate Seasat SAR data, sec/yr
Mapping and land-cover analysis	14	1 100	286
Food and fiber	168	3 800	1365
Water resources	57	1 700	910
Geology	38	4 600	1771
Maximum annual totals:	277	11 200	4332

1. Determination of the sensor map accuracy standard

2. Investigation of the potential for integrating Seasat SAR imagery into automated data base management systems capable of assessing and predicting the impact of changing natural phenomena on the land in a manner similar to that being undertaken in weather and oceanographic experiments on Seasat

Assessing the planimetric accuracy of Seasat-A synthetic aperture radar (SAR) image data.- A need common to all land applications of SAR data is the geometric rectification of raw data to ground coordinate systems, for ultimately most information obtained from SAR data will be related to surface data - or displayed in a map format. In addition, geometric rectification is a necessary step if the SAR data are to be merged with complementary data (e.g., Landsat data). An experiment to examine this problem is outlined in table 3-5.

At a minimum, an experiment should be performed to establish the equivalent national map accuracy standards obtainable with SAR data acquired by Seasat. Procedures for merging digital data from SAR with complementary data (e.g., Landsat data) would be an important part of this experiment.

The Active Microwave Task Force (ref. 3-1) strongly recommended that "NASA....provide digital radar data computer compatible with Landsat D." The study group recognized that raw Seasat SAR data would have limited utility to the user community because of the complex and costly processing required to relate the data to existing surface information and ancillary data.

The three areas chosen for the test represent three types of topography - flat (Garden City, Finney County, Kansas), undulating (Washington, D.C., region), and mountainous (Whittier-Portage region of Alaska). All three areas have highly accurate geodetic control points and represent sites of interest to several experimenters. The data for each site are to be checked for root mean square (rms) error over 15' by 15' quadrangles for the Kansas and Washington, D.C., sites and over a 15' by 30' quadrangle for the Alaskan case.

Land-cover mapping in metropolitan regions.- It is proposed that Seasat SAR digital imagery be utilized for selected metropolitan regions to (1) determine the feasibility of delineating the rural/urban fringe directly and (2) determine the improvement, if any, to be derived from the merging of SAR data with Landsat MSS digital imagery in urban-land-cover classification/mapping. An experiment to test this capability is outlined in table 3-6.

The metropolitan regions chosen for the experiment (Puget Sound, New Orleans, Houston-Galveston, and Miami) are characterized as being coastal, having rapid urban growth, and having a high incidence of cloud cover. All the potential sites are major (and growing) sources of coastal water pollution. The delineation of land cover and statistical summaries of areas could be used in conjunction with coastal zone experiments to assess the impact of nonpoint water runoff pollution.

TABLE 3-5.- ASSESSING THE PLANIMETRIC ACCURACY OF SEASAT-A IMAGE DATA

Item	Discourse
Objective	Determine the planimetric accuracy of Seasat SAR in terms of national map standards. Also, investigate the value of Seasat CCT data that have been geometrically rectified as they relate to interacting with other data sources. In particular, utilize SAR and Landsat data as input into digital classification algorithms.
Seasat-A sensor requirement	SAR.
Potential test sites	Flat terrain - Garden City, Kans. Undulating terrain - Washington, D.C. Mountainous terrain - Whittier-Portage, Alaska.
Data volume requirements	Two passes per site - one ascending, one descending.
Supporting remote sensor data	Multispectral scanner data available from Landsat.
Ground data	U.S. Coast and Geodetic Survey and USGS control points.
Potential users of data output	Common requirements for all land applications of SAR.
Recommendations	
Minimum	Experiment should be performed to define earthographic accuracy of space SAR data and procedures for digital merge with complimentary data (e.g., Landsat data).
Optimum	NASA should provide SAR computer-compatible tapes to users, geometrically rectified to be compatible with Landsat data.

TABLE 3-6.- LAND-COVER MAPPING IN METROPOLITAN REGIONS

Item	Discourse
Objective	Delineate the rural/urban boundary directly from Seasat SAR and interface Seasat SAR digital imagery with Landsat MSS digital imagery to improve multispectral classification in urban regions and assess flooding damage and nonpoint source coastal water pollution.
Seasat-A sensor requirement	SAR.
Potential test sites	Puget Sound, New Orleans, Houston-Galveston, Miami-Dade County (in order of priority).
Data volume requirements	Passes per site: one ascending, one descending. Flooding data: one pass. Area: 200 km long, 100 km wide.
Supporting remote sensor data	High-altitude color-IR and fine-grain black-and-white aerial photography.
Ground data	Field surveys.
Potential users of data output	U.S. Census, Geographic Areas Branch. U.S. Dept. of Housing and Urban Development (HUD) Federal Insurance Agency. Environmental Protection Agency and other coastal-water-pollution monitoring agencies.
Significance	Assist Census in annual delineation of urban fringe in high-cloud-cover regions, provide for automated assessment of flood damage in metropolitan regions, and assist in coastal water and tidelands water pollution modeling.

The high incidence of cloud cover over the selected sites has made it difficult to obtain timely Landsat coverage for the monitoring of urban development. As a proof-of-concept test, it would be useful to test whether Seasat SAR imagery can be advantageous to the U.S. Census in the execution of its recently imposed mandate to delineate urban/rural boundaries. Urbanized areas, defined as those areas with more than 386.1 persons per square kilometer (1000 persons per square mile), are to be delineated annually for the 275 standard metropolitan statistical areas after 1980. Comparative images such as those seen in figure 3-8, and research reports (ref. 3-1), suggest that resolution requirements for urban limits delineation from SAR imagery by using standard photo interpretation techniques should be met by the Seasat SAR sensor.

All the metropolitan areas mentioned are subject to flooding, either from storm water runoff or tidal surges associated with hurricanes or both. Disaster relief agencies not only need to know the regions inundated but also need to arrive at dollar estimates of the damage. As a proof-of-concept test, it would be useful to have land-cover digital images that conform to the scale and flightpath characteristics of Seasat SAR digital images in addition to the SAR imagery taken during flooding. The interfacing of land-use image and flooding-period image would permit an automated tabulation of area for each land-cover type flooded.

Panel members are aware that Seasat SAR data acquisition need not be confined to the cities mentioned in cases of specific significant environmental disruption. In such instances, it would still be possible, within the proof-of-concept nature of the Seasat mission, to conduct viable experiments. This task could be accomplished by going back through past Landsat data for the area under study and constructing the data base needed for the experiment. One problem that would arise, however, would be in connection with the amount and quality of the ground-truth data available for the study site. Ground data collection would be access dependent; and the cost associated with in situ data acquisition, which would depend on a variety of factors, could range from minimal to excessive.

Food and Fiber Experiments

A sizeable portion of the highly productive rangeland and commercial forest land in the western United States and Alaska is located in areas that are difficult to assess by using conventional remote-sensing methods. This fact is particularly relevant because the sensing of a phenomenon such as vegetation stress is highly time dependent. Managers of large tracts of forest and rangeland are in need of alternatives to conventional remote-sensing methods, which include the use of high-altitude-aircraft photography and Landsat MSS imagery.

The SAR, although virtually unexplored as a renewable resource assessment tool for wild-land areas, has the potential of being a highly beneficial complementary data source for performing time-dependent renewable resource evaluations.

Foresters, rangeland inventory specialists, and wildlife experts have suggested a number of specific experiments - "Forest and Range Biomass,"

(a) Landsat image.

(b) JPL imaging-radar image (simulates Seasat resolution).

Figure 3-8.- Landsat and radar image of La Canada/JPL/Pasadena area.

"Wild-Land Renewable Resource Evaluation," "Forest Fuels Assessment," and "Vegetative Cover/Wildlife Habitat Mapping" - for testing microwave capabilities. In addition to these experiments, the panel strongly supports the snow-mapping experiment proposed in the "Water Resources Experiments" subsection of this chapter. Whereas it is highly desirable to correlate satellite experiments with the collection of calibrated aircraft and field measurement data, such ancillary data are not mandatory to significantly advance the state of knowledge from the current base of understanding.

Forest and range biomass.- The Nation's forest and range resources managed by the USFS are an important source of food, fiber, and fodder. The yearly production of timber from our forest lands and cattle and sheep from our rangeland is evidence of the importance of this resource. Managers charged with the responsibility for the wise use of this resource require a wide range of timely, accurate information. Specifically, with respect to the range, resource managers require data on the readiness of a given range, as well as information concerning its carrying capacity and early indications of overuse. Such information, which is associated with biomass estimation, is important because managers try to plan the long-range use of both forest and range resources.

This experiment would test the capability of Seasat SAR data to provide management with information that would aid in the estimation of biomass for a given area (see table 3-7). Such biomass estimates could be used in forest fuels fire predictive models (see table in "Forest Fuels Assessment" subsection) in the case of forest biomass or to calculate range productivity and carrying capacity for livestock and wildlife (see table in "Soil Moisture/Crop Yield System" subsection).

Wild-land renewable resource evaluation.- To promote the wise use of this Nation's renewable resources, information concerning their state and extent must be gathered on a timely basis. In many areas, however, the acquisition of information concerning those renewable resources presents difficult problems. Such is the case in the State of Alaska. Much of the interior of Alaska has not been intensively inventoried with respect to natural resources because of environmental and technological obstacles. In this harsh environment, conventional survey techniques are hazardous and it is difficult and expensive to obtain the required data by using conventional remote-sensing techniques. The Seasat SAR system has the potential to provide an alternative source of resource information. This experiment is designed to test the feasibility of using the Seasat SAR system to provide information for the periodic assessment of the renewable resources in the interior of Alaska (see table 3-8).

The suggested experimental objectives are keyed to a specific geographic site that offers different challenges for a Seasat land-applications test. The test sites also provide opportunities for using collateral data in that they are established centers of research and development activity by resource management agencies such as the USFS.

The agricultural industry is the largest U.S. industry. Exports from its remarkably efficient system both account for the periods of favorable balance of payments and pay for vast amounts of imported petroleum.

TABLE 3-7.- FOREST AND RANGE BIOMASS

Item	Discourse
Objective	To estimate total biomass of vegetation in designated management areas. It is desirable to distinguish forest biomass from range biomass because the data are used in different management models.
Seasat-A sensor requirements	SAR, VIR, and scatterometer.
Potential test site	Grand County, Colo.
Data volume requirements	One pass in June and one pass in Aug., per year. Area: 64.8 by 88.9 km (35 by 48 n. mi.).
Supporting remote sensor data	High-altitude color-IR photography. Metric camera, 30.5-cm (12 in.) focal length, from 198.1 Mm (65 000 ft). Low-altitude color-IR photography. 70-mm strips at 1:1200 scale.
Ground data	Forest and range biomass inventory ground sites and collateral field measurement data.
Potential users of data output	USFS, BLM, Colo. Bureau of Fish and Game, and U.S. Fish and Wildlife Service.
Significance	Forest biomass estimates are used in forest fuels fire prediction models, and similar range biomass estimates are used to calculate range productivity and carrying capacity for livestock and wildlife.

TABLE 3-8.- WILD-LAND RENEWABLE RESOURCE EVALUATION

Item	Discourse
Objective	To determine the feasibility of using SAR data in remote areas of interior Alaska for periodic assessments of the renewable resources.
Seasat-A sensor requirements	SAR, SMMR, VIR, scatterometer, and radar altimeter.
Potential test site	Salmon, Alaska.
Data volume requirements	Passes per site: one ascending, one descending, July and August. Area: 175.9 by 203.7 km (95 by 110 n. mi.), centered on Salmon.
Supporting remote sensor data	High-altitude color-IR photography from 198.1 Mm (65 000 ft). Metric camera, 15.2-cm (6 in.) focal length. Low-altitude color-IR photography. 70-mm strips at 1:4000 scale.
Ground data	Ground inventory data.
Potential users of data output	USFS, BLM, USACE, SCS, and Alaskan Land Use Planning Team.
Significance	Much of interior Alaska has not been surveyed for an extensive inventory of renewable resources, and there are major obstacles in performing such an inventory because of the difficulty of obtaining conventional remote-sensing data. SAR data obtained from a special platform provide a potential alternative source of collateral extensive-type resource information.

Recent bans on important agricultural chemicals by the Federal Government have seriously damaged the efficiency of the American agricultural industry and significantly increased the cost of food. If the United States is to continue to pay for imported petroleum with exported agricultural crops, it is imperative that the agricultural community utilize every available and economically viable scientific and technological breakthrough.

Imagery obtained from Landsat, Skylab, and NASA high-altitude aircraft can contribute to the efficiency of modern agriculture. Imagery from these space platforms and from both visible and IR portions of the electromagnetic spectrum has value for identifying crops, detecting and monitoring stress, and evaluating crop yield potential. Unfortunately, clouds and related weather phenomena, as well as insufficient solar illumination, prevent collection of imagery during critical phases of the crop cycle. The experiments listed in the following subsections are designed to test the capabilities of the Seasat SAR system to impact the agricultural communities' information requirements, particularly in the critical area of crop stress evaluation (see tables in subsections "Soil Moisture/Crop Yield System," "Saline Seep/Soil Salinity Detection and Monitoring," and "Crop Discrimination and Stress Evaluation"). Improved information on crop stress can be of major importance with respect to both management decisions and economic considerations in U.S. agriculture.

Forest fuels assessment.- Each year, fires consume hundreds to thousands of square kilometers (hundreds of thousands of acres) of valuable timber and rangeland. The USFS, through its Firescan project, is currently employing remotely sensed data to combat this problem. Project Firescan is designed to detect areas of latent fire hazards and thereby contribute to minimizing the potential for environmental disruption. The experiment proposed herein is an attempt to determine whether this early warning capability can be augmented with a system that, hopefully, has the potential of providing data relative to the severity of the fire hazard that exists in a given area (see table 3-9). This determination would be accomplished by assessing the capabilities of the Seasat SAR for providing data relative to the moisture status of forest fuels - e.g., the total complex of dead materials that accumulate in forest and wild-land areas.

This information is currently gathered by using conventional ground survey techniques, which are often augmented in a number of areas by aerial surveys. A successful proof-of-concept demonstration would provide important information to foresters and wild-land managers as they attempt to minimize the impact of fires on our forest resource.

Soil moisture/crop yield system.- Recent experimental results and reference data indicate that soil moisture content may be measurable by using an L-band SAR imagery system. These data could have a significant impact on crop yield prediction models. Soil moisture is an important variable affecting the prediction of yield of agricultural crops. Yet, soil moisture is essentially an unmeasurable quantity as pertains to crop yield prediction models. Conducting a program of data acquisition by using conventional point-sampling techniques on a scale necessary to impact these models would be both costly and to a large extent unproductive. As a result, for crop yield prediction models, such as the wheat yield modeling system, a variety of surrogate data is used to supply information

TABLE 3-9.- FOREST FUELS ASSESSMENT

Item	Discourse
Objective	To monitor the moisture status of forest fuels that resulted from logging residue, the forest mortality from insect and disease infestation, and the total complex of dead material that accumulates in the forest and wild-land areas.
Seasat-A sensor requirements	SAR, SMMR, VIR, scatterometer, and radar altimeter.
Potential test sites	Idaho Panhandle, Salmon River north to the Canadian border.
Data volume requirements	Passes per site: one ascending, one descending. Area: 138.9 by 342.6 km (75 by 185 n. mi.).
Supporting remote sensor data	Two-stage high-altitude aerial photography from 198.1 Mm (65 000 ft). Metric camera, 15.2-cm (6 in.) focal length, with color-IR film. Reconnaissance camera, 61.0-cm (24 in.) focal length, with color-IR film.
Ground data	Fuel inventory ground plots and supporting field measurement data.
Potential users of data output	USFS, BLM, and State and private forest groups.
Significance	Fuel moisture data are a major input to a national fire model for predicting the rate of spread and fire hazard.

on soil moisture. The Earth Satellite Corporation (Earth Sat) Agmet system employs manual image analysis of Synchronous Meteorological Satellite (SMS) visible and IR images to produce data on cloud types, patterns, and amounts. These data are typically incorporated, together with data from other satellite systems and ground meteorological networks, to derive information on parameters affecting yields, such as precipitation, incoming solar radiation, net radiation, and potential evapotranspiration.

Data on the duration, type, and amount of precipitation are used in these prediction models as a surrogate for soil moisture. Soil moisture may be measurable by combining data obtained by the L-band imager and microwave radiometer during passage over rain-free areas. In regions undergoing precipitation, similar measurements may determine the areal extent of precipitation and perhaps its intensity. The IR radiometer data currently used to estimate precipitation probabilities from cloudtop temperatures could be improved with the microwave data. Although Seasat-A will not provide the frequency of measurements supplied by the SMS, this experiment would be useful in demonstrating the concept of remotely measuring soil moisture with microwave sensors (see table 3-10).

For this experiment, test sites should be carefully selected, be sufficiently large, be well instrumented or have adequate control, and exhibit a diversity of soil moisture conditions. In this respect, attempts should be made to include data from large-field commercial farms. In addition, the panel believes that it is important to include areas where a variety of irrigated commercial field crops are grown. Because of the intensified interest in predictive yield modeling efforts within the LACIE program, the panel believes that a determination of the interest of scientists associated with the LACIE to participate in this experiment should be made.

The Seasat passive microwave radiometer (the SMMR) may be used to reduce bias errors in the estimation of soil moisture content obtained by use of the SAR. This task can be accomplished by comparing the moisture estimate based on the radiometer temperature of its large footprint with the integrated moisture estimate based on the SAR data for the same footprint, and then using the ratio of the two estimates to generate a new high-resolution soil moisture contour map.

In addition to ground-truth data collection, it is proposed that airborne sensors with proven soil moisture sensitivity be used in support of this experiment. These sensors include C-band radar (preferably imager) and the NASA Lyndon B. Johnson Space Center (JSC) multifrequency microwave radiometer (MFMR) (see table 3-10).

Saline seep/soil salinity detection and monitoring.- Salt-affected soils are found in many agricultural areas of the United States and cause untold loss of income to the national economy. Saline seeps represent one form of salt-affected soils. In these areas, extremely high salt concentrations at the soil surface can cause significant crop losses; e.g., in Montana, biennial wheat loss has been estimated to be approximately $50 million. If saline seep areas can be identified early, alfalfa or similar crops can be planted to increase evapotranspiration and prevent the buildup of salts at the soil surface. Theoretical computations by Keith Carver,

TABLE 3-10.- SOIL MOISTURE/CROP YIELD SYSTEM

Item	Discourse
Objective	To determine the potential of the L-band SAR system to provide soil moisture data for input into agricultural crop yield predictive models.
Seasat-A sensor requirements	SAR, VIR, scatterometer, and SMMR.
Potential test sites	LACIE intensive sites: Williams County, N. Dak Hand County, S. Dak. Finney County, Kans. Southern San Joaquin Valley, Calif. Maricopa County, Ariz. Center pivot irrigation areas in Nebr., Colo., and Tex.
Data volume requirements	Passes per site: three to four passes during critical period in growth cycle (field prepared through fruiting). Length per site: 24.1 to 80.5 km (15 to 50 miles). Area: LACIE sample sites, 8.0 by 9.7 km (5 by 6 miles).
Supporting remote sensor data	Landsat data, including thermal-channel data. S-191 and large-scale high-altitude aerial photography, 1:32 000. Aircraft scatterometers: 1.6 GHz, C-band. Imaging radar: L-band, C-band.
Ground data	Field spectroradiometer. Precision radiation thermometer (PRT-5). Capability for systematic field soil moisture sampling and rainfall monitoring. Truck-based systems: MAS and microwave signature acquisition system (MSAS).
Potential users of data output	USDA, private industry, and food producers.
Significance	The data are important to upgrade the overflight quality of our agricultural yield forecasting capabilities.

New Mexico State University, indicate that saline soils can be differentiated from normal soils by using L-band radar data. Preliminary measurements at Texas A. & M. University also indicate that dielectric properties of saline-seep-affected soils can be detected. The L-band Seasat-A imager is therefore considered satisfactory for proof-of-concept verification (see table 3-11).

Several State leaders have recognized the problem of saline seeps. The Governors of Minnesota, North Dakota, South Dakota, and Montana, meeting in 1975, agreed on the need to obtain information on the location and degree of development of saline seeps. Areas of salt-affected soils are also found in areas of extensive irrigated agriculture in the arid southwestern United States. The Imperial Valley and southern San Joaquin Valley of California; Maricopa County, Arizona; and the lower Rio Grande Valley of southwest Texas are all potential sites for testing the capabilities of the Seasat sensors to complement existing systems and provide data relative to this important problem.

Crop discrimination and stress evaluation.- Cloud-related weather phenomena and insufficient solar illumination usually cause difficulties in the identification of crops and the detection of stress by conventional remote-sensing techniques. Visible and IR wavelengths will not adequately penetrate cloud cover during periods of adverse weather. Consequently, it is now virtually impossible to gather necessary crop identity and stress data over large portions of important agricultural areas during critical phases of the crop cycle.

The Seasat-A program can overcome some of these shortcomings. It can provide needed data and greatly enhance the value of Landsat and high-altitude-aircraft imagery. The wavelengths employed by Seasat's microwave sensors will penetrate clouds and thus may enable acquisition of crop stress and soil cover data during both nighttime and periods of adverse weather. Furthermore, the microwave sensors can penetrate leaf canopies and thus detect both surface and shallow root zone soil moisture. Such information can thus supplement the imagery obtained simultaneously by other means and greatly enhance the value of all remote-sensing systems employed (see table 3-12). It is recognized that the L-band SAR is not optimum for crop detection; however, recent test results suggest that some vegetation discrimination is possible even at these long wavelengths. This indication can be verified in the proposed experiment.

Although many investigators prefer and expect multidate imagery, ecomomic constraints sometimes necessitate that agribusiness interest groups limit their investigations to a single pass over a specified area during a critical phase of the crop cycle. Thus, if, during the single pass, imagery can be simultaneously obtained from the visible, near-IR, thermal-IR, and microwave portions of the electromagnetic spectrum, the optimum benefit to agriculture should be realized.

Vegetative cover mapping for wildlife habitat.- Wildlife habitat mapping is a difficult endeavor, complicated by the absence of an adequate definition of habitat. Simplistically, habitat and vegetative association can be used interchangeably. One virtue of this simplification is that it

TABLE 3-11.- SALINE SEEP/SOIL SALINITY DETECTION AND MONITORING

Item	Discourse
Objective	Detection of saline seeps by using Seasat-A SAR
Seasat-A sensor requirements	SAR and SMMR
Potential test sites	N. Dak.; NE. Ariz., Maricopa County; S. Dak.; central or west Calif., Imperial Valley or southern San Joaquin Valley; Tex., Rio Grande Valley; Mont., NE.
Data volume requirements	Passes per site: two per year Length per site: 241.4 to 482.8 km (150 to 300 miles)
Supporting remote sensor data	S-191 and photography Scatterometer (JSC), 1.6 GHz Imaging radar (JPL), L-band MFMR (JSC)
Ground data	Map of the saline seep
Potential users of data output	Farmers and ranchers USDA USACE Food processors
Significance	590 517.3-km^2 (228 000 mi^2) potential saline seep area

TABLE 3-12.- CROP DISCRIMINATION AND STRESS EVALUATION

Item	Discourse
Objectives	To aid crop identification and stress detection by combining reflective data from Seasat-A with spectral data from Landsat systems. To prove the concept that wide-band, multichannel, visible-to-microwave-frequency sensor data provide more timely and economically useful information than MSS data alone. To ascertain the value of Seasat-A sensors for measuring soil moisture. Degree of vegetation penetration and sensitivity of sensors to soil moisture changes should also be recorded.
Seasat-A sensor requirements	SAR and scatterometer.
Potential test sites	Maricopa County, Ariz.; lower Rio Grande Valley, Tex.; central Fla.; southern San Joaquin Valley, Calif.; Tex. High Plains. Test sites selected should be governed by availability of current ground truth, coincidence of Seasat/Landsat coverage, and presence of several types of economically significant field crops during most of the crop year.
Data volume requirements	Passes per site: one per peak growing season/coincident with Landsat overpass. Length: standard 100- by 100-km scene. Landsat coincident data.
Supporting remote sensor data	Underflight L-band imagery. Color-IR photography.
Ground data	See above.
Potential users of data output	Producers and processors of food.
Significance	If the proof of concept is achieved, future agricultural monitoring systems would be cost/benefit attractive to elements of the agribusiness community.

allows use of remote-sensing techniques to arrive at a first approximation of habitat. Conventional - i.e., visible/near-IR - instrumentation is perhaps the most versatile and most widely used in this respect. However, for areas in which cloud cover is a severe constraint in these wavelengths, other sources such as imaging microwave systems (SAR) must be considered.

Habitat is, of course, a function of the wildlife species under consideration; but, in general, loss of habitat is the major threat, especially when considered on the national level, to wildlife survival. Hence, the need exists to inventory and monitor wildlife habitat, especially for threatened and endangered species. Nearly all developmental activities (urbanization, agriculture, energy extraction, and water resources development) destroy or modify habitat. Thus, their effect is on population and not so much on individuals. Budget constraints of Federal and State agencies concerned with wildlife (habitat) preservation make it mandatory to use cost-effective methods for assessing available and impacted habitat. The use of SAR (in special cases) and other remote-sensing methodologies has become central to wildlife management. To test the applicability of Seasat SAR data for studying wildlife habitat, an experiment to assess the importance of these data for providing information relative to Arctic goose nesting success is proposed.

Each year, the Fish and Wildlife Service sets migratory-bird-hunting regulations, which form the basis for season lengths and bag limits established for each flyway and State. This task represents a multimillion dollar effort involving numerous data sources and resource inputs. A major component of the migrating waterfowl is Arctic nesting geese (snow geese, brant, Canada geese, etc.). Of the 1.8 million geese taken in the 1975 hunting season, fully 1.6 million nested in the Arctic. A critical datum needed in setting hunting limits is productivity (nesting success) each year. Because of the remoteness and vastness of the areas involved, these data are difficult, if not impossible, to obtain. The most critical information is whether or not the potential nesting sites are clear of ice at the time the goose-pairs are ready to build nests. If no ice-free nesting sites are available, the females resorb the eggs and no young are produced. The period involved is at most a month, generally less. Within 6 weeks of this period, preliminary hunting regulations incorporating that year's nesting success must be determined. Thus, for a short, crucial period, ice conditions determine nesting success or failure. The recent use of satellite data (NOAA-3 very high resolution radiometer (VHRR), Landsat MSS) has resulted in a significant increase in the ability to forecast ice conditions - hence, the probability of nesting success - on the Arctic breeding grounds. However, frequent cloud cover at the critical period limits the certainty of these data sources. The ability of the Seasat SAR to penetrate clouds and map ice versus ice-free regions (the freeze-thaw line) at 25-m resolution should finally provide a means to close this management information gap (see table 3-13).

Monitoring of aquatic vegetation.- Aquatic vegetation is of considerable importance. Kelp, for example, is a basic element in the aquatic food chain. In some cultures, it is a recognized food product in its own right; and it is an important harvestable commercial crop in such areas as California and the northeast coast. Similarly, the estuarine marshes of the gulf coast and eastern seaboard are central to marine food productivity. The wetlands,

TABLE 3-13.- VEGETATIVE COVER MAPPING FOR WILDLIFE HABITAT

Item	Discourse
Objective	To detect the freeze/thaw line and relate this information to lake ice conditions in the Arctic as a prediction of goose nesting success.
Seasat-A sensor requirements	SAR, SMMR, and scatterometer.
Potential test site	Yukon-Kuskokwim Delta, Alaska.
Data volume requirements	All passes over the study area from May 15 to July 15.
Supporting remote sensor data	High-altitude color and color-IR photography, L-band imaging radar data from aircraft.
Potential users of data output	U.S. Fish and Wildlife Service, Canadian Wildlife Service.
Significance	Demonstration of proof of concept would not only lead to improved management of Arctic waterfowl but would have important implications in many areas of wildlife management.

which are susceptible to man-imposed stress, have a significant direct impact on man, the ultimate food consumer. Conversely, noxious aquatic plants cause great damage worldwide in the freshwater environment by clogging waterways, by increasing losses of water from reservoirs, and by diminishing recreational potential. This seemingly disparate vegetation has a common denominator, that of necessitating management by man. A key element in aquatic vegetation management is the monitoring of its spread and condition, a task somewhat synonymous with the tracking of its areal extent and relative biomass.

Provision of timely information by remote sensing enables valid decisions to be made concerning how these vegetative classes are to be handled for optimum benefit to man. Imaging radar can provide the sort of broad, all-weather, detailed monitoring coverage that would not be possible to economically obtain with other sensor types.

Kelp is quite common in the west coast environment. A prodigious grower, healthy kelp can be cut several times per year by commercial harvesters in California, where it is the basis for a $46 000 000-per-year industry. Kelp is also susceptible to environmental damage from storms, marine organisms, and sewage outfalls. Consequently, a monitoring program designed to measure areal extent, plant rigor, and biomass is an important element in the optimal use of this increasingly economic resource.

As a result of research conducted by John Estes, University of California, Santa Barbara, the ability of Landsat and high-altitude visible-sensing systems to monitor kelp has been documented; however, as is common along the west coasts of continents, the extensive and persistent occurrence of stratus clouds severely inhibits the use of such procedures. The Seasat SAR system, with 25-m resolution and all-weather capability, should significantly improve the ability to monitor this resource. The X-band imagery of the Santa Barbara coastline obtained during a flight by the U.S. Coast Guard has already demonstrated the effectiveness of microwave sensing systems for this application. Seasat will provide an optimum test bed for determining the feasibility of a worldwide kelp-monitoring system.

A somewhat related phenomenon is the vast coverage of parts of the tropical North Atlantic Ocean by Sargassum weed; the chief component of this coverage is normally referred to as the Sargasso Sea. The potential for gaining information on the structure dynamics and morphology of this little-understood area could be assessed by using SAR data.

The natural estuarine habitat is many times more food productive than farmland of equal area. Most food from the sea is directly or indirectly dependent on estuarine basic productivity, which in turn is a function of the amount of available marsh vegetation. The wetlands environment is easily stressed by coastal construction, by estuarine pollution, and even by improper operation of reservoirs upstream, all of which are controllable management activities. The entire coastal fisheries industry, both finfish and shellfish, is directly dependent on the proper maintenance of the estuarine ecology.

The periods of greatest plant production in the gulf coast wetlands occur at a time when clear weather periods are at an annual minimum; thus, radar imagery has relevance as a monitoring sensor.

A relatively unknown but extremely damaging natural phenomenon is the fairly recent proliferation of noxious aquatic plants in the reservoirs and waterways of much of the United States. Their effect is to increase evapotranspiration of water from reservoirs, block navigable channels, destroy waterfront property values, reduce or eliminate recreational potential, block the flow in irrigation canals, and provide an ideal habitat for insect vectors of such diseases as malaria, encephalitis, and filariasis. Florida, which now expends over $15 000 000 per year on aquatic plant control measures, experiences damages on the order of $100 000 000 per year from their continuing presence. Florida agencies find themselves unable to cope with the problem of monitoring the extent of infestation in the State's 10 000 km^2 (10^6 ha) of freshwater lakes.

Texas, now embarked on a mammoth reservoir construction program that will eventually produce a greater freshwater area than that of Florida, has recently experienced major outbreaks of noxious aquatic plant infestations. If unchecked, the waterhyacinth infestation alone could account for 100 million dollars' worth of unanticipated water losses per year through evapotranspiration.

Louisiana is estimated to have a greater infestation of aquatic weeds than either Florida or Texas, comprising an area on the order of 5000 km^2 (500 x 10^3 ha). Many of these infestations occur in relatively inaccessible areas and are therefore difficult to monitor.

In all three States, agencies responsible for aquatic plant control are not able to track the location and extent of the infested areas. Ground monitoring is not feasible. Seasonal aerial photographic monitoring is considered to be too expensive. Landsat monitoring is inhibited by clouds and by the relatively poor resolution of the available sensor. With Landsat MSS imagery, by the time the infestation is large enough to be discernable, the situation has already gotten out of control.

The application is ideal for the SAR. Imagery from SAR experiments over Central America shows the presence of aquatic plants with great clarity, as would be expected from the sensor's high resolution and excellent capability for detecting vegetation. The SAR could provide all-weather monitoring of aquatic plants with a resolution significantly better than that currently available from Landsat.

With SAR data on hand, the aquatic plant control program managers would, for once, have timely and accurate information on the location and extent of noxious aquatic plant outbreaks. They could thus direct their herbicide application efforts far more effectively than is now the case and reverse the established trend of steadily increasing total infestation (see table 3-14).

TABLE 3-14.- MONITORING OF AQUATIC VEGETATION

Item	Discourse
Objective	Use Seasat for monitoring large-scale occurrences of aquatic vegetation.
Seasat-A sensor requirement	SAR.
Potential test sites	Kelp: Calif., Santa Barbara Channel, where there are ongoing kelp studies; Wash., Rosario Strait, where there may be a critical interaction between tanker navigation and kelp bed presence; and the Sargasso Sea, where vast areas of Sargassum drift in the tropical Atlantic. Coastal marshes: Tex. - Aransas Pass area, Pass Cavallo area, and Colorado River Delta area, where seasonal aerial photography and intensive ground truth are used in ongoing studies. Noxious aquatic plants: Fla., Rodman Reservoir, where extensive tests of aquatic plant control methods are being made; La., lowlands bayous, where upwards of 5000 km^2 (500 x 10^3 ha) of waterhyacinth are proliferating; and Tex., Lake Livingston, where aerial photographic monitoring tests are being undertaken and where the Texas Parks and Wildlife Department is undertaking a major test of chemical control of *Hydrilla verticillata*.
Data volume requirements	Passes per site: two per season - all. Length: 100 km - all.
Supporting remote sensor data	Landsat data. Color-IR underflights - all except Sargasso. L-band imaging radar (concurrent) - all except Sargasso.
Ground data	Taxonomic and phycological field surveys.
Potential users of data output	Kelp: U.S. National Maritime and Fisheries Service (NMFS), Fleet Weather Service (FWS), Calif. Dept. of Fish and Game, Wash. Dept. of Commercial Harvesters. Coastal wetlands: NMFS, FWS, commercial fisheries, Tex. Water Development Board, USACE, Tex. General Land Office (Coastal Zone Management), NOAA (Office of Coastal Zone Management). Noxious plants: Fla. Dept. of Natural Resources, La. Wildlife and Fisheries Commission, Tex. Parks and Wildlife Dept., Tex. Water Development Board, USACE.

Water Resources Experiments

By 1978, there will have been several results involving active microwave ground-based and aircraft measurements that will need to be evaluated and compared to spaceborne SAR observations available from Seasat-A. These results will have demonstrated the potential capability of observing variations in soil moisture, surface-water extent (particularly during stormy or cloudy periods), and spatial variations in runoff potential from small watersheds. This opportunity for evaluating the utility of active microwave data by using Seasat-A must be seized for the following reasons.

1. Microwave has an apparently strong potential for providing the capability to observe the fundamental parameters noted previously.

2. The Seasat-A SAR data evaluation opportunity is the first such opportunity, and it may be the only one until 1980, when the first Shuttle engineering flights occur. It may be, perhaps, the only opportunity until 1982 or 1983, when the flight of the SIR system is planned to occur.

The following subsections describe experiments, test sites, and the significance of these activities. The plans were configured to coincide with as many other ongoing activities and research programs as possible to minimize duplication of effort. Overall, it is with great anticipation that these plans have been drafted because the potential is great for providing substantial evidences of the beneficial observations for water resources by using active microwave and passive microwave observations from Seasat-A.

Watershed runoff.- Watershed runoff information is important to water resource managers. Decisionmaking in the development and management of water resources is based, to a large extent, on mathematical models of varying complexity - e.g., the Generalized Stream Flow Simulation System, Stanford IV, Watershed Model and the SCS urban hydrology procedures. Few of the Nation's watersheds smaller than 500 km^2 have acceptable and reliable model input data owing largely to the time and costs associated with the acquisition of these data. A representative model that is used by the USDA, SCS, uses a single number or coefficient to represent the combined effects of soil type, land use, and antecedent moisture conditions. Although objectively specifying this coefficient is difficult, results from studies of passive microwave data indicate that it is possible by using passive microwave observations averaged over the total small-watershed area. These results are illustrated in figure 3-9. Because active microwave observations are sensitive to roughness, moisture, and soil properties, they will also be quite useful in this regard.

The panel believes that it is important to test the ability of the L-band SAR imaging system Seasat to provide this type of data.

To assess the ability of the Seasat SAR to provide data to indicate the runoff potential of watersheds, three major sites are suggested. In these cases, runoff potential determination will involve interpreting the microwave observations for variability in hydrologically related land use

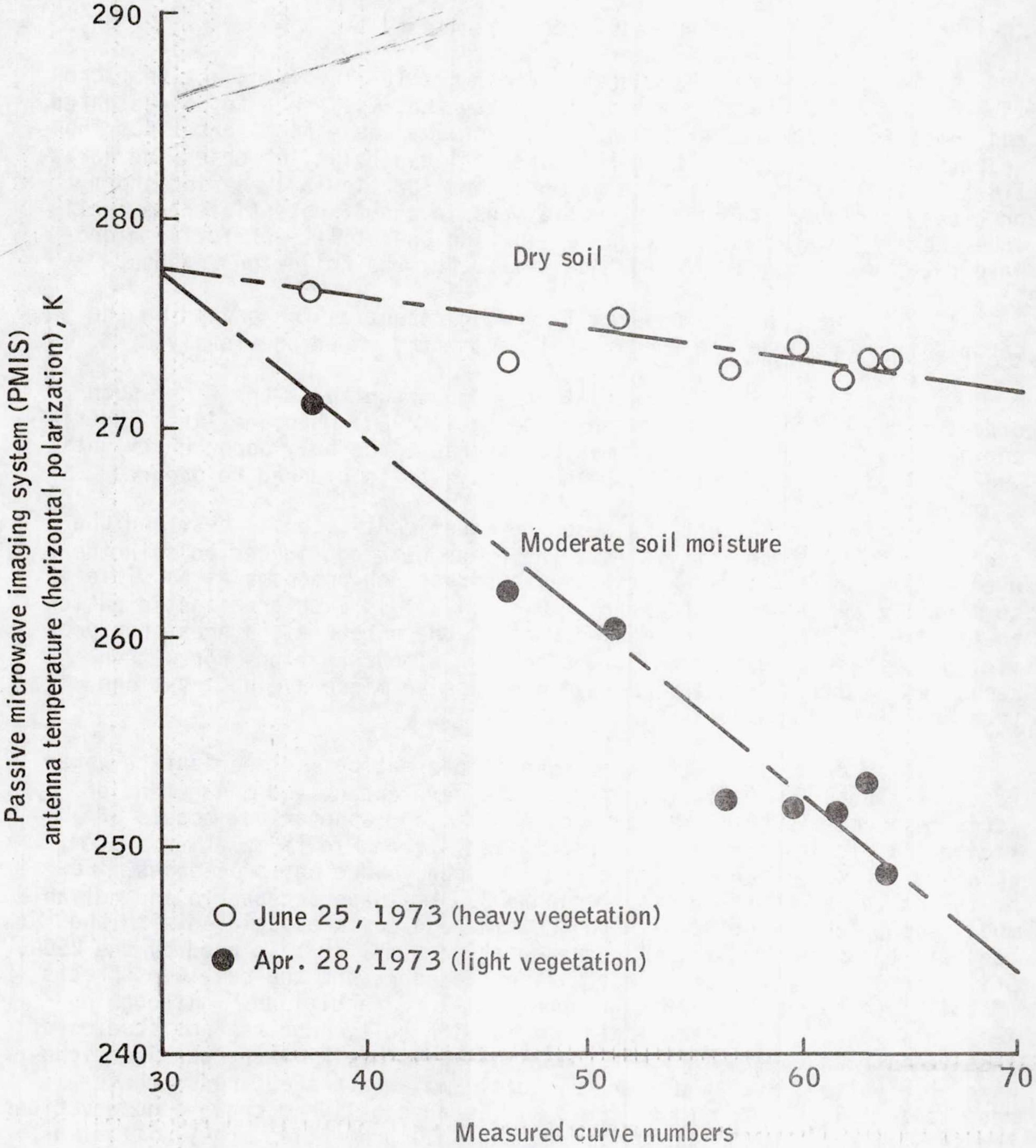

Figure 3-9.- Relationship between storm runoff (curve numbers) and microwave temperature.

(particularly related to imperviousness), soil type and permeability, vegetative cover, and soil moisture dynamics. The three areas suggested are as follows.

1. The Kern River watershed in southern California. This watershed is an analog test site to the Tashkent/Fergana Valley area of Soviet central Asia and affords a wide variety of surface cover, some snow cover, and moderate relief. These efforts would support one of the tasks of the Joint U.S./U.S.S.R. Working Group on the National Environment.

2. The southern Oklahoma-northern Texas area, including subareas near Chickasha, Oklahoma, and Waco and Refugio, Texas. The principal emphasis will be on objectively specifying runoff coefficients for small agricultural watersheds; but also, and in complementary fashion, the ability to monitor soil moisture in the watershed runoff prediction context will be assessed.

3. The Patuxent River watershed in Maryland. This watershed offers a wide variety of land use, heavy vegetative cover, and a substantial percentage of urban area.

In each of the test areas, considerable research has been or is being conducted as to the capabilities and limitations of remote sensor data in providing information related to watershed runoff potential. Should such analysis prove successful, in that pertinent information related to runoff potential is provided, these data should enable the SCS of the USDA, for example, to more accurately and quickly acquire runoff coefficients and help perform the approximately 1000 design studies that are in progress each year for the construction of flood control structures on small watersheds.

In addition to experiments conducted at the sites previously discussed, members of the Water Resources Subpanel believe that an assessment should be made of the feasibility of monitoring soil moisture variability over large regions by using the SMMR on Seasat. As previously stated, a considerable body of evidence exists detailing the capability of passive microwave systems to provide data relative to soil moisture conditions. To assess the Seasat SMMR capabilities in this area, it is suggested that the experiments be conducted in areas such as the southern High Plains of Texas, the Great Basin area west of Salt Lake City, and the lower Mississippi Valley. Successful and useful observations have been acquired for these areas with the Nimbus-5 electronically scanning microwave radiometer (ESMR) and the S193 and experiments on Skylab. Data from such experiments would be of interest to a wide variety of users (see table 3-15).

Concurrently with the SMMR experiment over the Salt Lake Desert, the SAR data would be used to determine the capability of the L-band radar to detect and map saline and moisture content in a desert playa. The water table in the Salt Lake Desert is about 1 m below the surface. Previous radar scatterometry experiments on Skylab succeeded in detecting high-moisture areas.

TABLE 3-15.- WATERSHED RUNOFF

Item	Discourse
Objective	To determine the capability of the Seasat-A sensor complement to provide data inputs to hydrologic models of use in assessing the runoff potential of watershed.
Seasat-A sensor requirements	SAR, SMMR, and VIR.
Potential test sites	SAR experiment: Kern River watershed, Kern County, Calif. Washita River Basin near Chickasha, Okla., and small watershed areas near Waco and Refugio, Tex. Patuxent River watershed, Md. SMMR experiment: Southern High Plains, Tex. Great Basin area west over Salt Lake City. Lower Mississippi Valley.
Data volume requirements	Passes per site: three to four per year. Pass length: average, 241.4 to 321.9 km (150 to 200 miles) per site. For the SAR, a 300-km path twice a year over the Salt Lake Desert is required; one path in Aug. and one in Dec.
Supporting remote sensor data	Landsat data. High-altitude aerial photography, 1:60 000 or 1:120 000. Aircraft radiometers: MFMR, PMIS. Imaging radar: L-band, C-band. Aircraft scatterometers: 0.4, 1.6, and 13.3 GHz.
Ground data	Field data: soil moisture, rainfall, etc. Truck-based systems: MAS, MSAS. PRT-5.
Potential users of data output	USDA SCS/USFS, public and private utility companies, commercial companies, regional and local water districts, NOAA, USACE, USGS, USBR, Bonneville Power Admin., Tenn. Valley Authority, etc.
Significance	These data are of value in determining the need for the construction of flood control structures and could be used in watershed and reservoir management. These data are useful for monitoring the saline content of a playa desert.

Surface-water/flood mapping.- Floods are major environmental hazards. Each year, lives are lost and property is damaged or destroyed. Individuals involved in disaster assessment and relief operations need timely, accurate information concerning the extent and severity of flood conditions. Often, these data are difficult to obtain owing to the presence of cloud cover. It has been estimated that flooding takes place almost weekly somewhere in the world. The nature of such events, however, precludes the selection of specific test sites and instead requires the adoption of the potential for including targets of opportunity within the Seasat mission-planning profile. The panel understands that this capability has been identified as significant by the Seasat SAR Team and that the Seasat Mission Design Team is currently working on this problem. This effort is strongly encouraged.

The ability to monitor flooding could be accomplished through the monitoring of U.S. rice-growing areas in the springtime, before vegetation covers the water (e.g., central Louisiana, the Texas gulf coast, and central Sacramento Valley, California). Monitoring of rice areas has the added advantage of providing data relative to an agricultural crop that is the basic staple in the diet of 90 percent of the world's population. In addition, the signature variation that will occur in these areas with vegetation growth and drainage will occur within a time frame and over a range of longitudes that appears appropriate to ensure coverage, on the basis of Seasat's projected orbital characteristics (see table 3-16).

Snow mapping.- The melting of snow in a majority of the watersheds in the western United States provides the most important portion of the total runoff. This runoff occurs over a relatively short period of time in the spring. Analyses and applications of satellite snow-cover observations from Landsat and NOAA satellites have demonstrated their contribution for improved management of snowpack runoff. However, the more fundamental observation of snowpack moisture equivalent and wetness would obviously contribute to better snowpack runoff forecasts by providing a more complete measure of the volume of water stored in the snowpack rather than an index of this quantity gathered from a few point measurements or measurements of snow-cover area. The microwave system would allow observations to be made through the cloud cover that persists most notably in the Pacific Northwest, where hydroelectric power generation is prevalent, and in Alaska.

Radar images have been acquired that show that there is potential for snowpack monitoring, and theoretical studies show the sensitivity of backscatter observations to variations in snowpack wetness. However, much more analysis of active and passive microwave observations needs to be accomplished to establish the potential in this area (Salomonson, in ref. 3-2; ref. 3-1). It would appear that the level of utility of successful observations would certainly justify such an effort (see table 3-17). It is recognized that the long wavelength of the Seasat SAR may be inappropriate for this application; however, an evaluation of these data is warranted because of the importance of the topic.

Alaskan lakes mapping.- During the winter season, the shallow lakes on the northern and western coasts of Alaska freeze at the top. The top ice layer is approximately 1 to 2 m thick. Because of the shallow depth,

TABLE 3-16.- SURFACE-WATER/FLOOD MAPPING

Item	Discourse
Objective	To assess the potential of the Seasat sensor compliment to provide data/ information to resource managers concerned with relief operations and disaster assessment.
Seasat-A sensor requirements	SAR, SMMR, and VIR.
Potential test sites	Target of opportunity. Rice areas: Central La. Tex. gulf coast near Houston. Central Sacramento Valley, Calif.
Data volume requirements	Passes per site: two to three per event. Pass length per site: 40.2 to 80.5 km (25 to 50 miles).
Supporting remote sensor data	High-altitude aerial photography, 1:60 000/1:120 000.
Ground data	Field verification of ground scene features. Water depth information. Land-water boundaries.
Potential users of data output	USACE, USGS, HUD, local water and flood control districts.
Significance	Rapid assessment of areas of environmental disruption and the potential for speeding information - discriminate and status briefings - for rescue relief and rehabilitation make this an important application area.

TABLE 3-17.- SNOW MAPPING

Item	Discourse
Objective	This experiment is designed to assess the information content of the L-band SAR and SMMR instrumentation for monitoring snow cover and snowpack moisture content and liquid-water content. The purpose of this effort is to provide improved input for watershed runoff estimates, which will lend toward improved reservoir management for hydroelectric power generation, irrigation, flood control, recreation, etc.
Seasat-A sensor requirements	SAR, SMMR, and radar altimeter.
Potential test sites	Mountainous areas (prioritized): The central Sierra Nevada Mts. near the CSSL. Steamboat Springs, Colo. Wind River Mts., Wyo. Great Plains areas (prioritized): Luverne, Minn., site. Upper Missouri River Basin.
Data volume requirements	Four passes per site during the winter/spring snowmelt season would be desirable. At least two passes are necessary (Mar.-May period). Passes over the sites with each instrument on the following basis: 100 km long, with SAR. 200 to 500 km, with SMMR. 200 to 500 km, with radar altimeter.
Supporting remote sensor data	Concurrent flights with the L-band imager, the SMMR simulator, and the L-band radiometer on the Convair 990, plus documentation photography. Concurrent flights with C-130 or P-3 microwave instrumentation would be desirable as resources permit.
Ground data	Concurrent measurements of depth, moisture content, wetness, etc. Use should be made wherever possible of snow-profiling gages and the snow wetness/microwave, ground-based instrumentation.
Potential users of data output	USDA/USFS; USDA/SCS; USACE; NOAA/U.S. National Weather Service/River Forecast Service; Snow Surveys Branch, State of Calif.; State of Calif. Water Resources Control Board; Bonneville Power Administration.
Significance	If a capability to measure wetness and water equivalent can be developed that is accurate to $\pm$ 10 to 15 percent at a given point, the high observational density afforded by satellite sensors will combine to provide a capability that is a significant (in terms of cost effectiveness and benefit) improvement over existing conventional systems.

some of these lakes freeze to the bottom. The L-band imaging radar, because of its capability to penetrate through fresh ice, can detect the presence of liquid water below the frozen layer. This capability is a result of the fact that the ice-water interface will reflect the electromagnetic wave much more than the ice-sediment interface, which corresponds to the areas where frozen ice reaches the bottom. This concept has been verified with the JPL L-band imaging radar.

There are two major applications: (1) These lakes are used as a source of freshwater in the winter season and (2) these lakes will be used as landing strips for large cargo aircraft, especially in the northwest region, where large oil deposits are located. It is critical to know which lakes are frozen to the bottom and thus can be used as landing strips. The Seasat radar can be used on an operational basis to map these lakes (see table 3-18).

Geology Experiments

Short wavelength (Ka- and X-band) side-looking aperture radar (SLAR) systems are established reconnaissance tools for the geologic mapping of areas where clouds or daylight conditions limit the operation of cameras and other visible-spectrum remote-sensing techniques. However, the geological utility of longer wavelength systems has been essentially ignored. Most of the demonstrated geologic applications of radar imagery have, in fact, publicized operational advantages rather than any unique information contained in the microwave spectrum. More importantly, very little research effort has been devoted to assessing the geological value of multispectral radar images, a technique that has received wide acceptance in the analysis of data from visible-spectrum sensors. Seasat SAR land-geology experiments can provide an important initial step in the ultimate design and experimental development of a multifrequency, multipolarization, free-flyer radar system that would satisfy a wide variety of geological requirements.

Seasat SAR imagery can be expected to provide minimal shadowing of subtle terrain features because of the relatively steep depression angles; and consequently, the detection of many geologic phenomena will be dependent on surface configuration and dielectric properties. Surface roughness (in both vegetated and nonvegetated areas) is expected to provide a significant contribution to the radar return signal. This roughness or texture sensitivity of the return signal adds another dimension to discrimination in cases wherein another sensor can provide information regarding homogeneity of material.

The proposed experiments have been assigned priorities based on (1) the liklihood of microwave applicability not previously possible through other systems, (2) the most immediate economic and/or scientific benefit, and (3) the contribution to the verification of design parameters for a Shuttle imaging radar and/or free flyer.

Because the proposed four-station reception of data corresponds to coverage of North America only, Alaska has emerged as a geologically unique area where the likelihood of immediate applicability may be greatest. The choice of the other experimental sites is based on a proof-of-concept testing

TABLE 3-18.- ALASKAN LAKES MAPPING

Item	Discourse
Objective	Map Alaskan lakes during the winter and determine which ones are frozen to the bottom and which ones are not.
Seasat-A sensor requirement	SAR.
Potential test sites	North Alaskan slope (Arctic coast). Bethel region, Alaska. Koyukuk region, Alaska. Mackenzie River Delta (Canada).
Data volume requirements	One path in Jan., one path in Mar. or early Apr.
Supporting remote sensor data	One underflight is desirable.
Ground data	Ground truth in a sample of 10 to 12 lakes of different sizes, simultaneously with overflight.
Potential users of data output	Department of Interior - for freshwater sources in winter. Oil companies, Navy - for use of frozen lakes as landing strips.
Significance	The classification of lakes in two categories, frozen to the bottom and not frozen to the bottom, would determine the lakes that can be used as landing strips for cargo aircraft and as sources of freshwater in the winter season.

to coincide with ongoing research activities in the greatest variety of terrain/geological environments.

Test site priorities (H, M, and L) are based on geological uniqueness in relation to Seasat SAR potential and usefulness of data. High-priority experiments are described in tables contained in the next eight subsections, medium-priority experiments in tables contained in the two subsequent subsections, and low-priority experiments in tables contained in the last four subsections. The objective of the Seasat SAR geology experiments is definition of the microwave parameters that are appropriate to particular geological problems; success therein may ultimately lead to the development of radar image products that more directly lend themselves to geological analysis.

Placer Gold Belt mapping.- This experiment is designed to test the capability of Seasat SAR imagery to provide data on the location of gold-bearing gravel deposits in the interior of Alaska. Mapping of these extensive gravel deposits has not been accomplished. Seasat SAR should be an ideal data source for gravel mapping because of its ability to provide high-quality, high-resolution image data under conditions of poor illumination or during periods of inclement weather. Gold reserve known to be associated with the gravels and the great need for gravel in an area where large construction projects are underway and planned are evidence of the economic importance in estimating these gravel reserves. The goal of this experiment is to provide a map of these deposits with the location of bedrock areas and potential placer deposits indicated (see table 3-19).

Assessment of glacial ice dynamics.- Glaciers contain a large amount of the world's freshwater supply. In addition, glaciers provide sensitive indicators of variations in global climatic conditions. Because of severe weather, low angles of solar illumination limiting the practicability of most remote sensor systems, and light snow cover on rocks, active microwave sensors are needed for the study of the massive glacial ice deposits in southeastern Alaska. The Seasat L-band SAR system should be capable of delineating these ice masses.

Mapping of the extent and structure of the large glaciers and icefields in the Chugach and St. Elias Mountain Ranges, Alaska, is important for estimating freshwater storage of the region. Also, it is important for determining possible hazards that glacial surges would pose to the proposed oil and gas development of the Yakataga and Yakutat oilfields, and for determining ice hazards to the tanker traffic of Prince William Sound and Yakutat Bay (see table 3-20).

Mineral and petroleum exploration.- Exploration methods used during the past two decades are inadequate for providing new reserves that will exceed the present consumption rate of mineral and petroleum products. Although an integrated exploration concept would take advantage of a host of exploration techniques, radar remote sensing such as that provided by Seasat SAR holds promise for revealing new areas of exploration potential (see table 3-21).

TABLE 3-19.- PLACER GOLD BELT MAPPING

Item	Discourse
Objective	Delineate and map the gold-bearing gravel deposits of interior Alaska. Present knowledge of these economically significant deposits is limited because of poor lighting, weather conditions, and snow cover.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Placer Gold Belt of interior Alaska.
Data volume requirements	Passes per site: two to four per year. Length of site: 1150 km. Area of site: 115 000 km^2.
Supporting remote sensor data	Landsat data and possible low-altitude-aircraft data.
Ground data	Limited field information; extent of deposits unknown.
Potential users of data output	Pipeline companies, mineral industries, Alaska State Geological Survey, USGS, BLM, Alaska State Highway Dept.
Significance	Mapping of the extensive gravel deposits of interior Alaska has not been done. Yet, it is of great economic importance that the gravel reserves be estimated because of the gold reserve associated with the gravels and the great need for gravel in an area where large construction projects are underway and planned. The Seasat SAR should be an ideal data source for gravel mapping. Assist in mapping extent of relatively unknown deposits.

TABLE 3-20.- ASSESSMENT OF GLACIAL ICE DYNAMICS

Item	Discourse
Objective	To study the massive glacial ice deposits of the icefields and the mountain ranges in areas that have persistent cloud cover, low Sun, and snow cover.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Glaciers of southeastern Alaska.
Data volume requirements	Passes per site: one to two per year. Length of site: 850 km. Area of site: 85 000 km^2.
Supporting remote sensor data	Landsat data.
Ground data	Published fieldwork.
Potential users of data output	Oil and gas companies, USFS, USGS, BLM, Coast Guard/NOAA.
Significance	Mapping of the extent and structure of the large glaciers and icefields in the Chugach and St. Elias Mountain Ranges to estimate freshwater storage of the region and to determine possible hazards that glacial surges would pose to the proposed oil and gas development of the Yakataga and Yakutat oilfields. Determining ice hazards to the tanker traffic in Prince William Sound and Yakutat Bay.

TABLE 3-21.- MINERAL AND PETROLEUM EXPLORATION

Item	Discourse
Objective	Evaluate the utility of Seasat SAR imagery interfaced with MSS imagery for mineral and petroleum exploration in heavily forested terrain having relatively complex geology with surface structure related to subsurface structure. Radar applicability to be evaluated includes viewing angle, vegetation penetration, temporal aspect, effect of snow cover, and compatibility with Landsat data.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Arkoma Basin, central Ark.
Data volume requirements	SAR, near-coincident with Landsat, seasonal coverage. Ascending and descending passes.
Supporting remote sensor data	Underflight coverage with shorter wavelength systems would be helpful but not necessary. Underflight with JPL L-band and NASA 102 systems requested.
Ground data	Reconnaissance of terrain and vegetation conditions at time of overflight.
Potential users of data output	Mineral and petroleum exploration companies, U.S. Bureau of Mines, USGS, State geological agencies, Ark. Geological Commission.
Significance	Long-wavelength radar data to be evaluated as a unique or supplemental tool for petroleum and mineral exploration. Provide geologists with an additional exploration tool for structural mapping. Assist geological mapping in relatively unmapped regions. The study area has relatively complex geology, with surface structures related to subsurface petroleum production. Long-wavelength radar data to be evaluated as a unique or supplemental tool for petroleum and mineral exploration. Central Ark. is ideally suited for evaluating the "penetration" capability of longer wavelength SAR systems.

The Landsat and Skylab programs have demonstrated conclusively the utility of spacecraft data for mineral and petroleum exploration. The exploration utility of a long-wavelength SAR system has not been proven, and the central Arkansas test site is ideal for an evaluation of SAR data in heavily forested terrain. The test site is masked with a cover of deciduous, conifer, and mixed forest areas. Beneath this canopy are complex surface structures that, in many cases, are related to petroleum production. A new technique for mapping previously unrecognized surface structures would provide the petroleum geologist with an important exploration technique.

Seasat SAR, being an active system, provides its own source of illumination and does not measure diurnal changes in the radiation emitted or reflected from the Earth's surface. This relative independence from time of day and weather may be a particularly important advantage for geological interpretation, especially for the detection of lineaments that are highly dependent on such parameters as viewing angle, look direction, radar frequency, vegetation penetration, temporal aspect, terrain roughness, soil moisture, snow cover, etc. The use of Seasat SAR data in conjunction with Landsat data holds a potential for improving terrain landform discrimination, an accomplishment that would be an important contribution to the mineral and petroleum phase of geological exploration.

Geomorphic mapping in coastal wetlands and marshes.- Coastal wetlands and marshes provide the locations for many highly productive oilfields and gasfields, especially salt domes. The expression of geological structure at the surface is so slight that the traditional use of a low incident angle of illumination for relief enhancement is not practical. Coastal geomorphic analysis to define petroleum prospects in coastal marsh and swamp terrains involves detailed examination of drainage patterns and texture and gross determination of plant community spatial relationships. The interpretation of physiographic features, coupled with the creation of vegetation maps and the measurement of primary food-chain production over large areas of the tidal marsh, would be especially useful to ecologists and other scientists. Seasat SAR provides a unique opportunity for examining the regional fabric of coastal marsh and wetlands. Local departures from the regional pattern would be considered anomalies, warranting further investigation. Because of the relatively steep depression angle used, the L-band imagery may provide a data format that will be a valuable supplement to imagery sources such as Landsat.

The Atchafalaya Basin in Louisiana provides a test site where oilfields and gasfields are sometimes defined by subtle changes in drainage, contrasting plant communities, and subtle terrain texture changes. This experiment test site provides for an abundance of ground-truth data where considerable remote-sensing data have already been acquired. The experiment design calls for using Seasat SAR imagery as both a unique and supplemental data source for terrain interpretation. As such, it will ultimately contribute to petroleum exploration in these low-relief environments.

Seasat SAR parameters such as viewing angle, look direction, vegetation penetration, and temporal changes in terrain conditions will be evaluated according to the detectability of geomorphic features (see table 3-22).

TABLE 3-22.- GEOMORPHIC MAPPING IN COASTAL WETLANDS AND MARSHES

Item	Discourse
Objective	Demonstrate the applicability of Seasat SAR imagery for geomorphic analysis (mineral and petroleum exploration) in coastal marsh and swamp environments, where the expression of relief is defined by drainage patterns, contrasting plant community associations, and subtle terrain texture changes.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Atchafalaya Basin, La.
Data volume requirements	SAR, near-coincident Landsat, seasonal coverage.
Supporting remote sensor data	Short-wavelength (Ka- and X-band) coverage would be necessary.
Ground data	Existing terrain and vegetation conditions at time of overflight.
Potential users of data output	Industry exploration geologists, wetland ecologists, hydrologists, USACE, USGS, coastal geomorphologists.
Significance	Assist in coastal mapping of high-cloud-cover regions. Aid in the detection of salt domes in low-relief areas. Provide an indication as to the utility of Landsat and Seasat SAR for coastal geomorphic definition. The expression of relief in the coastal marsh and swamp is so slight and the SAR depression angle so steep that the use of subtle shadowing for relief enhancement is not practical. Analysis of drainage patterns can sometimes offer a very sensitive indicator of small relief changes and thus the underlying structure. The steep SAR depression angle may provide an effective technique for rereading the surface expression of salt domes.

Land subsidence detection.- This experiment is designed to detect areas of subsidence caused by potash mining, natural saline seeps, and subcrop position of the potash-hosting Salado Formation.

The test site for this study is well documented and sparsely vegetated and provides a number of other geologic/mineral occurrences. It is underlain by producing oilfields and is currently under investigation as a site for radioactive waste disposal in the Permian salt deposits found in the area.

Domestic exploration for potash is a necessity because of the political and logistical sensitivity associated with this high-volume/low-value essential commodity. Recognition of distinctive subcropping occurrences of the soluble minerals mentioned could provide a valuable tool for exploration. It is anticipated that Seasat SAR imagery will provide data that can aid in the identification and mapping of the subcrop positions (see table 3-23).

Discrimination of hydrothermal alteration.- The experiment will test the capability of L-band systems to discriminate among types of hydrothermal alteration on the basis of surface morphological characteristics. More importantly, a test will be made of the separability of altered units and alluvium.

Landsat data are being used to separate out areas of hydrothermal alteration as potential exploration sites. However, many alluvial areas falsely register as areas of hydrothermally altered rocks. A separation should be possible based on surface scattering characteristics. This experiment has a reasonably high probability of success (see table 3-24).

Discrimination of construction materials.- Gravel and sand deposits and similar construction materials are in extremely short supply in many parts of the United States. Especially in heavily vegetated flood plains, the delineation of construction materials is difficult because of a vegetation canopy, masking by soils, or man's activities related to agricultural land use. Seasat SAR imagery interpretation may provide a new technique for finding these deposits, whose hard-mineral dollar value in the United States is only exceeded by that of coal.

The overall design of the experiment is to evaluate Seasat SAR as a unique or supplemental remote sensor data source for discriminating subtle terrain texture change. The northern Boeuf-Tensas Basin in the lower Mississippi Valley provides a test site ideally suited for Seasat SAR evaluation. The USACE has done considerable geologic and soils mapping in the area; and, as a consequence, the need for extensive ground truth is minimized.

Seasat SAR parameters such as viewing angle, look direction, vegetation penetration, and temporal changes in terrain conditions will be evaluated according to the detectability of sand and gravel deposits (see table 3-25).

Discrimination of terrain roughness and texture.- It is known that radar shadowing enhances such geologic features as joint systems, faults, and folded strata. However, terrain roughness-texture properties as seen

TABLE 3-23.- LAND SUBSIDENCE DETECTION

Item	Discourse
Objective	Detection of areas of subsidence caused by potash mining, natural saline seeps, and subcrop position of the potash-hosting Salado Formation in a district that is underlain by producing oilfields and is currently under investigation as a site for radioactive waste disposal in the Permian salt deposits found in the area.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Carlsbad Mining District, 16.1 to 48.3 km (10 to 30 miles) east of Carlsbad, N. Mex.
Data volume requirements	Site passes: two per year.
Supporting remote sensor data	Imaging radar (X-band) and Landsat.
Ground data	Environmental Analysis Report completed 1976. Terrain conditions at time of overflight.
Potential users of data output	Industry, Governmental agencies.
Significance	Domestic exploration for potash is a necessity because of the political and logistical sensitivity associated with this high-volume/low-value essential commodity. The experiment site is well documented and sparsely vegetated and provides the other geologic/mineral occurrences cited above. Recognition of distinctive subcropping occurrences of these soluble minerals could provide a valuable tool for exploration.

TABLE 3-24.- DISCRIMINATION OF HYDROTHERMAL ALTERATION

Item	Discourse
Objective	Separation of alluvium and outcrop in areas of hydrothermal alteration and separation of alteration types as a means of targeting likely areas for detailed mineral exploration.
Seasat-A sensor requirement	SAR imagery.
Potential test sites	Virginia Range (Reno, Nev.); Goldfield, Nev.
Data volume requirements	Passes per site: two. Length: 50 km each.
Supporting remote sensor data	Preflight aircraft coverage, Landsat, color airphotos in stereo.
Ground data	Particle size measurements, soil moisture.
Potential users of data output	Mineral exploration industry.
Significance	With present Landsat data, alluvial areas cannot be separated from outcrops of hydrothermally altered rocks; however, SAR imagery textural discrimination may provide the necessary signature. Alteration is used in mineral exploration as a means of targeting likely areas for undertaking ground geological and geophysical work. Because present Landsat data do not enable separation of alluvial areas from outcrops of hydrothermally altered rocks, many false alarms are generated. Separation of the types of alteration - for instance, silicon versus argillic or chloritic - has bearing on the exploration process. These types may be separable by their weathering patterns.

TABLE 3-25.- DISCRIMINATION OF CONSTRUCTION MATERIALS

Item	Discourse
Objective	Determine applicability of using SAR radar imagery to detect construction materials (sand/gravel) in typical alluvial environments (textural discrimination of actual deposits or their geomorphic expression).
Seasat-A sensor requirement	SAR imagery.
Potential test site	Alluvial flood plain of Mississippi River near Memphis, Tenn., where Seasat orbit nearly matches Landsat orbit.
Data volume requirements	SAR two-season coverage; near-coincident Landsat coverage.
Supporting remote sensor data	Short-wavelength (Ka- or X-band) underflight would be helpful.
Ground data	Terrain and vegetation conditions at time of underflight.
Potential users of data output	USGS; USACE; Federal, State, and local construction companies.
Significance	Gravel and sand deposits and other construction materials are in extremely short supply in many parts of the United States. SAR imagery interpretation may provide a new technique for finding new supplies of these hard-mineral deposits, whose dollar value in the United States is only exceeded by that of coal. In addition, the test site selected for this analysis is located in an area of high agricultural productivity that is subjected to seasonal flooding. By following the site through time, it may be possible to gain important insights into the capabilities of space imaging radar for several types of investigations.

on SAR images also need to be evaluated. This experiment will provide for this evaluation, as well as for derivation and comparison scattering models.

The Death Valley, California, test site is perhaps the best documented natural test site yet investigated for roughness backscatter modeling of radar return. Extensive studies have been done in this area, especially in detailed roughness mapping (see table 3-26).

Discrimination of geologic structure in areas of low relief.- This experiment is designed to determine the utility of SAR for revealing subtle geologic structure in low-relief, forested areas such as the Eastern Coastal Plain. Nuclear reactor powerplants have been built, and many more may be constructed along the Eastern Coastal Plain. Although this area is not considered to be an active earthquake zone, major historical earthquakes have occurred along a band stretching from Cape Ann, Massachusetts, to Charleston, South Carolina. Radar shadowing emphasizes geologic features and irregularities on the Earth's surface; terrain morphology, from which structural or geologic inferences can be made, is depicted more starkly than on photography. As a result, SAR image analysis is a potential means for providing a better understanding of the tectonic character of a region. In this experiment, various cosmetic, filtering, and band-stretching image enhancement techniques will also be evaluated. It is hoped that the results of this experiment will provide the proof of concept for the use of SAR data to provide information on the morphology of the terrain in areas of low relief, information that may lead to improved assessments of the geologic hazards in such areas (see table 3-27).

Evaluation of Arctic coastal ice structure and dynamics.- Alaska has approximately 53 000 km of coastline, over half of which is affected by ice most of the year. Surrounding this lengthy coastline are approximately 1.5 Mm^2 (150 x 10^6 ha) of continental shelf potentially exploitable through construction of offshore facilities. Climatically, Alaska is a prima facie case for radar monitoring, with severe weather and low angles of solar illumination limiting the practicability of most remote sensor systems. Fieldwork is typically difficult and hazardous. The discoveries of oil on Alaska's north slope have increased our Nation's potential for greater energy independence. However, because of heightened environmental awareness, these discoveries have generated controversy about the potential environmental disruption associated with exploiting these resources. Timely, accurate information is required to inventory critical resources and monitor this development to minimize or eliminate potential adverse environmental impacts. This experiment will focus on only one critical parameter affecting the ability to maximize the potential benefits to be derived from this important resource - i.e., the monitoring of Alaskan coastal ice structure and dynamics (see table 3-28).

Evaluation of high-relief terrain.- This experiment will test the advantages in using high-angle L-band radar to map surface geologic units in mountainous terrain.

Seasat will provide high-angle L-band radar images of land areas. These data will be of little value in enhancing subtle topographic features. However, in mountainous terrain, high-angle illumination is required to

TABLE 3-26.- DISCRIMINATION OF TERRAIN ROUGHNESS AND TEXTURE

Item	Discourse
Objectives	Evaluation of terrain roughness-texture properties as defined by SAR. Derivation and comparison scattering models from SLAR image data.
Seasat-A sensor requirements	SAR imagery, scatterometer, radar altimeter, and microwave radiometer.
Potential test site	Death Valley, Calif.
Data volume requirements	Four passes total, which would cover all of Death Valley: two ascending passes, one in June/July period and one in Feb./Mar. period; two descending passes, one in June/July period and one in Feb./Mar. period.
Supporting remote sensor data	Aircraft underflights with the JPL L-band radar are required.
Ground data	Complete ongoing effort by G. Schaber (USGS, Flagstaff) for detailed roughness mapping of the Valley, in situ field measurements at time of overflight.
Potential users of data output	Researchers in roughness modeling.
Significance	Proof of concept for terrain texture discrimination. Because of extensive studies in the area, the Death Valley test site is perhaps the best documented natural test site yet investigated for roughness backscatter modeling of radar return.

TABLE 3-27.- DISCRIMINATION OF GEOLOGIC STRUCTURE IN AREAS OF LOW RELIEF

Item	Discourse
Objective	Determine utility of SAR for revealing subtle geologic structure in low-relief, forested areas such as the Eastern Coastal Plain. Various cosmetic, filtering, and band-stretching image enhancement techniques will be evaluated.
Seasat-A sensor requirement	SAR imagery.
Potential test sites	Sites under extensive study by the USGS and others in the reactor hazards program.
Data volume requirements	Two-season coverage, near-coincident Landsat coverage.
Supporting remote sensor data	Short-wavelength (Ka- and X-band) data would be helpful but are not necessary. JPL L-band coverage is requested.
Ground data	Extensive mapping provided by USGS.
Potential users of data output	USGS, State surveys, exploration geologists.
Significance	Nuclear reactor powerplants have been built, and many more may be constructed along the Eastern Coastal Plain. Although this area is not considered to be an active earthquake zone, major historical earthquakes have occurred along a band stretching from Cape Ann, Mass., to Charleston, S.C. SAR image analysis may yield a better understanding of the tectonic character of the region.

TABLE 3-28.- EVALUATION OF ARCTIC COASTAL ICE STRUCTURE AND DYNAMICS

Item	Discourse
Objective	To study ice structure near the coast during the Arctic night.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Arctic Ocean coastal ice.
Data volume requirements	Passes per site: two to four per year, winter and summer. Length of site: 800 km. Area of site: 80 000 km^2.
Supporting remote sensor data	Aircraft-borne radar; suggest aircraft underflights.
Potential users of data output	Oil and gas companies, Navy, Coast Guard/NOAA.
Significance	Coastal ice cannot be studied because of darkness and/or cloudy conditions throughout much of the year. Oil and gas development has begun here and will continue for the next 15 to 20 yr. The unique ability of the Seasat SAR to obtain data during the Arctic night will be a great help in studying ice conditions.

image the surface. Low-angle illumination, common to existing radars, creates shadows in these areas.

Seasat will provide the first high-angle radar data available for geologic mapping. These data may help in discriminating geologic units in rough terrain because of the effect of surface characteristics on the L-band return signal (see table 3-29).

Linear assessment.- State and Federal agencies charged with the responsibility for siting nuclear power generating facilities are extremely interested in techniques that can improve the assessment of the geologic hazard that may exist in a given area. These agencies, together with other user groups with responsibilities for site evaluation for construction projects, are particularly concerned with faulting - especially that which has occurred in Holocene times - in regions where construction of nuclear powerplants is proposed. This experiment is designed to evaluate Seasat SAR imagery for the detection, identification, and mapping of linear - and to a lesser degree, circular - trends previously mapped in field studies. SAR imagery interpretation may provide a signficant data input by means of textural discrimination of geomorphically expressed structural units (see table 3-30). Demonstration of potential in this important area would be of significant benefit to a wide variety of users. It should be emphasized that the mapping of linears can provide clues to the location of mineral deposits.

Midcontinent base metals exploration.- An opportunity exists to provide a tool to aid base metal exploration - particularly, domestic - in the continuing search for nonoutcropping ore deposits. In the experiment, an evaluation of "blind" mining districts will be performed on Seasat SAR imagery. The capability of SAR systems to provide data on these districts could have considerable economic impact.

The U.S. production from Mississippi Valley-type deposits such as those in Tennessee and Missouri was valued at $243 million in 1973. In central Tennessee, deposits are largely undeveloped and occur at depths ranging from 300 to 1000 m. Solution-collapse breccias are hosts to mineralization and can possibly be detected as curvilinears at the surface. Stressed vegetation (retarded by metal ion content in soil or enhanced by moisture increase) may be detectable over such areas. In southeast Missouri, a discontinuous mineral trend approximately 100 km in length and 1.6 km in width has been under development and mined since 1958. This completely blind occurrence on the west side of the Ozarks Precambrian high is a more deeply buried extension of the nearer surface occurrences mined approximately 100 km to the east for more than 100 years. No direct, surface geophysical expression of the west side Viburnum trend has ever been recorded. The ore in Missouri has a greater variety of occurrences than that in Tennessee. However, the two areas provide an almost complete range that is representative of Mississippi Valley-type deposits (see table 3-31).

Sulphur deposit exploration.- Geologic structures and irregularities can be detected on radar imagery. In this experiment, the ability of Seasat SAR to define large petroliferous or paleopetroliferous environments by detecting structural changes associated with low-porosity capping rock that typifies the centers of such areas from the surrounding less-porous rock will be tested.

TABLE 3-29.- EVALUATION OF HIGH-RELIEF TERRAIN

Item	Discourse
Objective	Evaluation of steep depression angle SAR imagery in rough terrain, high-relief areas of mineral exploration, where conventional photography is often useless because of cloud cover or poor illumination.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Colorado Mineral Belt, Eastern Front Range, Colo.
Data volume requirements	One pass, 300 km.
Supporting remote sensor data	Aircraft photography. Aircraft SLAR 16.1-km (10 mile) strip, near-coincident Landsat coverage.
Ground data	Mineral and mine maps, provided by the USGS and exploration companies.
Potential users of data output	Mineral explorationists.
Significance	The unique high-angle illumination from Seasat SAR will provide a different view, potentially with which to map morphological and texture features on the slopes. Assist in defining optimum SAR depression angles for optimum geological data analysis. Provide an improved method for mineral exploration programing. In rugged terrain, aircraft photography and airborne radar become difficult to interpret because of the steep and often-shaded slopes. The unique high-angle illumination from Seasat will provide a different view, potentially with which to map morphological and texture features on the slopes.

TABLE 3-30.- LINEAR ASSESSMENT

Item	Discourse
Objective	Evaluate Seasat imaging-radar data for presentation of linear - and to a lesser degree, circular - trends previously mapped in field studies for the Nuclear Regulatory Commission.
Seasat-A sensor requirement	SAR imagery.
Potential test sites	Area in northeastern Kans. with a high clarity of lineaments and an area in which documentation of origin has been reasonably successful.
Data volume requirements	SAR - near coincident with Landsat.
Supporting remote sensor data	Multifrequency-imaging-radar underflights (at least shorter Ka- or X-band).
Ground data	Pertinent data (vegetation conditions, soil moisture, etc.) will be collected during the overflight.
Potential users of data output	Environmental and exploration geologists; Federal, State, and local geologic groups.
Significance	The Nuclear Regulatory Commission is concerned with faulting - particularly, recent - in regions where construction of nuclear powerplants is proposed. Seasat SAR imagery interpretation may provide a significant data input by means of textural discrimination of geomorphically expressed structural units. Provide an improved method for geologic mapping.

TABLE 3-31.- MIDCONTINENT BASE METALS EXPLORATION

Item	Discourse
Objective	Seasat SAR may provide a tool to aid base metal exploration (particularly, domestic) in the continuing search for what is increasingly becoming a search for nonoutcropping ore deposits. Solution-collapse breccias are hosts to mineralization and might be detected as curvilinears at the surface by examination of SAR imagery.
Seasat-A sensor requirement	SAR imagery.
Potential test sites	North-central Tenn. to south-central Ky. Southeast Mo. Viburnum trend.
Data volume requirements	Site passes: two per year (4). Pass length: 160.9 km (100 miles) each (4).
Supporting remote sensor data	Imaging radar, X-band, Landsat.
Ground data	State/Federal geologic mapping. Industry drilling results.
Potential users of data output	Industry, State, and Federal agencies.
Significance	Assist in mapping surface trends that may be indicative of subsurface mineralization. Provide a technique for detecting areas of vegetation stress or terrain textural changes over areas where soil geochemistry is related to mineralization. Provide the potential of correlating surface producing trends into nearby regions that appear geologically favorable.

Detection of criteria pertinent to the occurrences of sulphur deposits could aid continuing searches in the west Texas region and elsewhere. Chemical fertilizer industry requirements for native sulphur continue to grow. Gulf coast production from salt domes continues to decline as production costs increase and new discoveries become rare. The existence of an approximately 54.4-Tg (60 million ton) sulphur-producing property and at least five smaller, nonproducing sulphur occurrences in the potential test site area will provide ground truth for an orientation survey over these non-salt-dome-associated occurrences (see table 3-32).

CONCLUDING REMARKS

It is apparent from the variety of experiments suggested by the Seasat Land Experiments Panel that the Seasat mission has important implications in the area of land applications. Although the Seasat system is intended to serve users within the oceanographic community, the panel believes that Seasat synthetic aperture radar (SAR) can be used to carry out a variety of proof-of-concept experiments over land.

Seasat represents the first space program imaging radar available to the Earth resources community. This potential should be exploited to the fullest possible extent within Seasat mission constraints. The Seasat SAR will enable researchers to examine the potential of active microwave systems in a number of areas where the opportunity exists for gaining unique and significant information - areas such as soil moisture and snowpack wetness determination, range management, geological exploration, and flood monitoring. In addition, because the projected resolution of Seasat SAR approximates that projected for Landsat-C, there is significant potential for upgrading the capability of both systems for a variety of land applications. Finally, the all-weather, day/night capability of the Seasat SAR affords the potentiality that coverage can be guaranteed (within orbital constraints) to applications that require data within a narrow temporal window.

The experimental programs proposed are in a preliminary form. More work and detailed preparations would have to be accomplished before any of these experiments could be carried out. The ideas, however, are sound. The panel believes that these data should be particularly useful to NASA in general and to the Seasat program in particular, as the volume of experimental data required to conduct a successful land experiments program with use of the Seasat SAR is very reasonable.

Again, it is important that NASA take advantage of this opportunity. The planning of a Seasat land experiments program, already begun in several forms, should be continued and accelerated. A program should be identified and work begun on the gathering of background data to work out data flows and test experiment designs at the earliest possible date. Seasat SAR capabilities are important to the land applications area of the Earth observations program. Maximum use should be made of them.

TABLE 3-32.- SULPHUR DEPOSIT EXPLORATION

Item	Discourse
Objective	Test ability of SAR to define large petroliferous or paleopetroliferous environments by detecting textural changes associated with low-porosity capping rock that typifies the centers of such areas from the surrounding less-porous rock.
Seasat-A sensor requirement	SAR imagery.
Potential test site	Sixty-mile-wide zone centered on a north-south line from Orla to Van Horn, Tex.
Data volume requirements	Site passes: two per year. Pass length: 100 to 125 km.
Supporting remote sensor data	Imaging radar - X-band Landsat; aircraft photography.
Ground data	Geologic mapping to be provided by exploration companies.
Potential users of data output	Exploration companies, industry.
Significance	Chemical fertilizer industry requirements for native sulphur continue to grow. Gulf coast production from salt domes continues to decline as production costs increase and new discoveries become rare. The existence of an approximately 54.4-Tg (60 million ton) sulphur-producing property and at least five smaller, nonproducing sulphur occurrences in the potential test site area will provide ground truth for an orientation survey over these non-salt-dome-associated occurrences. Detection of criteria pertinent to the occurrences could aid continuing searches in this region and elsewhere.

On the basis of the discussions of the capabilities of the Seasat SAR, the Seasat Land Experiments Panel makes the following recommendations.

1. Land experiments, such as those contained in the body of this report, should be undertaken. The panel believes that the SAR systems on board Seasat have a wide range of applications to land experiments and a significant potential for improving both quantitatively and qualitatively the information base in a number of key areas.

2. Steps should be taken to begin to integrate specific land experiments into the Seasat mission plan. This task should include the initiation of experiments and the acquisition of data for a variety of test sites. Those data should include imagery from existing airborne L-band imaging systems, as well as such field verification and collateral material as is appropriate to ensure a high probability of conducting successful experiments with Seasat data as they become available.

3. For most land applications, the Cambridge (24 day) orbit is preferable. This orbit should be used for one of the first 2 years of the Seasat mission.

4. Finally, a Seasat Land Applications Team should be formed. This team may be incorporated into the existing Seasat SAR Team structure but could, if necessary, be an entity with appropriate channels of communication. However structured, the panel believes that such a body is necessary to ensure the successful completion of meaningful land experiments in which the Seasat SAR system is used.

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[3]This material was provided to panel members at or before the meeting for background.