COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Record No. 1970/112

Visit to United States — W. J. Perry and P. J. Hillman, July 18 to August 26, 1970

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VISIT TO UNITED STATES - W J. Perry
and P.J. Hillman, July 18 to August 26, 1970.

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VISIT TO UNITED STATES - W.J. PERRY AND P.J. HILLMAN
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ITINERARY

National Aeronautics and Space Administration Headquarters, Washington, D.C	Jul. 20th
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Western Geophysical, Houston (Hillman only)	" 23
Remote Sensing Inc., Houston	" 24
U.S. Geological Survey, Washington, D.C.	" 27-29
H.R.B. Singer Inc., State College, Pennsylvania (Hillman)	" 29
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North American Rockwell Corp., Seal Beach, California	" 19
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Hillman left the United States for Australia	" 20
Perry visited the Tektite II operation	" 24-26

Dr K. McCracken, of CSIRO Melbourne, accompanied Perry and Hillman from 29th July to 7th August.

SUMMARY

The visit to the N.A.S.A. establishments was made by the authors as part of the team of four officers selected by the Department in response to the invitation issued by the Administrator of N.A.S.A. to Australian Government agencies to study aspects of the N.A.S.A. programme. The other members of the team were Mr B. Lambert, Director, Division of National Mapping, and Mr M. Benson, Forest Research Institute. Two briefings were given on the E.R.T.S. and Skylab programmes, and the associated supplementary aircraft programme to evaluate sensor capabilities. The first was an outline of the basic philosophy of the programme by Dr A. Park in N.A.S.A. Headquarters, Washington, and the second a series of detailed lectures by specialists at M.S.C., Houston.

During the remainder of the period visits were made to the U.S.G.S., Universities and private companies to investigate the work being done on remote sensing applied to earth resources. The Universities and U.S.G.S. effort is directed mainly towards research projects whilst the private companies concentrate on the design of equipment and the practical application of remote sensing from aircraft.

GOVERNMENT ESTABLISHMENTS

1. N.A.S.A. The E.R.T.S. "A" Satellite is scheduled for launching in March 1972, into a polar sun synchronous orbit, and will contain a four-channel multispectral scanner, three return beam vidicon cameras, and a system for data collection from ground transmitters. The planned life of the satellite is one year with complete coverage of the earth every eighteen days. The area covered by each camera image is 100 nautical miles by 100 nm and the swath width of the multi-spectral scanner is also 100 nm. The major areas of interest are agriculture and forestry and their resources, geology and mineral resources, hydrology and water resources, geography, cartography and cultural resources, and oceanographic and marine resources. If the appropriate arrangements are made between the Australian and United States Governments, imagery of Australia could be obtained using the U.S. ground facilities for data acquisition and processing.

A second satellite, E.R.T.S. "B", is scheduled for launching in March, 1973. The payload will be similar to E.R.T.S. "A" but a five-channel multi-spectral scanner will replace the four-channel M.S S. of E.R.T.S. "A".

Skylab 1, part of the Manned Space Workshop, is scheduled for launch in July 1972, and will contain six cameras, an Infrared Spectrometer, a Multispectral Scanner, a Microwave Radiometer/Scatterometer-Altimeter, and possibly an L band Radiometer. The planned orbit will allow earth coverage from 50°N to 50°S.

The N.A.S.A. aircraft programme currently employs three aircraft with various height and range capabilities; each aircraft is fitted with sensors similar to those employed on the satellite programme.

2. The U.S.G.S. has devised a programme known as E.R.O.S., (Earth Resources Observation System) to utilize information acquired from the N.A.S.A. Satellite and Aircraft for application to land use and resource investigations.

The E.R.O.S. programme covers a wide field of interest, including Topographic Mapping, Marine Resources, Human and Cultural Activities, Mineral and Land Resources, and Water Resources. It is a cooperative one, involving collaboration with N.A.S.A., the Department of Agriculture, the Naval Oceanographic Office and numerous other Government and academic organizations. The Survey is extremely active in the field of remote sensing research.

Gemini and Apollo photographs have already been used to obtain information on the regional geology of the U.S.A. and other large land masses such as North Africa and Saudi Arabia. Photographic and infrared line scan imagery obtained from aircraft is being used for geological and geophysical research projects at Washington D.C. and Denver, Colorado. Sensors mounted on mobile towers are being used for geological and geobotanical research.

UNIVERSITIES

1. University of Michigan, Willow Run Laboratories, Infrared and Optics Laboratory.

The work here is principally in the field of infrared technology. Scientists have designed multi-channel scanners and supplied them to other agencies, including N.A.S.A. and Purdue University. The multichannel scanners record on magnetic tape, and data analysis is by a hybrid analogue/digital computer system with a four colour printout. The results achieved so far are exciting, but much research work remains to be done before the system is operational. The main applications so far have been in agriculture (crop differentiation), but work has also been done in hydrology, location of sinkholes, mapping of lava types, recognition of impervious areas in urban regions, oil pollution studies, identification of industrial pollution and studies of sea ice.

2. University of Kansas, Lawrence. Centre for Research Inc. Engineering Science Division.

This laboratory studies the use of remote sensors, particularly microwave, for earth resources surveys. The staff is composed of electrical engineers, geographers and geologists with the aim of supporting faculty and graduate research. Investigations are proceeding into new radar systems and into the application of radars to various problems, including the discrimination of crops and the identification of the growing stage of crops, detection of soil moisture, estimation of sea roughness, differentiation of sea ice types and discrimination between old and new snow. Much work is also being done on an instrument for the semi-automatic analysis of imagery - known as IDECS - Image discrimination enhancement combination and sampling system. The primary output from the system is a colour T.V. display, the colours of which can be varied, to maximize contrast between features of interest; the screen can then be photographed in colour if a permanent record is required.

3. Colorado School of Mines, Golden.

Two days were spent here with Professor Reeves and with the School of Mines Subcontractor, Martin-Marietta. Professor Reeves has selected as a test site for remote sensing work an area of 10,000 square miles in southern Colorado, and N.A.S.A. is providing overflights periodically. To date colour and colour-infrared photography at various scales is available, and graduate students are evaluating its application to their various projects. An independent evaluation of its usefulness is being made by scientists from the Martin-Marietta Company and they are also evaluating thermal infrared imagery flown by N.A.S.A.

4. University of California, Berkeley, School of Forestry. Forestry Remote Sensing Laboratory.

The work of this laboratory is naturally oriented towards forestry, but much of it has application to earth resources generally. Of particular interest are their studies in multispectral photography using a four lens camera and a four projector additive viewing system. By using particular filters in the optical path, the contrast between features of interest can be increased, and the enhanced images can then be photographed on colour film. Other work going on here includes a study of Apollo 9 colour infrared photography with the aim of making an inventory of crops; it has been found nearly impossible to differentiate crops with only a single date of photography; sequential photography is necessary. Another project is concerned with density measurements on panchromatic film to try to find whether crops can be identified by density readings on a single date. A further project is the interpretation of regional geology from Apollo photographs by a graduate student, who is following up the interpretation by ground checking.

5. Stanford University, Palo Alto, California.
Stanford Remote Sensing Laboratory.

This group has been concerned with research in sensing the thermal properties of natural materials - rocks, soils and water bodies. Considerable investigation has been done on the identification of rocks by their infrared emission spectra; airborne instruments have been constructed, and discrimination between simple rock materials has been achieved from the air, but the method is still in the experimental stage. Other work includes infrared exploration for shoreline springs, surface heatflow studies for remote sensing of geothermal resources, the use of remote sensing in exploration for mineral deposits and computer methods of handling the large amounts of data acquired by sensors.

PRIVATE COMPANIES

1. Western Geophysical Co.

The Western Geophysical Co., Houston has developed an integrated marine navigation system for use in shallow water, less than 100 fathoms which, they claim, has an accuracy of $\pm$ 0.1 miles across track and $\pm$ 0.01 knots in velocity. The system is being installed in M.V. "Western Endeavour" which will be used for marine surveys in Australian waters.

2. Remote Sensing Incorporated

This company is concerned with the operational use of remote sensing in the field of agriculture, pollution, geological exploration, and hydrology. They have three aircraft modified for remote sensing work and a fourth, a D.C. 6, being modified at present.

3. H.R.B. -Singer Inc.

The H.R B.-Singer company is primarily concerned with the development and production of infrared and multispectral line scanners for military application. Some of the infrared scanners are now available for commercial use and have been employed by N.A.S.A , the Chevron Oil Research Co., and other research organizations in the U S.A. to obtain imagery. The scanners are designed to record directly onto film but can be modified to provide an output for a high quality tape recorder. The company has an Environmental Sciences application group which works on the analysis of imagery and investigates possible applications of the scanners.

4. Bendix Corporation Aerospace Systems Division, Ann Arbor

Bendix is the subcontractor to General Electric (the company responsible for building the ERTS A Satellite) for the design and construction of the ground data facility required for processing the data from the satellite. Bendix makes three commercially available infrared line scanners and a 7-channel multispectral scanner, and has designed a 13-channel multispectral scanner and an associated ground data processing unit that will be built to order; and is also building for N.A.S.A. a 24-channel scanner. The company has in progress an experimental programme involving the flying of an IR line scanner over a mining district in Arizona to determine the effectiveness of thermal mapping for mining exploration. Bendix has also carried out tests indicating that gas leaking from a pressurized pipeline produces a sharp drop in temperature which affects the overlying soil sufficiently to be detected by infrared line scanning equipment.

5. Daedalus Enterprises Inc.

An Infrared Line Scanner and an Infrared Scanning Radiometer are produced in small numbers by this company specifically for commercial applications, and at present an attachment to provide a multispectral capability is being developed. The scanners are designed to record on high fidelity tape. Two playback units have been developed, one for use in the field at the survey base and the other more complex and sophisticated for use in the laboratory.

At present Daedalus is starting to develop a Synthetic Aperture Side-looking Radar for commercial use.

6. Geophoto Services Inc.

This company, a subsidiary of Texas Instruments Inc., concentrates on the operational use of remote sensing for mineral and oil exploration. Black and white, colour and colour infrared photography is used for most of the company's work. Geophoto has experimented with infrared line scanner images for oil exploration but abandoned this as uneconomic. The company is currently using a Gamma Ray Spectrometer to differentiate between rays from Bismuth, Uranium, Thorium and Potassium with very promising results.

7. Chevron Oil Research Co.

The remote sensing group's effort is directed toward the practical application of remote sensing for mineral and oil exploration and particularly to overcoming the problems associated with night time surveys using Infrared Line Scanners. They have used Bendix, H.R.B. Singer and Daedalus equipments for separate infrared surveys and consider the Daedalus equipment the most versatile and reliable in operation. At present they are doing a detailed interpretation of the Side-looking Radar imagery of the Californian Coastal Strip.

8. Geotronics

The application of the Bendix Infrared Line Scanner to various problems including pollution studies and highway construction in urban areas was discussed. The company is active in the field of multispectral photography and is investigating the use of a long wavelength radar to record depths to shallow bedrock.

9. North American Rockwell, Space Division

The company has a very active programme in remote sensing applied to earth resources with the aim of providing a commercial Resource Management Service. In addition to using Multispectral Cameras, an Infrared Line Scanner and Microwave Radiometers for current research, they are developing a Long Wavelength Radar System, an Active Infrared System, an Airborne Derivative Spectrometer and Ground Processor, and a High Intensity Light-Low Light Level Camera System for future work. They are also developing an Automated Data Interpretation System, a Digital Display of Multispectral Scanner Data and an Automatic Contour Plotter using either an analogue or digital data input for analysis of remote sensing information. A useful capability that has been developed is that of overlaying space photographs with a computer-generated distorted grid obtained from a minimum of three reference points on the photograph.

CONCLUSIONS

Because the other members of the Departmental team were absent at the time of preparing this preliminary report, no recommendation representative of the views of the whole team can be made. However, as far as BMR is concerned, it is felt that we should respond to the invitation contained in NASA memo. change 28 dated June 2, 1970 by proposing Australian scientific projects utilizing the data resulting from the ERTS A and B missions. Experience in the U.S has shown that in order to gain maximum benefit from these data, associated aircraft programmes and ground investigations are essential.

We believe that BMR should take an active part in the investigation of sensors and the application of remote sensing to geological and geophysical exploration. In order to do this satisfactorily some reorganization along inter-disciplinary lines seems desirable, and further consideration will be given to this aspect and appropriate recommendations made in the final report.

VISIT TO TEKTITE OPERATION - W.J. PERRY

Perry also visited the Tektite II operation from August 24th to 26th.

Tektite II is a multi-disciplinary underwater research project jointly sponsored by the U.S. Department of the Interior; N.A.S.A.; Department of the Navy; National Science Foundation; Smithsonian Institution; Department of Health, Education and Welfare; United States Coastguard; Government of the Virgin Islands; the General Electric Company; University of Pennsylvania; Marine Biomedical Institute of the University of Texas Medical School and Texas A & M with participation by other technical institutions, Universities and Industry.

The project is designed to permit marine scientists to carry out a variety of in situ research missions under saturated diving conditions. It is being carried out at the same location as Tektite I, namely Greater Lameshur Bay, St. John, U.S. Virgin Islands, so as to provide continuity to the marine scientific studies begun in Tektite I and to take advantage of existing operating facilities.

All missions, from the start in April up to the present have been at 50 feet; the habitat accommodates 4 scientists, 1 engineer; duration of missions has been from 14 to 20 days for scientists and up to 30 days for some engineers.

A second habitat to accommodate a crew of two is planned to operate at 100 feet, mainly to see whether this depth is safe for utilizing a nitrogen/oxygen breathing mixture for saturated diving conditions. If it turns out to be safe, as is expected, it will open up hundreds of additional square miles of continental shelf to divers and investigators who do not have the support facilities required for using more exotic breathing systems such as helium. This habitat had not become operational by the end of August.

The whole project is scheduled to finish at the end of October.

Associated with the scientific work carried on from the 50-foot habitat, known as the Ocean Floor Programme, is the Ocean Survey Programme of special studies and oceanographic surveys to supplement and provide supporting data for the Ocean Floor Programme. It is being carried out from an

oceanographic research vessel, between the end of March and September 13th. A N.A.S.A. overflight of the Tektite II site was made during July with the purpose of evaluating factors affecting the resolution of bottom features in aerial photography.

The following extract from United States Department of Interior "Tektite II Program Plan" dated April 1, 1970, shows the principal investigators and activities for both the Ocean Survey Programme and the Ocean Floor Programme.

3.1 OCEAN SURVEY PROGRAM - The Ocean Survey Program has been designed partially to supplement and provide supporting data for the Ocean Floor Program described in section 3.2.

In addition, there will be a substantial effort to collect over a broad geographical area basic information having to do with physical oceanography, meterology, and geology. Included in the above studies will be special aircraft overflights for the purpose of obtaining aerial photographs of the surrounding water and land using different types of film and photographic techniques. These flights will be coordinated with both the aquanauts and with surface support personnel.

The Ocean Survey Program will be supported primarily by the ADVANCE II, an oceanographic research vessel described in section 2.1.3.

3.1.1 PRINCIPAL INVESTIGATORS AND ACTIVITIES - The principal investigators are listed according to the chronological order in which their activities have been scheduled.

1. Dr Oswald A. Roels, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York

   (a) Conduct bottom topography profile survey along a line 329° true from station located on North Shore St. Croix at 17°47.1'N and 64°47.3'W to 2000 fathom line

   (b) Collect bottom grab samples along transect "a" from 100 through 500 fathoms

   (c) Conduct three hydrographic and water sampling stations along transect "a" water samples at 500, 1000 and 1500 meters. XBT observation at each station

(d) Field test multiple plankton sampler.

(e) Lay underwater pipe along transect "a"

(f) Radar-controlled topographic survey and current profile measurements

2. Dr Louis Garrison and Dr Charles Holmes, U.S. Department of Interior, U.S. Geological Survey, Office of Marine Geology, Corpus Christi, Texas

(a) Seismic survey. Conduct transects - Complete survey at St. Thomas Harbor, 15 April

(b) Seismic survey-Anegada Passage using 20 K_j sparker, if available

(c) Geochemical Survey.

3. Mr Lloyd Lewis, University of Rhode Island, Kingston, Rhode Island and Mr James Gallagher, U.S. Navy, Underwater Sound Laboratory

(a) Test and Evaluation of a Deep Ocean Sediment Probe (DSOP)

4. Dr Lyman A. Ripperton, University of North Carolina, Chapel Hill, North Carolina

(a) Factors affecting Ozone Concentration in a Marine Environment. Measurement of Ozone, organic aerosols, and meteorological parameters.

5. Dr John Bunt, University of Miami, School of Marine and Atmospheric Sciences

(a) Processes of Primary Production in the Waters of the Virgin Islands. Measurements of CO production by Phytoplankton and associated organism (mass spectrometer). Measurements of Photosynthesis and respiration to natural phytoplankton populations. Assays of nitrogen fixation Carbon-14 measurements. Hydrology and routine biological data.

6. Mr William J. Merrell, Jr, Texas A & M University, Teague Research Center, College Station, Texas

(a) Correlation of Physical Oceanographic Data with NASA Aircraft Remote Sensor Data.

7. Dr E.J. Softley and Mr H. Sadjian, General Electric Company, Ocean Sciences Laboratory, Philadelphia, Pa.

   (a) Measurement of Scattering and Absorption of a Light Beam in the Sea (Laser-5145 A).

8. Dr William D Garrett, Naval Research Laboratory, Interface Chemistry Section, Ocean Sciences Division, Washington, D.C.

   (a) Use of Monomolecular Surface Films to Enhance Underwater Visibility.

9. Dr Edward L. Towles, College of the Virgin Islands Caribbean Research Institute, St. Thomas, Virgin Islands

   (a) Plankton tows (MacLean)

   (b) Small island flora and fauna collecting: Shore and terrestrial

   (c) Marine ecology

   (d) Marine geology

   (e) Biology, Geology, Marine Sciences.

10. Dr Charles W. Welby, North Carolina State University, School of Physical Sciences and Applied Mathematics, Geoscience Department, Raleigh , N.C.

   (a) Study of Sedimentation on the Virgin Island Platform.

3.1.2 OCEANOGRAPHIC SURVEYS - In addition to the special studies described, routine descriptive oceanographic surveys will be conducted. Student trainees will participate in the survey activities. Supervisor personnel will be designated from the Cape Fear Technical Insitute, Southern Maine Vocational Institute, South Portland Maine, Research Triangle Institute, and participating colleges and Universities. Student trainees will be from North Carolina State University. Supervisory personnel:

Cape Fear Technical Institute
Ed Foss, Dale Buck, Jim Martin, Tom Rhodes

Research Triangle Institute
Ron Strong, Jim Smith

3.1.3 DURATION - The ADVANCE II is scheduled to depart Wilmington, N.C , on 21 March 1970, arrive at Lameshur Bay on 26 March and assist in the ballasting of the TEKTITE habitat until 30 March 1970. The ocean survey program will begin on about 31 March 1970 and will continue until about 13 September 1970. During this period some time will be spent in logistic support of the UNDAUNTED (support vessel for the minitat) and in port for personnel transfer and reprovisioning.

3.1.4 NASA OVERFLIGHT - During the periods of 6-25 July 1970 and 13-25 July 1970, overflights of the TEKTITE II site by N.A.S.A. research aircraft are scheduled. The principal investigators for this part of the ocean survey program are Dr Dean R. Norris and Dr Curtis C. Mason of the Manned Spacecraft Center at Houston, Texas. They will attempt a comprehensive evaluation of factors affecting the resolution of bottom features in aerial photography.

3.2 OCEAN FLOOR PROGRAM (50-FOOT DEPTH)

MISSION	EXPERIMENT TITLE & PRINCIPAL INVESTIGATOR
1-50	"Precise In Situ Measurements of Some Chemical Parameters": Dr Paul Cratin, Mr Richard W. Curry, & Mr Roger J. Dexter, Institute of Marine and Atmospheric Sciences, University of Miami
1-50	"Observations of Fish Behaviour in Relation to Fish Pots": Dr Alan J. Beardsley & Mr William L. High, U S. Bureau of Commercial Fisheries, Seattle
2-50	"Continuation of Underwater Geologic Studies in the Lameshur Bay area, St. John, U.S. Virgin Islands": Dr H. Edward Clifton & Dr Ralph E. Hunter, U.S. Geological Survey, Menlo Park, California
2-50	"Ecology, Behaviour and Population Dynamics of the Spiny Lobster, Panulirus argus, in the Virgin Islands": Mr John VanDerwalker, TEKTITE II Program Office; Mr Ian Koblick, Government of the Virgin Islands
3-50	"Continuation of Underwater Geologic Studies in the Lameshur Bay Area, St. John, U S. Virgin Islands": Dr Kendall A. Dickinson, U.S. Geological Survey, Corpus Christi, Texas; Mr R. Lawrence Phillips,

U.S. Geological Survey, Menlo Park, California (Continuation of 2-50)

3-50 "Dynamics of Predation by Invertebrates and Fishes on Coral Reef Associations": Dr Charles Birkeland & Dr Gordon Robilliard, University of Washington, Seattle

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4-50 "Passive and Experimental Bio-Acoustical Studies on Marine Organisms in Their Natural Habitat": Dr Thomas J. Bright & Mr William W. Schroeder, Texas A & M University, College Station, Texas

4-50 "Comparative Studies of Sublittoral Vegetation in the Virgin Islands and the New England Coastlines": Dr Arthur C. Mathieson & Mr R. Fralick, University of New Hampshire, Durham

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6-50 "The Ecology and Behavioral Patterns of the Motile Fauna Associated with Tropical Marine Soft Bottom Communities": Dr Renate True, Tulane Medical School, New Orleans

6-50 "Reef Vegetation: Qualitative Distribution and Observations on the Influence of Fish Herbivores": Sylvia Earle, Farlow Herbarium, Harvard University, Cambridge, Massachusetts

6-50 "The Escape Response in Pomacentrid Coral Reef Fish": Dr Peter H. Hartline, Mrs Ann C. Hartline, Miss Alina M. Szmant, Scripps Institute of Oceanography, University of California, San Diego

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8-50 "Biology Studies on Benthic Cephalopoda, Especially Octopods": Dr Frederick G. Hochberg, Jr, University of California, Santa Barbara; Mr John A. Couch, Bureau of Commercial Fisheries, Oxford, Maryland

8-50 "Ecology, Behaviour and Population Dynamics of the Spiny Lobster, Panulirus argus, in the Virgin Islands": Dr William F. Herrnkind, Florida State University, Tallahasse; Mr Louis M. Barr; Bureau of Commercial Fisheries, Auke Bay, Alaska (Continuation of 2-50)

10-50 "Zooplankton and Coral Feeding": Mr Thomas F. Dana, Scripps Institution of Oceanography

10-50 "Photosynthesis in Coral-Algal Associations": Dr J. Morgan Wells, Jr, Wrightsville Marine Bio-Medical Laboratory, Wilmington, North Carolina

10-50 "Effects of Man-Made mpollution on the Dynamics of Coral Reefs": Dr Richard H. Chesher, Westinghouse Ocean Research Laboratory, Miami; Dr Lawrence R. McCloskey, Marine Biological Laboratory, Woods Hole, Massachusetts

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12-50 "Biochemical Studies of a Benthic Ecosystem & In Situ Measurements of Nitrogen Fixation by Benthic Blue-Green Algae": Dr J.S. Bunt & Assistant, Institute of Marine and Atmospheric Sciences, University of Miami

12-50 "Ecology, Behaviour and Population Dynamics of the Spiny Lobster, Panulirus argus, in the Virgin Islands": Mr Robert Ellis, Bureau of Commercial Fisheries, Auke Bay, Alaska; Dr Richard Cooper, Bureau of Commercial Fisheries, West Boothbay, Main (Continuation of 2-50)

15-50 "Diurnal-Nocturnal Activity Patterns of Reef Fishes": Mr Bruce Collete, U.S. National Museum, Washington, D.C.; Mr Frank Talbot, The Australian Museum, Sydney, New South Wales, Australia

15-50 "Habitat Selection and Resource Sharing in West Indian Fish Communities": Dr C. Lavett Smith, The American Museum of Natural History, New York; Dr James C. Tyler, The Academy of Natural Sciences of Philadelphia

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17-50 "The Trophic Relation Between Coral and Sand Endofauna and Benthic Carnivores During a 24-Hour Cycle": Dr Jean-Georges Harmelin, Marseille, France

17-50 "In Situ Measurement of the Metabolic Activity of Tropical Benthic Communities": Dr Merrill A. True, Tulane University, New Orleans

It should be noted that mission 17-50 has not been finalized. When the aquanaut-scientists have been selected, their names and programs will be supplied.

APPENDIX I

Documents obtained from University of Kansas Center for Research, Engineering Science Division		No. of Copies
1.	Research (A review of CRES activities).	Two
2.	The potential of Low Resolution Radar Imagery in Regional Geologic Studies. Authors Dellwig, Kirk & Walters.	"
3.	Effects of Roughness on Emissivity of Natural Surfaces in the Microwave Region. Authors Ulaby & Fung.	"
4.	Regional Slopes with Non Stereo Radar. Authors Dalke & McCoy.	"
5.	Optimum Radar Depression Angles for Geologic Analysis (Maps and Graphs).	"
6.	Using Radar Imagery for Crop Discrimination A Statistical and Conditional Probability Study. Authors Haralick, Caspall, Simonett.	"
7.	Snowfield Mapping with K Band Radar. Authors Waite & MacDonald.	"
8.	The apparent temperature and emissivity of natural surfaces at microwave frequencies. Authors Ulaby, Fung & Wu.	"
9.	CRES Publications List June 1970.	"

Documents from U.S Government Printing Office, Washington D.C.		
1.	Thermal Radiation Heat Transfer Vols I & II Authors Siegel & Howell.	One
2.	Handbook of Military Infrared Technology. Ed. Wolfe.	"
3.	Geology, Catalogue of documents	
4.	Space (Missiles, The Moon, N.A.S.A. Satellites), Catalogue of documents.	"
5.	Principles of Optical Data Processing for Engineers. Author Shulman.	"
6.	Image Interpretation Handbook Vol 1. Naval Reconnaissance & Technical Support Center.	"

Documents from Remote Sensing Inc., Houston.		No. of Copies
1.	Airborne Fluorometer Applicable to Marine and Estuarine Studies. Authors Stoerz, and Hemphill (U.S.G.S.) & Markle.	One
2.	Five examples of I.R Imagery and their interpretation (Altitudes 5000 ft. (est.) to 35,000 ft.)	"
3.	Aircraft Sensor Systems (Remote Sensing's A/C Fleet and equipment Installations).	"
4.	Advertising Brochure.	"

Documents obtained from Bendix Aerospace Ann. Arbor.		
1.	Bendix Thermal Mappers (Pamphlet & Imagery).	Two
2.	Lockheed 417 Wideband Recorder (Pamphlet).	"
3.	Thermal Mapper Price list.	"
4.	Preliminary Report on Thermal Mapping of Lone Star Mining District, Arizona.	"
5.	A Scanning Radiometric System for Light Aircraft Remote Sensing.	"
6.	Thermal Detection of Simulated Pipe Leaks. Tech. Report B.S.R. 2852 Jan '70.	"
7.	Environmental Detection Systems. Author R.C. Carnes.	One
8.	Multispectral Scanner 9 channel (Pamphlet).	"
9.	Multispectral Data Processing Facility (Pamphlet).	"
10.	Multispectral Imagery Information Content. Authors Carnes & Hanson.	"
11.	Multispectral Data Gathering and Analysis. Authors Rogers & Carnes.	"
12.	Multispectral Scanning for water pollution. Author R.C. Carnes.	"
13.	A Reflectance Calibrated Multispectral Scanner (9 Channel) Author H.I. McDevitt.	"
14.	Multispectral Interpretation (Outline of 24 channel Scanner).	"
15.	Bendix EMSIDE Airborne Systems (Multispectral Scanners).	"
16.	Earth Resources Back grounder.	"
17.	Long Path Spectrophotometer Ozone Monitor (Pamphlet).	"

		No. of Copies
18.	A Digital Infrared Telespectrometer for Research Studies in Measuring Ozone & Other Pollutants.	One
19.	Experimental Applications of the Bendix Thermal Mapper to Mining Geophysics. B S.R 3026 Oct '70 (Final report on Lone Star Mining District).	"

Documents obtained from H.R B-Singer, State College.

1.	Reconofax XIII A Infrared Line Scanner	"
2.	Manual for Reconofax IV Mk IV and Reconofax VI Mk IV I.R Mapping Sets	"
3.	The Reconofax IV Earth Sciences I R. System (ESIRS)	"
4.	Develop Infrared Scanner for Canadian Uses	"
5.	Criteria for Regional Airborne Infrared Geological Surveys. Author Stingelin	"
6.	The effect of Ground Temperature on Thermal Resolution in Infrared Imagery Author Bastuscheck	"
7.	Review of H.R. B. Singer Activities and products (Advertising)	"
8.	Terrain Mapping by Use of Infrared Radiation. Authors Harris & Woodbridge	"
9.	Using an Airborne Infrared Imaging System to locate Sub-surface Coal Fires in Culm Banks. Author Knuth	"
10.	Infrared Imagery Mosaics for Geological Investigations. Authors Williams & Ory.	"

Documents obtained from Daedalus Enterprises Inc.

1.	Advertising Pamphlet with 12 sheets in outer cover	Two
2.	Price List	One
3.	Lease Rental Schedule	"
4.	Installation Drawing of I.R. line scanner	"
5.	Effect of Low Frequency response on Noise Amplitude from Mullard Hq/Cd/Te. Detectors (Photograph).	"

Documents obtained from Willow Run Labs Ann Arbor.

1.	The University of Michigan Notes for a Program of Study in Remote Sensing of Earth Resources.	"

		No. of Copies
2.	Advanced Infrared Technology. An Intensive Short Course	One
3.	Fundamentals of Infrared Technology (An Intensive Short Course)	Two
4.	Infrared and Optics Laboratory Organisation Chart. (Outdated)	"
5.	List of Current Documents in Centre for Remote Sensing Information and Analysis (Out of date)	"
6.	Likelihood Ratio Processing of Multispectral and Scanner Data. Author Larrowe	One
7.	Preprocessing Transformations and Their Effects on Multispectral Recognition (Sixth Symposium). Authors Kriegler, Malila, Nalepka & Richardson	Two
8.	Use of Multispectral Recognition Techniques for Conducting Rapid, Wide area, Wheat Surveys. (Sixth Symposium) Marshal, Thomson N, Thomson F, & Kriegler.	One

Documents obtained from Berkley University

1.	Machine-Aided Photo Interpretation Techniques for Vegetation Analysis. Authors Lent & Nichol	"
2.	Applications of Earth Orbital Remote Sensing to Forest and Range Problems. Author Colwell	"
3.	Remote Sensing of Natural Resources. Author Colwell	"
4.	Earth Resource Sensors on Aircraft, On Spacecraft and on the Ground? Authors Lauer & Olson	"
5.	The Inventory of Earth Resources on Enhanced Multi-Band Space Photograph. Authors Colwell & Lent	"
6.	Analysis of Remote Sensing Data for Evaluating Forest and Range Resources, Annual Report '69 Authors Colwell, et al.	"
7.	Organization Chart for School of Forestry and Conservation.	"

Documents obtained from Chevron Oil Research Labs.		No. of Copies
1.	Preprint of Geologic Applications of Remote Sensing. Author Sabins	One
2.	Photographs of Hasselbladt Camera, Timer, Power Unit, Drift Mount and Exposure meter used for terrain photographs.	"

Documents obtained from Geophoto Services Inc. Denver.		
1.	Digital Airborne Gamma Ray Spectrometer System (Developed by Texas Instruments)	"
2.	Digital Airborne Gamma Ray Spectroscopy. Author Darnley	"
3.	Digital Airborne Gamma Ray Spectrometry.	"

Documents obtained from Stanford University.		
1.	Terms in Geologic Remote Sensing, a Condensed Glossary (Lyon)	Two
2.	The Multiband Approach to Geological Mapping from Satellites: Is it Redundant or Vital. Author Lyon	"
3.	Airborne Geological Mapping Using Infrared Emmission Spectra "I". Authors Lyon & Patterson	Three
4.	Pseudo-Radar: Very High Contrast Aerial Photography at Low Sun Angles. Authors Lyon, Mercado & Campbell	Two
5.	Remote Sensing in Exploration for Mineral Deposits. Authors Lyon & Lee	Three
6.	Stanford Remote Sensing Lab. Technical Report Series	Two
7.	Stanford Spectral Data Management System. Author Heathman	One
8.	Mission 78 - Flight 1 & 2 Ninety Day Report. Authors Lyon & Kilinc	"
9.	Geophysical Analysis of Thermal Infrared Imagery near Goldfield Nevada: Exp. the Correlation Analysis. Author Ervine	"
10.	Infrared Exploration for Shoreline Springs at Mono Lake, California, Test Site. Author Lee	"
11.	Pamphlet on Kodak Infrared Interference filters	"
12.	8 Pamphlets on Optics Technology Inc. Interference filters	"

		No. of Copies
13.	Pamphlet on International Imagining Systems, Product Information and Price Data (Multispectral Camera and Additive Viewer)	One
14.	Copy of Applied Optics Sept '68 on Infrared Uses	"
15.	To Locate & Establish the Geological Significance of Vegetation Anomalies in Proximity to Mining Districts. Author Lyon.	"

Documents obtained from U S.G.S. Washington and Denver.

1.	Infrared Imagery and Radiometry Summary Report. Authors Moxham, Greene, Friedman, Gawarecki	"
2.	Radar Images - San Francisco Volcanic Field, Arizona - A Preliminary Evaluation. Author Schaber	"
3.	A Distinction between Bedrock and Unconsolidated Deposits on 3-5u Infrared Imagery of the Yellowstone Rhyolite Plateau. Author Christiansen	"
4.	Geological Evaluation of Infrared Imagery, Eastern Part of Yellowstone National Park, Wyoming & Montana. Author Smedes	"
5.	Thermal Anomalies and Geological Features of the Mono Lake Area, California, as Revealed by Infrared Imagery. Author Friedman	"
6.	Evaluation of Radar and Infrared Imagery of Sedimentary rock terrain, South Central Yellowstone National Park, Wyoming. Author Keefer	"
7.	Arizona Regional Ecological Test Site A Multidiscipline Study of Arid Environment	Two
8.	Technical Letter N.A.S.A. 62 Radar Images - Meteor Crater Arizona. Author Schaber	One
9.	Technical Letter N.A.S.A. 30. Preliminary Evaluation of Radar Imagery of Yellowstone Park, Wyoming . Authors Christiansen, Pierce, Prostka and Ruppel	"
10.	Infrared Surveys of Hawaiian Volcanoes. Authors Fischer, Moxham, Polcyn, Landis	"
11.	Infrared Spectral Returns and Imagery of the Earth from Space and Their Applications to Geological Problems. Authors Gawarecki, Lyon and Nordberg	"

		No. of Copies
12.	Sensor Detection Capabilities Study. Author Wilso	One
13.	Satellite Imagery of the Earth. Authors Merifield, Cronin, Foshee, Gawarecki, Neal, Stevenson, Stone & Williams	Two
14.	Infrared Survey of Irazu Volcano and Vicinity, Costa Rica. Authors Gawarecki, Moxham, Morgan and Parker	One
15.	Remote Multispectral Sensing in Agriculture (LARS, PURDUE)	"
16.	Mission 73 Summary and Data Catalog. Authors Pascucci and North	"
17.	Geologic Studies of Yellowstone National Park Imagery Using an Electronic Image Enhancement System. Author Smedes	"
18.	Remote Detection of geochemical soil anomalies. Author Canney.	"

Documents from N.A.S.A. Goddard and Houston

1.	Ecological Surveys from Space	Two
2.	Geological Orbital Photography: Experience from Gemini Programme. Author Lowman Jr.	One
3.	Geological Analysis of Selected Apollo 10 70 mm Lunar and Terrestrial Photographs. Authors Blodget, Lowman Jr, and O'Keefe	"
4.	Apollo 9 Multispectral Photography: Geologic Analysis. Author Lowman, Jr.	Two
5.	Operational Manual Model 608-3M + 608-6M Four Colour Isodensity Tracers	One
6.	Design Study Specifications for the Earth Resources Technology Satellite ERTS-A + B. Revision B Jan '70	Two
7.	Earth Resources Program Synopsis of Activity	One
8.	Earth Observations Program Review 4th/5th Nov. '69	"
9.	Pamphlets on Image Control Keyboard IC4, Microstar Reader PR1 + Easematic Reader PR CD	"
10.	Earth Resources Aircraft Program Status Review 1968 Vol I. Geology, Geography & Sensor Studies	Two

		No. of Copies
	Vol II. Agriculture, Forestry & Sensor Studies	Two
	Vol. III. Hydrology, Oceanography & Sensor Studies	"
11.	Earth Resources Aircraft & Sensors	"
12.	Apollo Earth Photographs Index Maps. Missions 6, 7 and 9	"
13.	Peaceful Uses of Earth Observation Spacecraft. Vols 1, II & III.	"

Documents from Space Division of North American Rockwell.

1.	Applications of Optical Signature Enhancement Techniques to Space Photography	One
2.	Geothermal Exploration	"
3.	Earth Applications Program	"
4.	NR Earth Resources Program: Capabilities and Data Handling System.	"

Documents from Colorado School of Mines, Golden.

1.	Geology and Geological Engineering (Faculty Information)	"
2.	The Bonanza Project - Remote Sensing for Mineral and Water Resources. Authors Reeves, Jefferis, Knapper, Mars and Raines.	"