 25X1

19 June 1972

MEMORANDUM FOR: [redacted] 25X1

SUBJECT : Material (mostly re Lunar Cartography) forwarded by Don Steininger on 15 June 1972

REFERENCES : Attached Memoranda; Report of U.S./USSR Experts on Lunar Cartography, and its attachments

1. Probably the most important paper for you in this bundle is the memorandum of 16 May 1971 from Mr. Frutkin, Assistant Administrator for International Affairs, NASA, to senior officials in his organization (the top memo). He notes that, at a meeting of the UN Outer Space Legal Subcommittee, friendly sources suggested privately the advisability of proposing that the boundary between "national air space" and "outer space" be set at 54 nm (100 km). He asks the NASA officials if NASA has any satellite or spaceflight prospects for operating below this altitude. Would another boundary limit be preferable? He ended by noting that previously the U.S. resisted a definition of outer space at a fixed altitude.

2. The remaining papers relate to the joint U.S./USSR meeting of experts in the field of Lunar Cartography, which met in Washington D.C. 8-12 May 1972. I think you may find my paragraph 5 of interest.

3. The two delegations recommended that lunar cartographic activities be undertaken:

a. to conduct a joint development of basic principles for compiling lunar maps--including standard scales, a coordinate system, cartographic projections, etc.;

b. to develop a joint program for compiling a complete map of the Moon at 1:5,000,000 scale; and

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c. to develop a common basic system of selenodetic coordinates. /Selenography is the study of the surface and of the Moon. "Selenodetic" equates with "geodetic", the latter referring to the Earth./

4. The remaining material is made up of both Soviet and U.S. reports. My impression is that the Soviet reports are much more generalized than those furnished by the U.S., the latter containing a great deal of detailed and technically imaginative information.

5. I discussed the Lunar Cartography meetings with
25X1 [redacted] who was a U.S. participant. He stated that the meetings were very interesting, that there was good rapport between the Soviet and U.S. participants, and that it was clearly evident that the know-how of the Soviets in obtaining positions of points on the lunar surface was as good as ours. They assumed that the U.S. participants knew much more about their lunar cartographic efforts than was, in fact, the case.
25X1 [redacted] told me that one of the women Soviet scientists gave him the following information. Their ZOND 6 and 8 vehicles were both once-around flybys of the Moon reaching no closer than 2-3,000 km and as far away as 10,000 km while taking photography. The camera focal length was 400 mm and the frame format 15 x 18 cm. Obviously, the photography was greatly inferior to the U.S. Apollo photography of the Moon. It was returned to earth by automatic retrieval. The LUNA 9 is now orbiting the Moon. They would not discuss what it
might be accomplishing. [redacted] conjectured that, if LUNA 9 were in 25X1
polar orbit, it might conceivably photograph the entire Moon's surface in 28 days.

6. I do not see any security problem regarding the lunar cartography meeting and the related papers that might cause you concern.

[redacted] 25X1

Attachments

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16 May 1968

MEMORANDUM FOR: [redacted] (not for distribution) 25X1

SUBJECT: Discussion with Ed Risley and Bob Porter

1. On 13 May 1968, I lunched with Edward Risley, Executive Secretary of the Committee on Space Programs for Earth Observations, Advisory to the U.S. Geological Survey (COSPEAR/GS). This Committee is considered part of the National Research Council. Robert Porter, responsible officer for NASA's Earth Resources Satellite Program, was also present at the luncheon. Both have [redacted] clearances. The following remarks are for your information. 25X1

2. Ed Risley, as a staff member of the National Academy of Sciences, works in the interests of the scientific community and with many from foreign countries. He is involved with scientific meetings of various sorts to which foreign scientists are frequently invited. He is oriented toward the "white" side of the earth sensing from space by use of satellites. As a result he has had his problems with the DoD with regard to clearance of proposed papers, attendance of foreigners at meetings, etc. The attached report by Fred Doyle was presented at a meeting in Texas before revision, after approval of the text by DoD. Later NRO [redacted] disapproved having 25X1 it presented by Fred Doyle at a meeting in Canada. Its publication in "Photogrammetric Engineering" is also not allowed. This type of DoD response to basically unclassified technical information is rumored to be of some concern to interested members of the American Society of Photogrammetry. Release of the Proceedings of the Woods Hole Conference of last summer is also being held up at the present time, since portions relate to earth sensoring from orbital satellites. I do know, however, that a few copies, at least, of Volume I, have been distributed within the Government.

3. Ed Risley tends to favor a separate "white" effort for earth resource surveys and is a bit unhappy about complexities of problems that might arise from the ARGO exercise.

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He feels that major contributions can be made by use of a variety of sensors recording above the established "threshold", realizing at the same time that benefits must be measured against costs and availability of funds. He feels that, under present security conditions, those U.S. social and physical scientists who hope to keep at all current in their research in the resources field need [redacted] clearances. At the same time, he recognizes that living in two worlds ("black" and "white") creates frustrating experiences.

4. Bob Porter said that he had had a lot of feed-back from his remarks at the ARGO briefing seminar in early March and was really surprised that so many attending were concerned about his statement regarding NASA's intention to carry out its ERS program. He feels that there is a good deal of sympathetic understanding of the program among CIA people, but that the DoD people just don't want to see it established and are putting up roadblocks. He believes much more attention needs to be given to policy matters inherent in the management of these two somewhat parallel programs, each carried on separately. He worries about how to sort out future collection requirements in terms of which can be most effectively fulfilled by "black" versus "white" programs. He has the impression that DoD dislikes open discussion of currently unclassified sophisticated sensor instrumentation, and heard a rumor that DoD has the lid on [redacted] Ed Risley later talked with a [redacted] representative who knew nothing about this.

5. Bob feels that, in terms of cost and benefits, more policy consideration should be given to possibilities of letting certain types of unclassified sensors ride along on some future classified missions, with proper share of cost assigned to these secondary sensors, the data from which would be publicly available. This should result in eliminating undue duplication in mounting missions. He also feels that a hard look should be given to policy regarding retaining data in the [redacted] system, and would hope for at least partial declassification, with due regard to essential national security. He would not be surprised if the President at some future time would step in to help clear the air. He feels that the benefits of maximum unhampered use, particularly in the economic field, to the U.S. in its foreign aid and in its need to understand foreign markets and investment potentials, in large part override many present rationalizations for maintaining high security treatment, especially when we know pretty well what the

Soviets are doing in their reconnaissance programs, and they must be rather knowledgeable regarding the quality of the data obtained by our reconnaissance satellite missions.

6. The following remarks on the attached report by Fred Doyle, (who does have [redacted] clearance and therefore, as author, enhances the security problem envisaged by the DoD) do not stem directly from the discussion at the subject meeting. You may be interested in scanning the whole paper, but I am noting points of possible special interest: 25X1

a. On page 1 -- percentages of world-wide and U.S. coverage by compiled maps of various scales.

b. On pages 4 and 5 -- under "Orbital Restraints", the last two sentences in first paragraph on page 5 and the illustration on page 6.

c. On pages 5, 7, and 8 -- the section on "Resolution and Map Scale".

d. On pages 11 and 12 -- the summarization of the "Camera System Capability" and the following paragraph.

e. On page 12 -- the RCA anticipated vidicon performance for EROS.

f. On pages 15 and 16 -- the NASA data recovery capsule as described in the last two paragraphs on page 15 and page 16.

g. On page 18 and following -- the section "Is It Economically Feasible." The values are not necessarily those currently quoted within the MC&G community, but they are close.

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Attachment

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MAPPING FROM SATELLITE PHOTOGRAPHY

(Revised for publication, December 1967)

Frederick J. Doyle
Chief Scientist

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AMERICAN SOCIETY OF PHOTOGRAMMETRY
National Science Foundation
Visiting Scientist Program

MAPPING FROM SATELLITE PHOTOGRAPHY

Frederick J. Doyle

Within the memory of many men now alive, maps were made by the ground surveyor lugging his theodolite, plane table, and alidade across the plains and up the mountains. In the years following World War II, the ground surveyor was largely replaced by the cartographic aerial camera and the photogrammetric plotting instrument. This innovation produced quantum jumps in production, geometric accuracy, and content of topographic maps.

Where Do We Stand Today

At the present time fully ninety percent of all new map compilations are produced photogrammetrically. Yet in spite of more than half a century of effort, the mapping task is woefully incomplete. Around the world only about half of the land area is covered by principal arcs of triangulation, and much less than half by first and lower order triangulation. The status of compiled maps is indicated in this table.

WORLD WIDE AND U. S. MAP COVERAGE

World Map Coverage

Quality	Small Scale 1:600,000 and Smaller	Medium Scale 1:75,000 to 1:600,000	Large Scale 1:75,000 and Larger	Remarks
Adequate	---	15%	5%	} Principally U. S. and Europe
Require Revision	30%	5%	5%	
Inadequate	70%	40%	10%	
Nonexistent	---	40%	80%	

U. S. Map Coverage

Quality	Small Scale 1:600,000 and Smaller	Medium Scale 1:75,000 to 1:600,000	Large Scale 1:75,000 and Larger
Adequate	100%	96%	64%
Inadequate	---	4%	4%
Nonexistent	---	---	32%

Data compiled by Army Map Service, and exclude Antarctica

Of primary concern is the fact that the rate of obsolescense of existing maps nearly equals the production of new maps, so that with present techniques the job will never be completed. Furthermore, the map production cycle is about three years from photography to printing so that the new map is three years out of date on the day it is published.

Geographers would like to see the million scale map of the world (IMW) completed. They state that most 1:250,000 maps are deficient in content. They need large scale 1:25,000 maps of all populated areas. Geologists, engineers, and other map users need similar scales. However, of first priority to all is the rapid revision of existing maps. Some sort of Parkinson's Law operates to make maps most difficult to compile and most rapidly obsolete in precisely those areas where they are needed most urgently. Maps of large urban areas should be recompiled annually. The current cycle in the United States is five to ten years.

The Gemini Photography

The use of the artificial satellite as a camera carrying vehicle is expected to provide a jump in mapping capability comparable to that which the airplane made over the ground surveyor. The Gemini photography was made with an ordinary hand held Hasselblad camera. On missions 5 and 7 photographs were made of the Cape Kennedy launch area. These two pictures, never intended for cartographic purposes, were used to revise the planimetric detail on the existing Army Map Service 1:250,000 map of the area.

In another application of the Gemini photography, the U. S. Geological Survey compiled a mosaic of most of Peru, parts of Bolivia and Chile. Control points were selected from existing 1:1,000,000 maps and identified on the individual Gemini Frames. These were then rectified and photograph tilts of as much as 40° were removed. Despite 20,000 feet of topographic relief a reasonable match was obtained, and the resultant photomap gives a view of the country never seen before.

But these are baby steps. What could be done with a system actually designed with cartographic objectives in mind?

Map Requirements

Before exploring the potentialities of space cartographic systems, it would be well to recall the requirements for producing maps.

A topographic map contains three kinds of information. The first is content, i.e., the details which are represented on the map. Content is provided by photographic resolution and scale, or more directly by ground resolution. In this area the exact capability of space photography remains to be demonstrated. For a variety of reasons it seems probable that the ground resolution obtainable with a given lens-film resolution will be higher from space than a simple geometric extrapolation from the scale of airplane photography would indicate. A useful criterion to apply is that the photography can be enlarged until its resolution is equivalent to between 10 and 20 line pairs per millimeter. This will present all the information which the human eye can extract without enlarging the map scale by magnification. Not all map information is obtainable directly from photography, regardless of its scale or ground resolution. Data such as political boundaries, place names, and detail obscured by vegetation must be compiled on the ground or from other sources. It is estimated that if the suggested resolution criterion is applied, about 80 percent of the total map information can be extracted from the photographs.

The second kind of information is the position of the objects shown on the map. For some applications the relative positions of all objects will be sufficient, but it is usually necessary and always desirable to attempt to specify all positions with respect to some well defined coordinate system, either local or national. Map positions are indicated by the reference graticule: longitude and latitude, state coordinates, or military grid lines.

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The third kind of information is elevation - generally shown by contour lines above a reference surface - usually mean sea level.

In the United States, criteria for position and elevation on maps exist in the National Map Accuracy Standards. Applied to photogrammetric mapping, these standards, and the higher resolution criterion defined above, result in the values given in the following table. A fixed contour interval does not necessarily go with a given map scale. An interval fine enough to depict the terrain will be chosen.

MAP ACCURACY REQUIREMENTS

Map Scale	Std. Error Position	Ground Resolution	Contour Interval	Std. Error Elevation
1,000,000	300 meters	50 meters	500 meters	150 meters
250,000	75	12.5	100	30
100,000	30	5.5	50	15
50,000	15	2.5	25	8
25,000	7.5	1.3	10	3

The numbers in this table represent the objectives against which a space cartographic system should be evaluated.

Orbital Constraints on Photographic Coverage

It is immediately clear that if full coverage of the Earth is required, a near polar orbit is necessary. Of course, if mapping is to be restricted to specific areas, orbits of lower inclination can be employed. But for elementary discussion only near polar orbits will be considered.

An orbit is approximately fixed in inertial space and Earth rotates beneath it. At practical altitudes the satellite period is approximately 1 1/2 hours and in that time the Earth will rotate some 22 1/2° of longitude, i.e., about 2500 km. Since no reasonable camera can cover 2500 km on a single photograph it is necessary to arrange the mission such that consecutive days will fill in the gaps. There exist so called "resonant" altitudes at 4, 145, and 303 nautical miles, at which each day's coverage would exactly duplicate the preceding day and the gaps would never be filled. In order to perform the gap filling function efficiently, it is necessary to make compromises in selecting orbital altitude, eccentricity, and inclination. Although orbits as low as 80 n.m. can be flown, for several reasons including spacecraft lifetime, an altitude of about 125 n.m. (232 km) is desirable.

As illustrated in Figure 1, the other critical parameter is the width of the ground track covered by the camera. This dimension, divided into the 2500 km between consecutive orbital passes will determine the minimum number of days in orbit which would be required to obtain complete coverage in the gaps. Quite obviously, if the spacecraft can remain in orbit for more than this minimum time, it will get more than one look at each spot. This is clearly desirable in view of the cloud cover which may be expected.

Resolution and Map Scale

The relationship between camera focal length, orbital altitude, lens-film resolution, and ground resolution is shown in Figure 2. For a wide angle cartographic camera, current technology limits average lens-film resolution to approximately 50 lines per millimeter. Thus, as indicated by line 1, a standard 6 inch camera, flying at 125 n.m. altitude, with this resolution, would produce a ground resolution of about 27 meters. Comparing this number against the resolution requirements stated earlier, it is evident that such a camera system would provide map content adequate for maps at about 1:500,000 scale. In order to obtain the 12 to 15 meter resolution required for maps at 1:250,000, a frame camera of 12 inch focal length, indicated by line 2, would be required.

To produce adequate resolution for the larger map scales with wide angle camera systems restricted to 50 lines per millimeter would

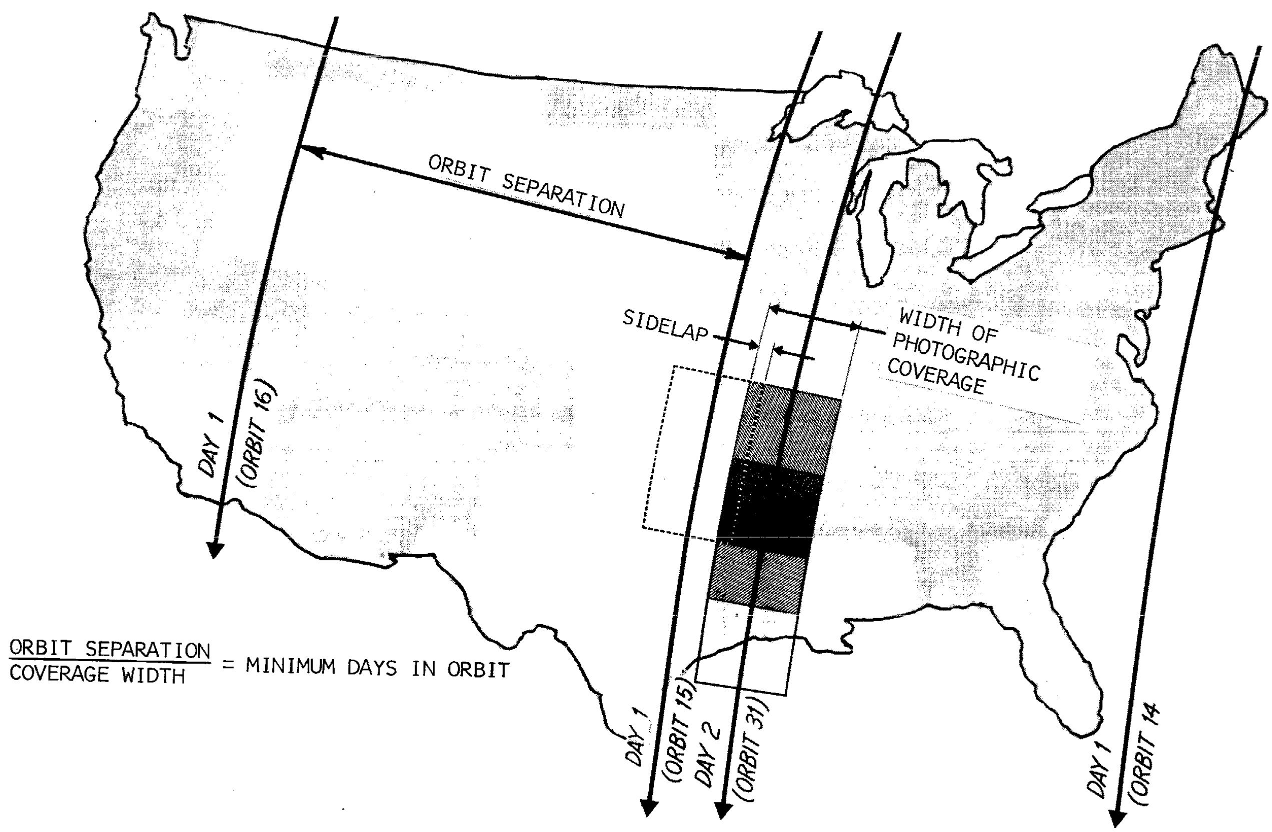

Figure 1 - Coverage of Satellite Photography

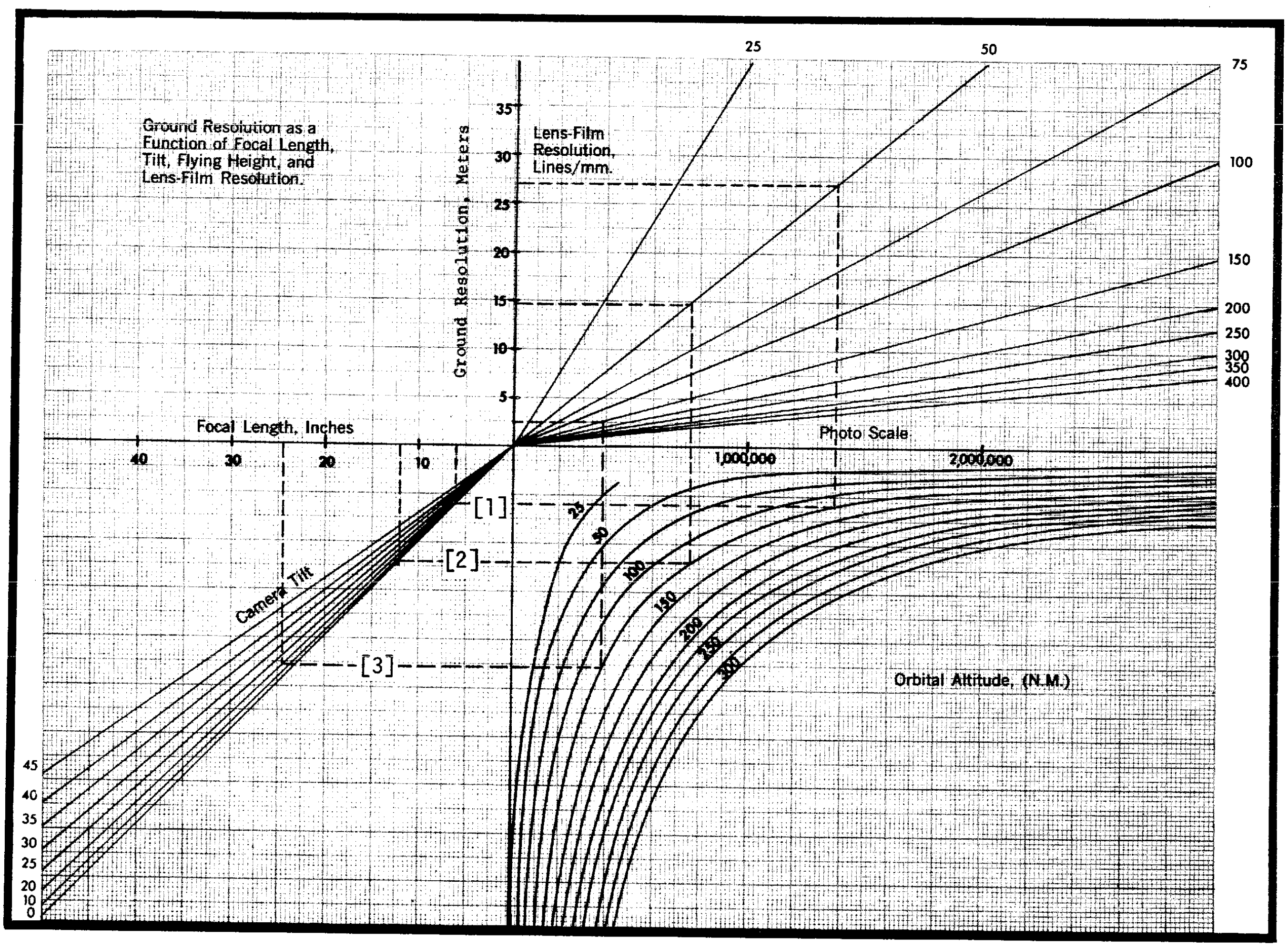

Figure 2 - Relation Between System Parameters

require cameras of extremely long focal lengths and unreasonable film formats. For this reason consideration is given to panoramic cameras which are capable of producing resolution between 100 and 200 lines per millimeter. Such cameras, however, have inherently poor geometric fidelity, and cannot satisfy the requirements for position and elevation accuracy. Line 3 on the chart shows that a 24 inch panoramic camera at 150 lines per millimeter could produce about 2 meters ground resolution - adequate for standard maps at scale 1:50,000, or, by relaxing the resolution criterion slightly, for maps at scale 1:25,000. Panoramic cameras require sophisticated and expensive photogrammetric instrumentation not generally available. For this reason an eventual operational system for producing or revising large scale maps may well go to longer focal length, narrow angle, frame cameras, which might attain 100 lines per millimeter and a corresponding ground resolution of 3.5 meters. The ground width covered by such a camera would necessarily be small. As a consequence the satellite would require a very long lifetime in order to be able to photograph any desired area with vertical pictures, or else the camera would have to take oblique pictures to the side of the ground track.

Geometric Map Accuracy

At an elementary level, the position and elevation accuracy obtainable by photogrammetric procedures is:

$$dP = \frac{H}{f}\,dx$$

and

$$dH = \frac{H}{f}\;\frac{H}{B}\,dx$$

where

dP = ground position accuracy

dH = ground elevation accuracy

H = flight altitude

B = distance between exposures making up a stereo pair

dx = accuracy of image measurement

Stereo base B is obtained by exposing the photographs at time intervals such that some part of the ground area covered by one photograph is also covered by a following photograph. With the 6 inch standard camera, consecutive photographs overlap by 60 percent and B = 0.6 H. In order to obtain adequate B with a 12 inch camera, a film format of 9 x 14.5 inches is proposed with a 9 inch dimension perpendicular to the flight direction. Consecutive photographs will overlap by 67 percent, and a stereo model will be composed of alternate photographs. This arrangement will provide an effective B = 0.8 H. Because 24 inch cameras have a narrow field of view, they cannot achieve adequate B by overlapping vertical photographs. Consequently two cameras will be required in a "twin convergent" configuration with one camera directed forward along the flight line and the other directed aft. If the angle off the vertical is 20° for each camera, the effective base in each stereo model will be B = 0.7 H.

The current level of accuracy in recovering the position of an image on a single photograph is approximately dx = 0.005 mm. This is representative of the relative accuracy which can be obtained in a single stereo model. However, as every photogrammetrist knows, a stereo model must be scaled, positioned, and levelled before geometric map data can be extracted from it. Conventionally this is done by reference to ground control, and errors accumulate alarmingly as one departs from the control.

In this regard, satellite photography will have an enormous advantage over aircraft photography. The satellite orbit is mathematically predictable, and if the time of each camera exposure is recorded precisely, the position of the camera can be accurately determined. Furthermore, as shown in Figure 3, a photograph of the star field can be made in synchronism with each terrain photograph, and measurement of the stellar photograph will provide the absolute angular orientation of the camera to a few seconds of arc. These data are equivalent to having ground control in every stereo

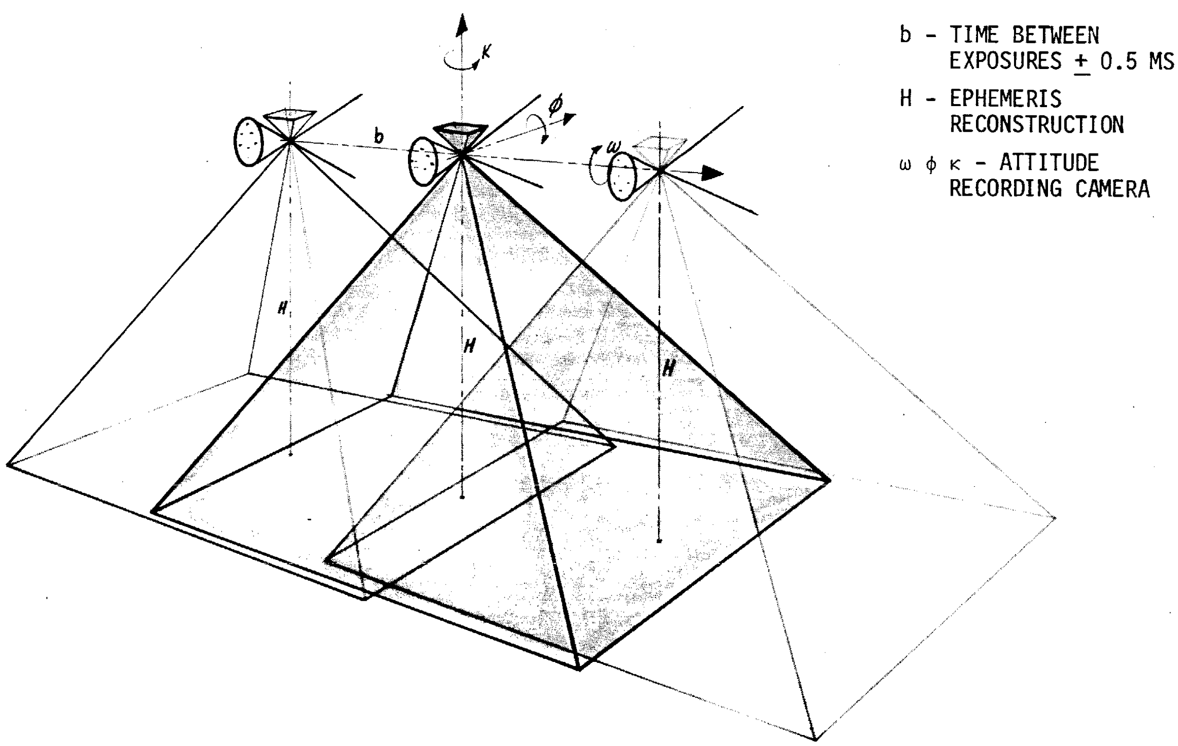

Figure 3 - Exterior Orientation of Satellite Photography

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model. The consequence is that errors will not accumulate to the same extent when the photographs are triangulated in a strip or block, and a value of dx = 0.020 mm is expected to be a reasonable estimate of the absolute accuracy with which image positions can be recovered.

If the appropriate values of H, f, B and dx are applied for the three camera systems under consideration, the values listed in the following table are obtained.

GEOMETRIC MAP ACCURACY OBTAINABLE

	6 inch camera	12 inch camera	24 inch camera
Altitude H (125 n.m.)	232 km.	232 km.	232 km.
Focal length f	152 mm.	305 mm.	610 mm.
Relative accuracy position dP	7.7 m	3.8 m	1.9 m
elevation dH	12.8 m	4.8 m	2.7 m
Absolute accuracy position dP	30.7 m	15.2 m	7.6 m
elevation dH	51.3 m	19.0 m	10.9 m

If these geometric numbers and the resolution numbers previously discussed are compared with the requirements for mapping at different scales, the capabilities of the three camera systems can be summarized.

CAMERA SYSTEM CAPABILITY

Relative Mapping	6 inch camera	12 inch camera	24 inch camera
Content for map scale	500,000	250,000	25,000 to 50,000
Position accuracy for map scale	25,000	25,000	10,000
Elevation accuracy for contour interval	50 m	15 m	10 m
Absolute Mapping			
Content for map sclae	500,000	250,000	25,000 to 50,000
Position accuracy for map scale	100,000	50,000	- - -
Elevation accuracy for contour interval	200 m	50 m	- - -

The 6 inch system could satisfy the requirement for world wide small scale 1:1,000,000 and 1:500,000 mapping. The much more serious problem of medium scale 1:250,000 mapping could be satisfied by the 12 inch camera system which also has the important capability of providing adequate geometric control for the preparation of large scale 1:50,000 and 1:25,000 maps. The content for these large scale maps could be provided by the 24 inch camera systems. Thus an ideal system would be composed of both the 12 inch and 24 inch cameras. This would largely satisfy all current requirements for mapping at scales smaller than those needed for actual engineering construction.

What Are The Prospects

A year ago, the Department of the Interior announced its project EROS - for Earth Resources Observational Satellite. Although a number of proposals are under consideration, the most promising seems to be a camera system designed and built by RCA Astroelectronics Division. The camera is the ultra sophisticated child of the highly successful camera used in the now operational TIROS TV weather satellite system. The characteristics of the TIROS and the new vidicon are as follows:

COMPARISON OF TIROS AND EROS VIDICONS

	TIROS	EROS
Tube diameter	1/2 inch	2 inch
Picture area	1/4 inch square	1 inch square
Resolution	400 lines	8000 lines
Resolution elements	160,000	64,000,000
Sensitivity	0.4 ft. candle sec.	0.01 ft. candle sec.

In order to meet the requirements of a large number of scientists in the fields of agriculture, forestry, geology, geography, hydrology, and other natural resource disciplines, it is proposed to use three cameras to acquire photography in three different spectral bands.

These bands are selected to provide:

(a) The sharpest demarcation between land and water areas,
(b) The maximum discrimination of vegetation types,
(c) The greatest penetration of water.

Each frame of the proposed pictures will cover an area of 96 x 96 nautical miles and will provide a ground resolution of 100 to 200 feet from a circular orbit at 300 nautical miles. The orbit inclination will be 97° sun synchronous so that the illumination conditions will be identical for adjacent orbital passes. The satellite will weigh about 850 pounds, and can be launched by a Thor Delta from the Western Test Range. Solar cells and batteries will provide power for the cameras and for a 4 megacycle communication bandwidth required to transmit the pictures to ground stations. A video tape recorder will store the pictures until the satellite is within range of a ground receiving station. A lifetime of at least one year is planned so that repeated coverage can be obtained to determine the time variant characteristics of areas of special interest.

NASA's Lunar Orbiter program has clearly demonstrated the ability to acquire and transmit extremely high resolution photographs from space. However, photogrammetrists have learned to be suspicious of the geometric integrity of transmitted and reconstructed pictures. This fact and the lack of adequate stereo overlap makes the use of EROS photography for geometric mapping marginal.

In the Apollo program, it will be necessary to perform a number of Earth orbit missions to check out various parts of the system and procedures. NASA is studying the possibility of using one of these missions to carry a number of Earth sensing experiments. Among these would be a 6 inch focal length, 9 x 9 inch format, cartographic camera with a coupled stellar camera.

A study has been performed by Martin-Marietta Corporation to define the integration of this experiment with the other sensors and the spacecraft. They have proposed a new equipment carrier module which would replace the Lunar Module. It will consist of a welded aluminum truncated cone enclosure 84 inches in diameter at the experiment mounting end and 110 inches long overall. A truss, which will support the cone in the spacecraft adapter, will also serve to support all experiments not requiring in-flight access or pressurization. The cone itself will be pressurized and the camera system will be among the experiments in the pressurized section. The astronaut will have access to the experiment section through the air lock for such functions as changing the film magazines.

In operation the command and service module with the equipment carrier module will have its longitudinal axis normal to the Earth's surface and the cartographic camera will look down through the base of the cone. This configuration will provide the astronauts maximum terrain visibility through the Command Module windows.

The proposed parameters for the Apollo mission are:

APOLLO MISSION PARAMETERS

- Cartographic camera

  6 inch focal length, 9 x 9 inch format
- Orbit

  140 n.m. circular, 50° inclination
  (provides complete U. S. coverage)

- Lifetime

  14 days
  (provides 2 looks at every point)

- Film load

  900 frames each covering 210 x 210 n.m.
  (limited by stowage in CM for return to Earth)

- Total coverage

  13 million square miles

- Proposed launch date

  Spring 1969

Manned missions are extremely costly to fly, and they are restricted in the amount of photographic film and other data which can be physically returned to Earth. For these reasons, NASA is also considering unmanned photographic missions, and a study has been performed by Lockheed Missiles and Space Company to define the characteristics of such a system.

NASA envisions a spacecraft, illustrated by Figure 4, carrying three 6 inch focal length, 9 x 9 inch format, cartographic cameras. The use of three cameras will provide the multi-spectral capability for resource evaluation in addition to cartography.

The exposed film would be returned to Earth in a data recovery capsule. This part of the system has been developed and proved by General Electric Re-entry Systems Division for use in several Air Force experimental programs.

The general procedure is to mount the experiment instrumentation (cameras in this case) in the spacecraft and to feed the data (exposed film) to the attached re-entry vehicle. When the data acquisition mission is completed, the recovery vehicle is separated from the spacecraft and re-enters the atmosphere. A parachute is deployed and the data package is snatched by aircraft. The spacecraft itself is then deboosted and splashes into the ocean. The recovery technology is clearly available. It remains

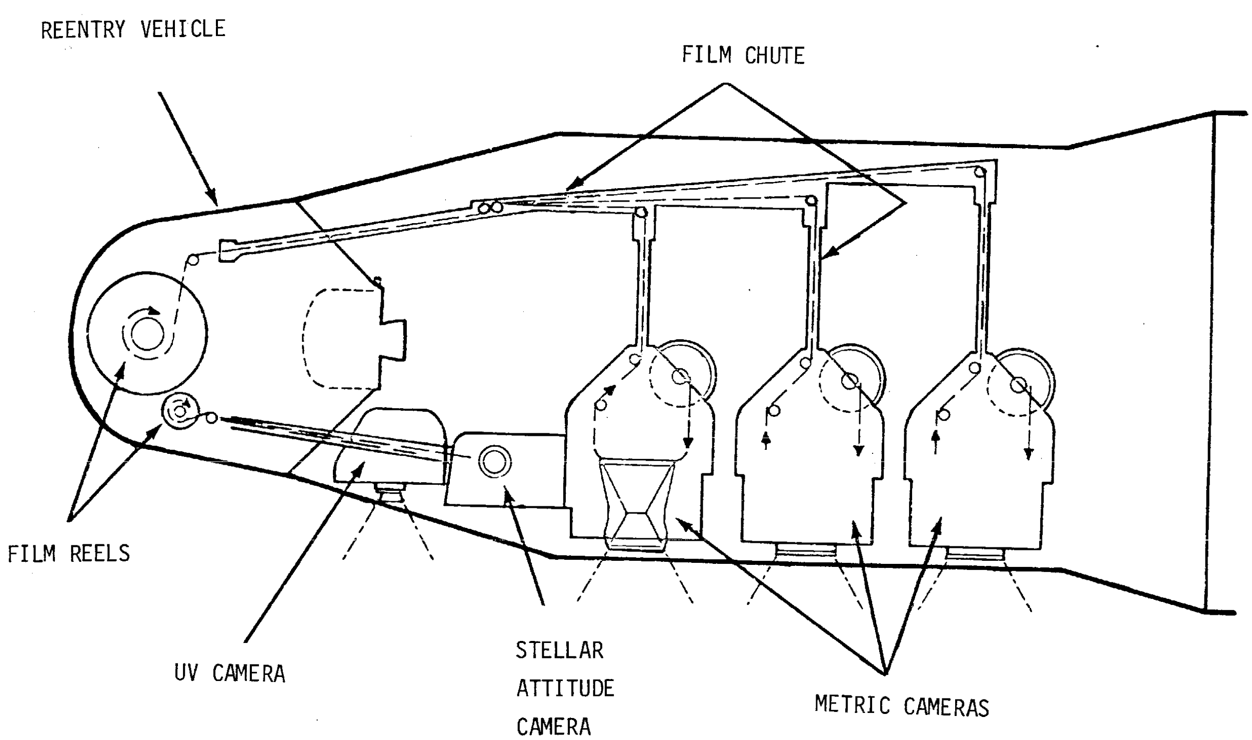

Figure 4 - Schematic for Film Recovery Satellite

to adapt the re-entry vehicle to the handling of photographic film. It is estimated that between 100 and 200 lbs. of exposed film could be returned from a single mission. With the vehicle in a sun synchronous polar orbit, with a lifetime of 3 weeks, a single camera could photograph nearly 30 million square miles. If the film load were divided among three cameras, the system could cover the entire United States in several spectral bands with a high probability of getting successful coverage.

<u>What Are the Chances of Success</u>

When a spacecraft is in orbit, its lifetime is necessarily limited. Since all costs have been accrued when the lifetime is terminated, the success depends entirely upon whether the mission objective has been accomplished during the lifetime. For a photographic mission, this is critically dependent upon the weather--or more specifically on the percentage of cloud free area during the daylight hours. Many studies of world wide cloud distribution have been performed, and the results of a number of them may be summarized as follows:

(1) With one look, a satellite will probably photograph 50 percent of the desired area. A second look will probably get 50 percent of the remainder; a third look 50 percent of what is left. This series would require an infinite number of looks to get 100 percent coverage. On the other hand, 4 looks would give 94 percent coverage and 5 would give 97 percent.

(2) To acquire photography at least 84 percent cloud free over the United States, a satellite launched in September would require 2 looks for the total southwest and a major portion of the midwestern and eastern sections; 3 looks would get most of the northwest but would still lose a section through Texas, Missouri, and the Dakotas.

(3) The probability of successfully photographing an area as

Percent of sunshine	Probability of success 2 looks	4 looks
Over 90	0.99	0.99
80 - 90	0.95	0.99
70 - 80	0.90	0.99
60 - 70	0.82	0.96
50 - 60	0.75	0.93

(4) The percentage of coverage with an 0.9 probability of 1 or more cloud free passes is:

	2 looks	4 looks
U. S. - summer	84%	98.5%
U. S. - winter	20	77.5
World - all year	17	65

As a generalized conclusion, these studies seem to converge on the fact that a system providing 4 looks at the areas of interest is approaching the point of diminishing returns. With a 4 week lifetime for the spacecraft, the 12 inch camera would get 2 looks, and the 24 inch camera 1 to 4 looks depending upon the configuration selected. One or two satellites would probably achieve adequate coverage of all areas which are not perenially cloud covered. To hope to photograph such areas from a satellite is probably not realistic.

Is It Economically Feasible

Presume that an unmanned satellite is launched carrying both the 12 inch and 24 inch camera systems, and that a 200 lb. film load is distributed so that both cameras would be able to photograph the same total area. Using thin base black and white film and the orbital altitude of 1[illegible] 9×10^6

Compared to these costs, conventional aircraft photography in the U. S. costs the U. S. Geological Survey between \$2.50 and \$4.00 per square mile on contract basis. Foreign photography, based on 650,000 square miles in South America, costs the U. S. Air Force about \$12 per square mile for single coverage. Thus purely on the basis of cost per square mile, space photography, particularly of remote areas, is clearly more economical.

The problem with these figures is that 1000 square miles from a satellite would cost the same $\$15 \times 10^6$ as the 9×10^6 square miles. Looking at the problem in this way, and using \$4 per square mile as the cost of airplane photography, the breakeven point would occur at 3.75×10^6 square miles. That is, if more than 3.75×10^6 square miles of photography are required the satellite is the economic way to get it.

The fact of the matter is, however, that the total map producing capability of the United States could not turn out 3.75×10^6 square miles of conventional mapping in a year. However, the basic reason for this is found in the number of photographs involved.

Figure 5 shows the coverage produced by conventional aircraft photography compared to that which would be given by the 12 inch frame and 24 inch panoramic cameras. Also shown is the area of a standard 1:250,000 scale map sheet.

To photograph the 3×10^6 square miles in the United States, a standard 6 inch mapping camera flown at 30,000 feet would require a minimum of 100,000 stereo pairs. The proposed 12 inch camera system flown in a satellite would cover the same area in about 500 stereo models. To process 100,000 stereo models is unreasonable, whereas 500 is clearly within the capability of most agencies.

In addition to the simple processing of 100,000 stereo models, mapping by conventional photogrammetric procedures would require several

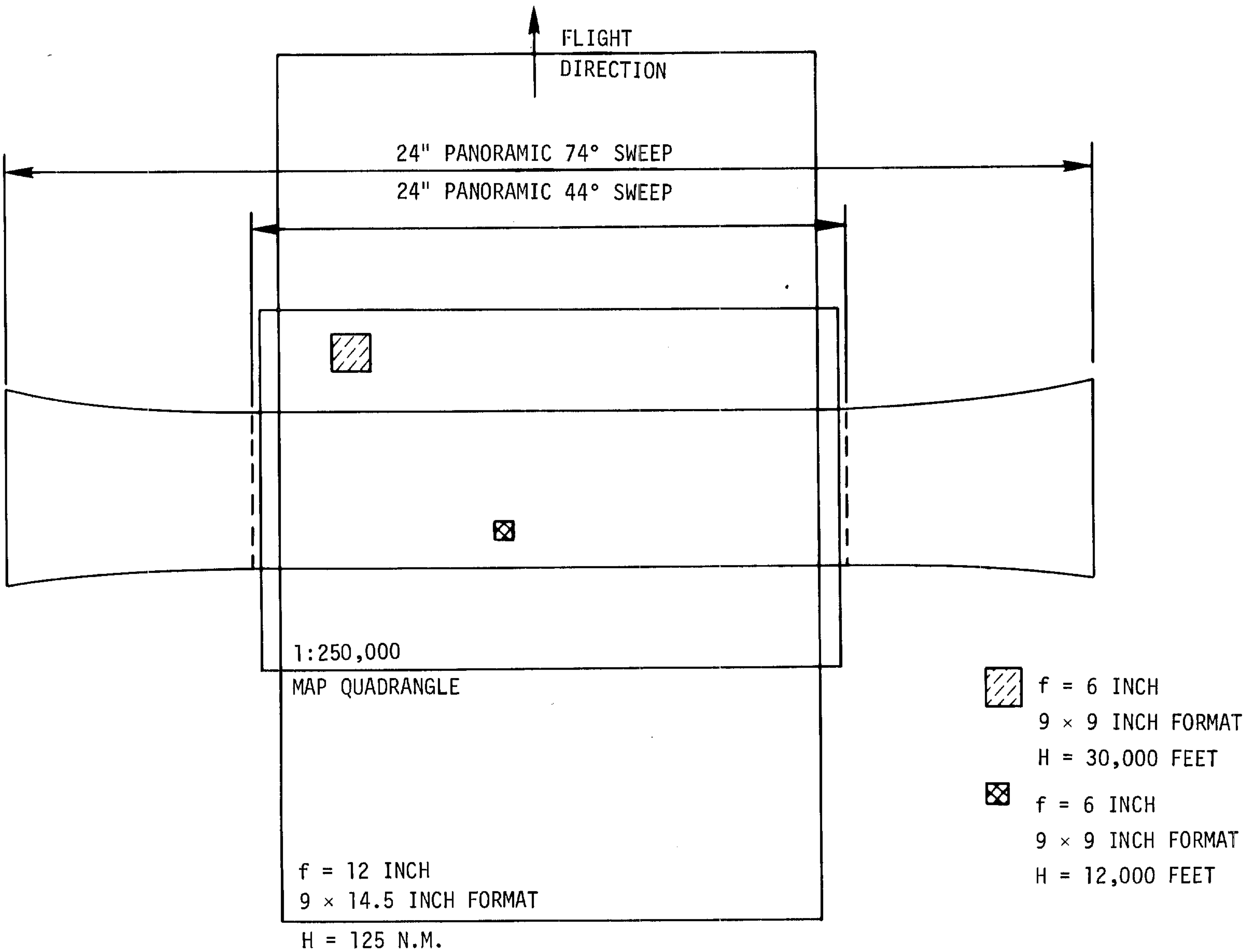

Figure 5 Comparison of Coverage Obtained From Aircraft and Satellites

the control points for the space photography could be established by triangulation of the photographs themselves. This is not possible with the conventional photography because the errors in the triangulation accumulate with the square of the number of photographs involved. This is basically what makes it possible to predict that space photography will be able to do the job at all.

The remaining question is whether the 500 stereo pairs will do the same mapping job as the 100,000. This is the great imponderable, because there is no experience in mapping from space photography. The figures indicate that the proposed systems will probably do the job, if other parts of the mapping system are given the same attention as the spacecraft and its cameras.

The final fact is that with space photography, useful products can be made which are totally impossible from conventional aerial photography. These include:

a) A synoptic mosaic of continental areas at scale of 1:1,000,000 or 1:500,000 which is obtainable from the 6 inch photography.

b) Photogrammetric control for maps at scale 1:24,000 anywhere in the world. This is obtainable from the proposed 12 inch photography.

c) Compiled maps at scale 1:250,000 anywhere in the world. This is also obtainable from the proposed 12 inch photography.

d) Large scale, rapid response, mosaics and revised maps for any selected area in the world. These are obtainable from the proposed 24 inch photographs.

No economic analysis of space cartography would be complete without consideration of the data processing part of the map production routine. Only about one third of the current processing involves the photographs. A cartographic satellite does not improve the remaining two thirds. But it drastically alters the inputs, both in type and in quantity. The formats and focal lengths of space photography may be, to a large extent, incompatible with the current data reduction instrumentation. Clearly, if satellite photography is to be useful on a production basis, detailed consideration and planning is required throughout the whole course of the map making cycle. This extends as far as a re-education of map users who may find it necessary to revise their notions of what is an acceptable map.

Conclusion

We see before us both an opportunity and a challenge. We have the prospect of obtaining a knowledge of the Earth's surface and its resources in detail which we could not have imagined ten years ago. Our generation may be in the position to complete the world mapping task which was started 5000 years ago when the Babylonians first put stylus to clay to guide a caravan across the desert.

18 January 1968

MEMORANDUM FOR: [redacted] 25X1

SUBJECT: Meeting of the Subcommittee on Geography of the Committee on Space Programs Advisory to The U.S. Geological Survey

1. The Committee on Space Programs for Earth Observations, Advisory to the U.S. Geological Survey, of the Earth Sciences Division of the National Research Council - National Academy of Sciences/National Academy of Engineering (what a title!) has a Subcommittee on Geography as well as other subcommittees covering fields of interest to the Department of Interior. (Attached is a copy of a statement issued by the main Committee in August 1967.) Funding has been by NASA, and a line item on the program for $400,000 is carried in the Interior's budget for FY '69. The money is used now for support of university and private industry contracts and National Academy of Sciences support.

2. In NASA, the space applications program is under Dr. Newell (about 2% of NASA's budget or $100,000,000 in FY '68.) There is hope for more in FY '69. An increasing amount of this space applications money can be expected to go into the earth resources program. Problems of the Earth Resources Disciplines (SAR) are under Bob Porter (who has been with NASA for only a month or two). The Earth Resources Flight Programs (SAB) are under Mr. George and have to do with hardware, instrumentation teams, etc. Bob Porter is the man most closely associated with the group with which I met. He has had a lot of help and advice from General Smart and from General Cabell.

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3. The Committee convened at 0930 on 15 January 1968 and spent most of the day in reviewing contract proposals and procedural matters. I arrived in the late afternoon and took part, with a very few other guests, including Paul A. Adams of the AF Science Advisory Board and a Rand consultant, in discussion of a forecast for the geographic applications program over the next few years. The next day was devoted to a resume of NASA's interest in the work of the Subcommittee, presented by Bob Porter, and to various problems and prospects of how geographic approaches and training could contribute to the earth resources program. The meeting broke up at 1530 on 16 January 1968.

4. The discussions, when I was first present, revolved around the thought that the geographic approach could best be directed toward the inventory, over time, of enviromental changes through the effective use of appropriate remote sensors. The objectives of the geographic applications program were to improve the future use of the land, monitoring change, and to predict changes that might effect the use of the earth's resources. There was much talk about land use analysis and metropolitan studies. I ventured to say that the categorizations to be developed should be responsive to the needs of planners and those involved in the management of our own and possibly other countries' resources. On the morning of 16 January, Bob Porter unknowingly backed me up by pointing out that the Bureau of the Budget would want evidence of how the group's objectives and goals would be of help to individual agencies of the U.S. Government and to national goals generally.

5. Bob Porter pointed out that the EROS/ERS program must have goals that can be expressed in dollars and cents. What are the areas to concentrate on in terms of cost effectiveness? He personally felt that there was considerable support for a ERS program that could predict useful, practical results.

6. Although it was recognized that many domestic tasks could make excellent use of the experimentation with remote sensors

now undertaken from aircraft platforms, the purpose of the Subcommittee's meeting was to discuss remote sensoring and its potential from orbiting satellites. Typically, one member said that geographic applications should be interested in inventory of natural and human resources: What is where; dynamically what will be where in the near future; and why? In my own mind the Subcommittee must express these thoughts in terms of practical problem-solving.

7. Roughly $1 million has been funded and encumbered through January 15, 1968, for studies in this field. The Bureau of the Budget will want to know how effectively this has been allocated and is being used. The group did not feel that any excuses were necessary--since the field of investigation is new and much thinking and experimentation with specific sensors, in simulated fashion, have taken place.

8. It was decided that analyses of land use and metropolitan problems are the major tasks, that the mapping of pertinent data from available photography is a means of portrayal, and that training and education in the use of sensor data and their potential and, more importantly, the manner of building meaningful and widely useful data banks were essential to getting the job under way and oriented toward future uses as the state of the art advances.

9. Mr. Bickmore, from Britain, described the experimentation in high speed and accurate digital information input for computers programmed for cartographic purposes. We, of course, are aware of much of this type of activity. His work is being funded at Oxford's Cartographic Laboratory by Britain's Natural Environment Research Council. Mr. Bickmore's remarks started a discussion in the field of data banks of information on earth resources that might be obtained through the geographic applications program. The

many remarks drifted into the potentials and possible difficulties of unrestrained international cooperation, with the U.S. in large part serving the smaller nations with computer read-out on request. Some diplomatic problems were recognized. One member felt that hot infra-red sensors in orbit could, with proper analysis, provide a better measure of the GNPs of individual countries than could all the statistical work of economists! He did not address himself to the hardware problem involved to obtain such data from orbit. So went the discussion - some of it very interesting and fruitful, and some which seemed to me to be quite impractical within the foreseeable future.

10. Prior to the next meeting, which will be on 25-26 April 1968 several reports will be prepared, one in particular addressing itself to the potentials for inventorying earth resources with earth orbiting cameras providing 100 foot resolutions with and without TV transmission. There will probably be similar approaches with respect to other types of sensors to determine minimum resolutions required.

11. The participants were seriously involved, and I am glad to have had the opportunity to have been an observer.

25X1

NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING

2101 CONSTITUTION AVENUE WASHINGTON, D.C. 20418

COMMITTEE ON SPACE PROGRAMS
FOR EARTH OBSERVATIONS, ADVISORY
TO THE U.S. GEOLOGICAL SURVEY
OF THE DIVISION OF EARTH SCIENCES

DEVELOPMENT OF OPERATIONAL SATELLITE SYSTEMS

The Committee believes that the mission of the U. S. Geological Survey requires the immediate development and programming of small, automated satellites which are currently within the state-of-the-art. Two classes of satellites are deemed necessary:

a. A long life satellite with advanced TV cameras providing repetitive observation of the earth's surface, for the purpose of assessing earth resources.

b. A short life satellite providing one time observation of the earth's surface with a physical film recovery system, for the purpose of control extension and map compilation.

To satisfy the first objective, the Committee strongly recommends that the USGS, in collaboration with other interested agencies of government such as the Department of Agriculture, urge upon NASA the selection and development at once of a program necessary to effect the flight by 1970 of a satellite having the characteristics for a first system described in the published Earth Resources Observation Satellite (EROS) specifications of the Department of Interior and the initial ERS specifications of NASA.

The Committee, having studied the applications and benefits of such a system, affirms that initially it should have a minimum life of one year so that changes in terrain conditions can be assessed throughout the seasons. Resolution of the advanced TV cameras should be between 100 and 200 feet in order to provide necessary discrimination of significant features without exceeding reasonable data transmission rates.

The spectral resolutions for the imaging systems calling for three wave lengths in the visible and solar infra-red spectrum as described in USGS and Department of Agriculture memoranda are compatible for plotting purposes and will accomplish observation of (1) the surface configuration; (2) the distribution of water; (3) the distribution and quality of vegetation; and (4) land use and population distribution.

Since 1970 is the year of the national census, it is considered particularly important that the satellite system be operational at that time when a maximum of "ground truth" will be available for correlation with the satellite imagery. Delays in making a decision on proceeding with one of the several technically sound proposals now before NASA will result in an unnecessary stretching out of the program and consequent loss of data vital for resource exploration and management.

With regard to the second objective, the Cartography Panel of the Committee has noted that the geometric integrity of photography is impaired by the process of transmitting and reconstruction specified in the EROS/ERS plan. Further, the higher ground resolution (better than about 20 feet) required for cartographic tasks requires a data transmission rate that cannot be economically attempted by presently envisaged TV systems. The Committee is aware that earth observation satellites using the film recovery technique can now be constructed and operated with a high probability of success.

The Committee recommends that the USGS and other agencies with a mapping responsibility collaborate with NASA and with industry in developing the specifications for a class of small (about 1,000 pound payload in orbit) automated film recovery satellites which will be complementary to the first generation EROS/ERS.

The Committee believes that cameras with focal lengths of 6, 12 and 24 inches are available or can be built. These configurations could yield ground resolutions from 125 n.m. altitude on the order of 30, 15 and 5 meters respectively.

The 6-inch system could be used for world-wide small scale mapping at 1:1,000,000 and 1:500,000. Maps of this scale are required as a basis for plotting the earth resource data obtained from the EROS/ERS TV satellite.

The Committee believes that greater attention should be directed to the 12-inch camera possibilities. This camera system could provide the data needed for medium scale maps of 1:250,000 scale and, at the same time, provide geometric control for the preparation of 1:50,000 and 1:25,000 large scale maps. The lack of such control is, in many parts of the U.S. and the world, the fundamental impediment to the compilation of large scale maps.

The 24-inch camera systems can provide the detailed content for the compilation of large scale maps.

In summary, the Committee believes that both long life, low resolution TV satellites for monitoring the earth's surface, and short life, high resolution film recovery satellites for precision mapping are required, and are technically and economically feasible. Both can be deployed by the small class booster (Thor Delta or Agena) at relatively modest cost and would provide data of inestimable value to the disciplines represented by this Committee. It is strongly recommended that NASA proceed with all necessary additional steps to assure a first flight of a prototype of each of these systems at the earliest possible date and by 1970 at latest.

8/11/67

2 January 1968

25X1 MEMORANDUM FOR: [redacted]

SUBJECT: Comments on Working Draft Entitled "Security Handling of Satellite Reconnaissance Material"

1. Ed Proctor's comments are on the attached buckslip
25X1 and copy of draft. [redacted] personally feels that subparagraphs 2b and 2c are useful in order to jog the Director's memory. /The flow of thought would, in fact, be smoother by omitting subparagraphs 2b and 2c and the reference in paragraph 3 to subparagraph 2a. As an alternative, subparagraphs 2b and 2c could be combined into a single 2b by omitting the present 2b, adding after publications in line 3 of present 2c "including permissive identification of source as 'satellite photography'", and replacing the rest of the sentence after 1960 in lines 5 and 6 by "to permit acknowledgement of the fact of a U.S. satellite photographic reconnaissance program at the SECRET level."/

2. In the absence of Art Lundahl, [redacted] 25X1
25X1 Hank Knoche, and [redacted] agreed that the draft was fine. They felt, however, that the paragraph 9 would probably strike the Director as obvious and could therefore be omitted.

3. I haven't been able to reach Carl Duckett. [redacted] 25X1
told his secretary that he knew nothing about the draft. [redacted] 25X1
25X1 [redacted] are both out today--the former for the rest of the week. The buckslip of 27 December to the DDS&T was for
25X1 [redacted] attention.

[redacted] 25X1

28 November 1967

25X1 MEMORANDUM FOR: [redacted]

SUBJECT: Display of Camera/Reproducer Systems for Spacecraft Applications

1. On 20 November I visited the [redacted] display of the equipment described in the attached materials. I was given a very interesting briefing and it appears that the developments could provide good real-time imagery readout for low-resolution purposes. The one problem that is bothering [redacted] in this system is storage of information between readouts to ground stations. 25X1 25X1

25X1 2. [redacted] has been developing this system on its own, without Government contract, in the hope that it will meet some of the requirements for EROS, the USGS reconnaissance satellite which is still expected to be flown--not in 1969 as originally planned but possibly by 1970.

3. Please return the material to my files after you,
25X1 [redacted], and any others interested, have noted them. I have sent
25X1 copies to [redacted] for his retention. He was very interested in receiving them.

[redacted] 25X1

NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING

2101 CONSTITUTION AVENUE WASHINGTON, D.C. 20418

COMMITTEE ON SPACE PROGRAMS
FOR EARTH OBSERVATIONS, ADVISORY
TO THE U.S. GEOLOGICAL SURVEY
OF THE DIVISION OF EARTH SCIENCES

MEMORANDUM

TO: Staff Officers of Divisions, Offices, and Committees

FROM: Edward Risley

Subject: Display of Camera/Reproducer Systems for Spacecraft Applications

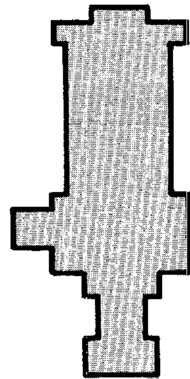
The Earth Sciences Division is showing a new high-resolution camera/reproducer system for spacecraft applications, on Monday and Tuesday, November 20 and 21, 1967 in room 702 of the Joseph Henry Building, 2100 Pennsylvania Avenue, N.W. It may be seen at any time on these dates between the hours of 9:00 a.m. and 4:00 p.m.

The sensor chain on display was developed by RCA to fulfill anticipated mission requirements for an Earth Resources Satellite in providing data on agriculture, geology, geography, oceanography, hydrology and other related fields. It uses a camera designed to scan a scene on earth 100 miles square from a height of 500 miles, sending back a picture with a ground resolution of 100 feet. The TV picture will have 6,000 lines, as compared to the 525 lines of the home TV image. The highest resolution yet used in space is about 800 lines.

The significant advance in TV cameras was made possible by a two-inch return beam vidicon tube developed by Dr. Otto H. Schade, of RCA's Electronic Components and Devices Division. A laser beam image reproducer converts the vidicon's signals into a picture by scanning conventional photographic film with a beam of laser light.

The system,now being evaluated by NASA and several other agencies of Government, was demonstrated for the first time on October 23, 1967 at the Fourth Annual Meeting of the American Institute of Aeronautics and Astronautics at Anaheim Calif.

RETURN-BEAM VIDICON CAMERA SYSTEM



MAJOR ADVANCE IN SPACE TV CAMERA SYSTEMS

The Model QTV-8 Return-Beam Vidicon Camera System, designed and developed by the Astro-Electronics Division of RCA, represents a major advance in satellite-borne TV-camera systems. A new, unique image sensor employed in the camera yields the highest image resolution and sensitivity ever achieved in a satellite television camera. This sensor, a 2-inch return-beam vidicon, operates on the principle of beam modulation, and incorporates an electrostatically focused electron multiplier to amplify the current of the modulated scanning beam. The high gain achieved by the multiplier results in a greatly improved signal-to-noise ratio for the entire system, and enables successful operation at lower levels of light excitation.

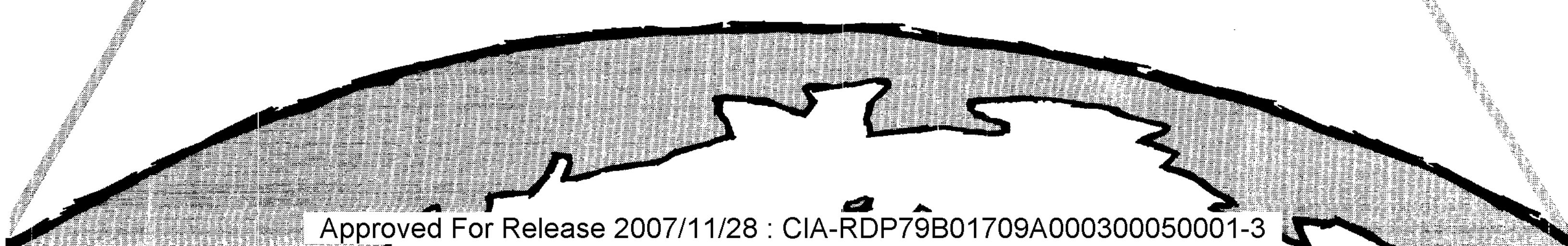
FIVE TIMES THE RESOLUTION CAPABILITY OF PRESENT VIDICON CAMERAS

The resolution capability of the system is 5000 TV lines — approximately five times the resolution of present vidicon cameras for satellite applications! Equipped with a 130-millimeter focal-length, f/2.8 lens and placed at a satellite altitude of 500 nautical miles, this system will provide coverage of a 100 x 100-nautical mile area at a ground resolution of approximately 100 feet per TV line.

ELECTRONICALLY TRIGGERED, VARIABLE-SPEED, FOCAL-PLANE SHUTTER

An electronically triggered, variable-speed, focal-plane shutter allows picture-taking over a wide range of scene brightness and provides uniform exposure of the vidicon. The camera system is a complete functional entity, requiring only 24-volt DC power from the spacecraft. The video output of the system may be fed directly to the modulator of the spacecraft communication system.

RCA SPACE CENTER • ASTRO-ELECTRONICS DIVISION



TECHNICAL SUMMARY

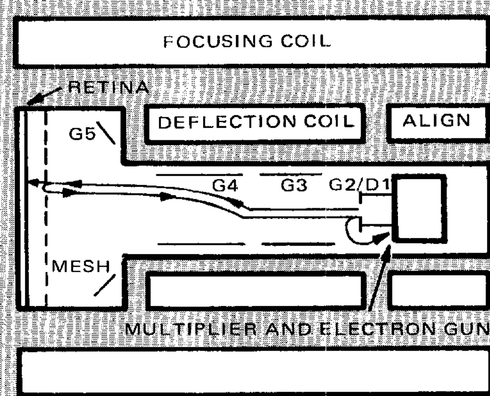
MODEL QTV-8 RETURN-BEAM VIDICON CAMERA SYSTEM

Sensor	2-inch return-beam vidicon
Deflection	Electromagnetic
Focus	Electromagnetic
Image Size (scanned area)	1 x 1 inch
Camera System Resolution	5000 TV lines (100 cycles per millimeter)
Power requirements	30 watts at 24 volts DC
Weight	30 pounds
Size	11 x 18 x 8 inches (includes Camera Head and Electronics Assembly)
Spectral Response	Visible and near-infra red

POTENTIAL APPLICATIONS

The Model QTV-8 Return-Beam Vidicon Camera System was designed originally for use on the Earth Resources program. However, the high-resolution capability and sensitivity of the system make it ideal for a variety of space missions, such as synchronous meteorological observations or reconnaissance from satellites. Placed at synchronous-satellite altitude, this system will provide simultaneous coverage of a 5000 x 5000-nautical-mile area at a ground resolution of approximately 1 nautical mile per TV line.

Among the possible modifications to the system are lens type, exposure times, scan time, and required bandwidth. Because of the space-proved designs used in the system, the QTV-8 can be used for new space camera programs with substantial savings in cost and development time.



Within each RCA camera system the individual circuits are packaged according to function; that is, individual circuits are replaceable as individual mechanical entities. (Typical packages are sensor, high-voltage power, video preamplifier, timing, etc.) Such circuit packages are made as small, as lightweight, and as rugged as possible and are individually subjected to environmental tests much more severe than those imposed on the overall system. Therefore, the user can conceive systems directly in terms of pre-engineered, pretested, compatible building-block components. (The modular concept is carried to its maximum extent within the present state of the art by RCA's use of integrated circuits, which enable complete electronic circuits to be packaged in a unit roughly the size and weight of a single low-power transistor.) During the overall design and fabrication effort, this modular construction technique reduces interface problems and therefore reduces integration time. The extreme ruggedness which is built and then tested into the individual assemblies provides a high confidence level even when selecting new configurations, and minimizes the necessity of rerunning environmental test sequences. Successful applications of RCA's television components and circuits have proven the soundness and versatility of the production versions. For further information contact: **Marketing Manager, Astro-Electronics Division, Defense Electronic Products, Radio Corporation of America.**

LASER-BEAM IMAGE REPRODUCER

HIGH QUALITY FILM COPIES OF VIDEO IMAGES NOW POSSIBLE

RCA's Laser-Beam Image Reproducer provides high-quality film copies of video images. It can be used to reproduce the picture output of ultra high-resolution television cameras and line-scanning systems in orbiting spacecraft.

The need for an instrument with the resolution-reproducing capabilities of the Laser-Beam Image Reproducer (75 percent response at 6000 TV lines) arose with development of a new television sensor for the Earth Resources Observation Satellite. RCA is introducing the Laser-Beam Image Reproducer as the first ground-based instrument to meet the resolution capability of any TV sensor or line-scanning system.

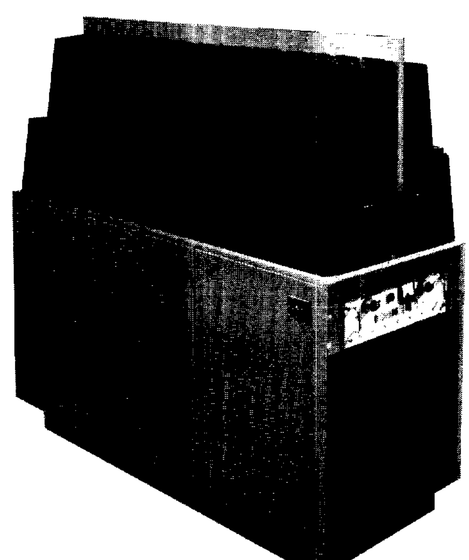
ENTIRELY NEW CONCEPT OF VIDEO REPRODUCTION

The Laser-Beam Image Reproducer (LBIR) consists of a laser, light modulator, beam-enlarging optics, imaging lens, a four-sided mirror fastened to the shaft of an air-bearing-type hysteresis synchronous motor, and a film-transport table. The reproducer, which uses a high-intensity, Helium-Neon gas laser, has the necessary small spot size and high writing rate needed to reproduce high-resolution, hard-copy pictures.

The laser beam is modulated by an incoming video signal and is then formed by optical components to provide a recording spot of high-energy intensity. The spot is deflected by a high-speed scanning mirror which produces the horizontal scan. Vertical scanning is accomplished by moving the film-transport table past the scanning beam. The scanner and film table motors are precisely locked to the video synchronizing signals for good geometric fidelity in the reproduced pictures.

The Laser-Beam Image Reproducer can be used with high-resolution TV sensors, such as the RCA Return-Beam Vidicon Camera or the RCA Dielectric Tape Camera and with high-resolution line-scanning systems, including those that observe the scene directly or those that scan an already exposed film (e.g., the Lunar Orbiter system).

A single-frame output of the LBIR corresponds to a full frame from the ultra high-resolution camera. Therefore, no mosaicking or piecing together of portions of an individual picture is necessary as is done presently in lower resolution reproducers. The lower resolution reproducers cannot display simultaneously the full frame and the maximum data resolution. The LBIR full-frame capability eliminates the following problems of mosaicking (1) interfering edge transitions, (2) photometric inconsistency, and (3) lack of registration due to display non-linearities, such as kinescope pincushioning. These features are especially important for reproducing large-area scenes from high-altitude satellite observations.



RCA SPACE CENTER
ASTRO-ELECTRONICS DIVISION

VERSATILITY

The LBIR becomes more versatile by the addition of varied operating rates, a roll-to-roll film-handling feature, and a "quick-look" facility. Fifty-foot film rolls (cassettes) with provision for automatic film advance on a frame-by-frame basis can be used. For a quick determination of system performance, the image can be reproduced directly on a "rapid-access" photographic paper and developed in 15 seconds with a rapid processor. If an archival film image is desired, photographic film can be exposed, developed, and processed in 1-1/2 minutes.

TECHNICAL SUMMARY

Image Format:
- 9 x 9-inch image

Image Quality:
- Resolution
  - 75% response at 6000 TV lines (15 optical line-pairs per millimeter on 9 x 9-inch image)
  - Limiting response beyond 15,000 TV lines
- Tone Reproduction
  - 13 $\sqrt{2}$ gray steps
- Density Uniformity
  - 2%
- Linearity
  - 0.5%

Recording Rate:
- Scanning
  - 1200 lines per second
- Frequency Response
  - 5 MHz within ± 0.5 db

Laser:
- 15 milliwatts CW
- Helium-Neon
- 6328 Å

Light Modulator:
- Ferroelectric crystals
- No piezoelectric effects
- 105 volts peak to peak for full modulation
- Contrast greater than 100 to 1

Signal Processing:
- AGC for laser output stabilization
- Automatic black-level control
- Keyed clamping
- Gamma correction

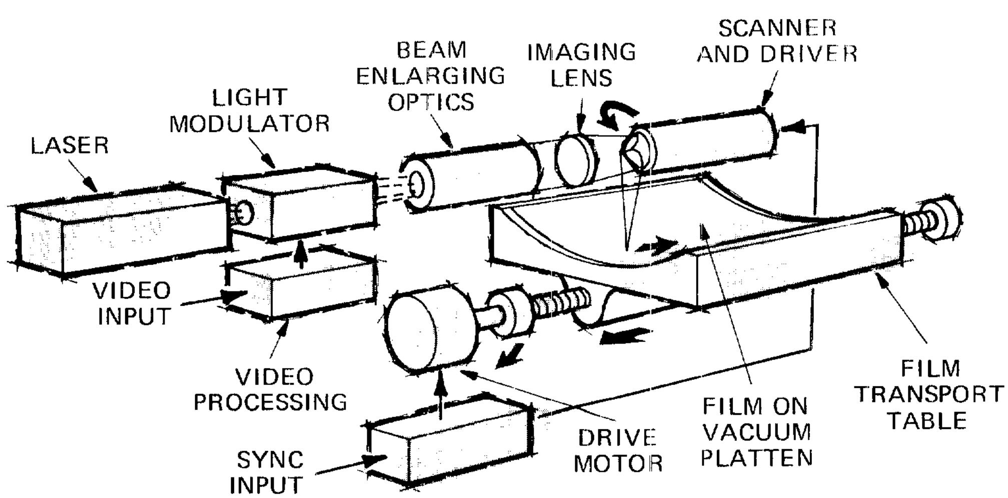
Optical System:
- Beam enlarger with spatial filters
- Laser imaging lens corrected to 1/10 wavelength

Input:
- 1 volt, black-to-white signal (a-c coupled)

Dimensions:
- 66 inches wide, 23 inches deep, and 54 inches high

Environment:
- Operates in a normally lighted room at ambient temperature of 65° to 90° F.

Power Requirements:
- 110 volts, 28 amperes, AC, single phase



From:
RCA Defense Electronic Products
Astro-Electronics Division
Princeton, New Jersey

Release: Wednesday, October 11, 1967

This print of the Salton Sea was reproduced by the RCA Two-Inch Return Beam Vidicon-Laser Beam Image Reproducer. The photograph was originally taken during the Gemini 5 flight.

Approved For Release 2007/11/28 : CIA-RDP79B01709A000300050001-3

28 November 1967

MEMORANDUM FOR: [redacted]

SUBJECT: Display of Camera/Reproducer Systems for Spacecraft Applications

1. On 20 November I visited the [redacted] display of the equipment described in the attached materials. I was given a very interesting briefing and it appears that the developments could provide good real-time imagery readout for low-resolution purposes. The one problem that is bothering [redacted] in this system is storage of information between readouts to ground stations.

2. [redacted] has been developing this system on its own, without Government contract, in the hope that it will meet some of the requirements for EROS, the USGS reconnaissance satellite which is still expected to be flown--not in 1969 as originally planned but possibly by 1970.

3. Please return the material to my files after you, [redacted] and any others interested, have noted them. I have sent copies to [redacted] for his retention. He was very interested in receiving them.

[redacted]

2 November 1967

25X1

MEMORANDUM FOR: [redacted]

SUBJECT: Potential Role of COMIREX in Programs for Peaceful Uses of Earth Orbiting Sensors

1. Under DCID 1/13, COMIREX shall advise, assist and generally act for the USIB on matters involving the coordinated development of intelligence guidance for imagery collection by overhead reconnaissance. Within this framework, it is expected to maintain cognizance and keep the USIB advised of the plans and capabilities of all Government agencies for the collection of imagery by overhead reconnaissance. It is expected to provide a focal point for the expeditious exchange of information in the interests of coordinated procurement programs.

2. To what extent should COMIREX monitor and/or coordinate civilian activities in planning and developing earth orbiting vehicles and sensors that approximate those that are being used or contemplated in the covert program? To what extent should COMIREX monitor the development of earth orbiting sensors, developed by civilian agencies, that might yield useful and timely intelligence information not obtained by covert reconnaissance sensors?

25X1

3. [redacted] feel strongly that the MC&G Working Group should be charged with tasking out responsibilities that might be placed on COMIREX in these fields and that the membership should be revised to include selected individuals from civilian agencies, such as Commerce and Interior. I personally tend toward establishment of a separate working group if COMIREX is to become involved in the problems described above. 25X1

4. I refer you to my memorandum on the ARGO Steering Committee meeting of 27 October 1967 which mentions that the formal presentation of the results of ARGO is scheduled for 11 January 1968. In view of many articles in professional and technical publications and minutes of advisory committees on earth orbiting applications programs, as well as the probable very favorable reactions of high officials to the findings of the ARGO Project, [redacted] and I both believe that pressure will increase to tidy up the activities on the overt and covert sides of earth sensoring by reconnaissance orbiting vehicles. If it is judged that COMIREX has a role to play, this role should be clearly defined as soon as possible. It would also be useful to have the mechanism established for carrying out necessary tasks and for those who might be involved in a coordinated group to be selected and engaged in identifying the more important problems that might arise.

25X1

25X1

5. [redacted] would like to meet with you and me and with whomever else you might desire to discuss the types of questions that are implicit in the above paragraphs.

6. To illustrate the status of the thinking of some people on the overt side I am providing a few excerpts as follows:

"Commercial Development of Space Urged," Aviation Week & Space Technology, May 15, 1967:

> It is expected that the Government will be the major market for spacecraft and systems for the next decade or more. There are many satellite programs being studied and many more are expected after the initial success with remote sensing from the weather satellites and the Gemini flights. The Interior and Agriculture Departments are planning data banks for the future, tailored to keep pace with population expansion and changes for the planning of resources. To provide these data satellites are planned in sufficient number to provide continuous surveillance of the free world's land and water masses with remote sensors, and ground systems to receive the data inputs, analyze, and store the pertinent information for ready use.

25X1

> With radically new approaches to the use of computer systems necessary for analyses, storage and retrieval, and the constant improvement in high resolution remote sensors, the applications of satellite surveys are being continuously increased and extended.

"Remote Sensing Techniques Considered Most Promising." Technology Week, June 5, 1967:

> Agriculture is participating as a junior partner in what promises to be the biggest remote sensing project in history, the Earth Resources Observation Satellite (EROS), along with the National Aeronautics and Space Administration, and the Depts. of Commerce, Interior, and Defense. Agriculture's role is concentrated in ground "signatures" and automatic data analysis (TW, Feb. 13, p. 34), but Secretary Orville Freeman forecasts a time when the Department will have its own satellite.

From: "New Horizons for Earth Studies from Space." A paper presented by Winston Sibert, U.S. Geological Survey, at the U.N. Cartographic Conference for Asia and the Far East, Canberra, Australia, March 8-23, 1967:

> The EROS program will be evolutionary, that is, the resolution of the data produced by the various sensors is expected to be improved as new technological advances are incorporated. Ground image resolution of about 100 to 200 feet is expected from the television camera system that will be used in the initial EROS flights. Through the evolutionary process, it is expected that in time direct-viewing instruments can be developed to provide ground resolution of 10 to 20 feet and that stable film-base material can be returned to earth for study and extraction of detail by various mensuration techniques. An intensive research program will be conducted to develop the ultimate remote-sensing system as now conceived.

25X1

1 August 1967

MEMORANDUM FOR: [redacted] 25X1

SUBJECT: Additional Note to that of 27 July 1967 re Woods Hole Conference

1. You will recall that I was to have lunch on Friday with Bill Fischer of the U.S. Geological Survey to question him on his views of progress at Woods Hole on the NAS/NRC study being undertaken there this summer at NASA's request. Bill was pessimistic regarding the possibility of pulling together a meaningful report on the discussions held there regarding Earth Resource Applications of Spacecraft.

2. He noted that the so-called sensor "experts" from each discipline were not coordinating their views, were not considering the incompatibility of the use of some of them in unison, not only in terms of not understanding problems relating to configuration and power difficulties, but even more in terms of a lack of appreciation of light conditions required for sensing different types of phenomena.

3. In mentioning the emphasis placed by the economic types on cost benefits to each discipline, Bill was concerned that no recognition was given to the great number of man years, not to mention equipment, that would be needed to exploit and analyze the data, particularly by those who want frequently repeated coverage.

4. Bill told me that the NASA boys, reflecting Mr. Webb's views, were strongly pushing for the manned craft. He added that the EROS, as a "white" unmanned satellite, is very much alive and apparently is grudgingly accepted--at least not unalterably opposed--by Mr. Webb's staff. Although initially there were strong views against EROS expressed by the top leaders who were really upset by the lack of coordination, many people involved in this general area of endeavor were glad to see that action was being initiated to go for an unmanned "white" earth viewing satellite. Several foreign nations want to cooperate where possible.

[redacted] 25X1

27 July 1967

MEMORANDUM FOR: 25X1

SUBJECT: Informal Note on Conversation with Participant at Woods Hole Conference

1. In conversation with Warren Nystrom, Executive Secretary of the Association of American Geographers, I was given some flavor of the meetings of the Earth Resources Application of Spacecraft Group of the series of study groups called by the NAS/NRC at Woods Hole at the instigation of NASA.

2. The Earth Resources group met for three weeks, mostly in early July 1967. Dr. Booth, a physicist, was appointed by NAS/NRC as over-all chairman of the Earth Resources Group. He turned out to be a very poor organizer, called three successive preliminary meetings to select men from the various disciplines as potential participants, then ended up by phoning others to determine his personal preferences. The programming at the Whitney Estate at Woods Hole was very poor although the surroundings were beautiful.

3. The Earth Resources Group was broken down into (1) Forestry, Agriculture, Geography, and Geology; (2) Cartography and Geodesy; (3) Hydrography; and (4) Meteorology. Soon after the first sub-groups met, it became evident that the geologists couldn't agree with the rest of their sub-group, so the geologists essentially formed a separate sub-group, leaving the others to be called the FAG sub-group (Forestry, Agriculture, and Geography).

4. Each sub-group had its own ideas of the types of sensors and vehicles needed, the number of orbits required per time period, the resolutions desired from photography, etc. NASA consultants seemed to be pushing for manned space platforms, while many of the participants felt non-manned vehicles would be adequate and more feasible in the nearer future. There was talk of television or electronic relay of data to earth stations.

5. Nearly each discipline had associated economists who estimated the costs of constructing and orbiting vehicles and the benefits in dollars per year that would be derived for each discipline from results obtained from various alternative collection systems. There was little real information for these cost-effectiveness approaches and great variations resulted.

6. Warren Nystrom showed considerable compassion for the third study group which later this summer will be engaged in drawing up a final report of over-all findings and recommendations. He thought the lack of coordination during the study sessions would make the final task extremely difficult. How useful the report will be is problematical.

7. I'll be seeing Bill Fischer of the USGS tomorrow. He went to Woods Hole as a consultant to the Earth Resources Group and can speak on a cleared basis.

[redacted] 25X1

SECRET

28 March 1967

25X1

MEMORANDUM FOR: [redacted]

The following points may be of interest with respect to paragraph 4 of the attached memo:

1. Environmental information portrayed at various scales is a recognized military requirement. The nature of the terrain and surface materials, the types and densities of vegetation, and the hydrology and soil moisture conditions are among the factors of interest particularly to the Army. More R&D in the study of color photography for analyzing and mapping the distribution of significant environmental data should be of great benefit to the military. Much can be done in varying color densities, etc., to assist in photo-interpretation. Also exposure parameters are important and controversial, particularly the sun angle.

2. The reference to compatible data reduction procedures brings to mind a report that the UNAMAC can be used to obtain orthophotos in color. Color separations can be made on plates and introduced individually into the UNAMAC for scanning. This means three runs for the three primary colors. The resultant color-separated films can then be processed to obtain the full color orthophotos.

[redacted] 25X1

25X1

[redacted]

SECRET

SECRET

28 March 1967

25X1

To: [redacted]
From:
Subject: Navy Memos re MCGWG Material

25X1

1. [redacted] called to say that a copy of the memo of 16 March 1967 to the Director, Defence Intelligence Agency (DIAMC) was sent to you for information and not for any action at this time in the interest of the MCGWG. You sent 26 copies out to all participants under cover of MCGWG-D-8.

2. A copy of another memorandum, dated 15 March 1967 and relating to geodetic data support of a program is also being sent to you for information only and not for any action on your part.

25X1

3. [redacted] wants to have the opportunity to coordinate such internal DoD questions prior to formal presentation to the MCGWG, since this is DIAMC's function. He stressed that he had no objection to your receipt of information copies of such memoranda but requests that no distribution action be taken for the reasons given.

Attachments:
1. 16 Mar memo
2. 15 Mar memo.

[redacted] 25X1

SECRET

17 March 1967

25X1

To: [redacted]
From:
Subject; Conversation with [redacted] today. 25X1

1. In accordance with your instructions, I discussed with [redacted] his progress on a report relating to the need of color satellite photography. In his draft minutes for the last meeting of the MCGWG, he indicated that [redacted] was charged with preparing the report. The draft report is practically finished and [redacted] has every intention to provide you with a draft copy by Wednesday, 22 March. He will also be distributing draft copies to representatives of the Army, Navy, and Air Force and would hope that comments could be received promptly so that the draft could be placed before the Working Group at an early date.

25X1 25X1 25X1

2. He indicated that the Air Force, and secondarily the Army, could not justify the use of regular color aerial film in obtaining mapping and charting coverage from satellite photography, chiefly because of the degradation of resolution associated with this type of film. The Navy feels that there might be very substantial benefits to hydrographic charting and oceanographic studies if such color satellite photography could be obtained. The report will also indicate that there is very considerable interest in "color from black and white process" as being developed by [redacted] If the film under development maintains its high black and white resolutions and only slightly degraded color resolutions, the military could be assured of the high resolutions necessary for mapping and charting and would also be able to meet many additional requirements by the analysis of the color images. 25X1

25X1

3. When [redacted] was asked to report aerial measurements in square nautical miles, he indicated an unwillingness to do so. He said that there would be no problem in converting square statute miles to square nautical miles but that having square nautical miles included in various formal papers distributed within the community could create great confusion in the working level and in the military shops. He, of course, recognizes that there may be good reasons for using "nautical miles" for measuring orbital heights and swath widths.

25X1 25X1

4. Although [redacted] now feels that the study being prepared under [redacted] direction should not in any way be tasked to staffs or working groups in the COMOR structure, he does feel that the MCGWG should be apprised of the fact that the study is under way and that it will very probably have some influence on policy in the mapping and charting field.

Orig - MCGWG file

8 February 1967

25X1 MEMORANDUM FOR: [redacted]

SUBJECT: Dr. Hornig's Proposal for Civilian Use of Satellite Photography

1. Attached are advanced copies I picked up in [redacted] 25X1
office of his summary of Dr. Hornig's proposal, of [redacted] memo to the 25X1
25X1 DCI, and of [redacted] draft of the DCI's response to Dr. Hornig.

25X1 2. [redacted] affirmed that Dr. Shapley of NASA had been
told by Dr. Steininger about Dr. Hornig's proposal and had bought
25X1 it. [redacted] was so informed, so I guess that the people we know in NASA
are fully aware of what's cooking. 25X1

[redacted]

TOP SECRET

[redacted]

25X1

Copy No. 4

8 February 1967

Summary of Dr. Hornig's Proposal of 26 January 1967

1. The proposal is for a feasibility study to find out what civilian uses can be made of aircraft and satellite photography.

2. A civilian team of no more than 15 men will be drawn from Interior, Agriculture, Commerce, AID and NASA.

3. This team will work in [redacted] cleared facility in Alexandria under sponsorship by GIMRADA (Geodesy Intelligence and Mapping Research and Development Agency of the US Army Corps of Engineers, Fort Belvoir). 25X1

4. GIMRADA sponsorship means that GIMRADA will be responsible for planning and coordinating various phases of the effort, maintaining proper security, arranging for briefings, procuring photography from NPIC and taking care of general housekeeping chores.

5. The team will use aircraft and satellite photography, except
25X1 [redacted] Only photography of non-Bloc areas will be used. All photography will be supplied through NPIC under rules to be laid down by CIA.

6. The team will be briefed by NPIC and DIA and will use the photography to produce a resource inventory of some area in Central or South America. Each agency's representatives will also develop plans for subsequent uses of photography by their respective agencies.

7. All products of this program will be classified as specified by the Director of Central Intelligence. Actual classification will be determined by the Office of Security working with NPIC.

8. The time allotted for the program is about six months.

9. At the end, the resource inventory will be used by the Bureau of the Budget and other authorities to decide whether to go ahead with a separate civilian photosatellite program or find ways to use satellite photography for civilian needs instead.

25X1 10. [redacted] believes that the NSAM 156 Committee should take part in this decision.

25X1 [redacted]

25X1 [redacted]

[redacted]

SECRET

[redacted] 25X1

Copy No. 4

The Honorable Donald F. Hornig
Special Assistant to the President
for Science and Technology
The White House

Dear Dr. Hornig:

I have studied your memorandum of 26 January and the Program Plan for a Study of Satellite Photography for Earth Resources Information. I am glad to support this pioneer effort and feel that it will prove useful in many ways. Please let me know if there are further needs from this Agency. In the meantime, I would like to hear of your progress from time to time and will be most interested in the final study and agency plans.

Sincerely,

Richard Helms
Director

25X1 DDI/CGS/[redacted](2/8/67)

Distribution:
#1 and #2 - DCI
#3 - DDI
#4 - Hornig File
#5 - CGS Chrono
#6 - [redacted] 25X1
#7 - Civ Use of Photo File [redacted] 25X1

TOP SECRET

[redacted]

[redacted] 25X1

Copy No. 4

8 February 1967

MEMORANDUM FOR: Director of Central Intelligence

THROUGH : Deputy Director for Intelligence

SUBJECT : Dr. Hornig's Proposal for Feasibility Study of Civilian Agency Use of Satellite Photography

REFERENCE : Dr. Hornig's Memo to Director of Central Intelligence and Secretary Vance dated 26 January 1967 (attached)

1. This memorandum gives you background on Dr. Hornig's proposal of 26 January. Attached are a summary of the proposal and a draft reply from you to Dr. Hornig. These papers have been coordinated within the Agency by [redacted] Mr. Duckett, [redacted] The proposal has also been agreed to by DIA and has been checked for general concurrence with Dr. Pecora of US Geological Survey of the Department of Interior, Mr. Gaud of AID and Dr. Shapley and Mr. Jaffee of NASA. I recommend you sign the reply. 25X1 25X1

2. On 7 November, Dr. Hornig sent you and Mr. Vance a preliminary proposal for a review of existing satellite photography by civilian agency teams to determine its usefulness for economic, social and natural resource surveys. He also proposed that this review be conducted under the sponsorship of the Army Corps of Engineers working in the cleared facility o[redacted] [redacted] in Alexandria. The civilian teams would study photography of an area in Central and South America, thus accomplishing an economic and resource evaluation while also supporting the objectives of the Frontiers of South America program--a project of Dr. W. Rostow's when he was in State to identify items for a Latin America Summit meeting. 25X1 25X1

3. Mr. Vance replied to Dr. Hornig on 7 December generally accepting the proposal in principle and specifically agreeing to the use of the [redacted] facility. [redacted] was chosen in the belief that CIA would not want NPIC to be diverted to this project. You replied on 13 December also agreeing in principle but raising your concern that proper security be applied to the project. You offered the support of NPIC, at least in the initial stages, to work with the Army Engineers and [redacted] 25X1 25X1 25X1

[redacted]

[redacted]

[redacted] 25X1

4. This proposal is the result of conversations among Dr. Steininger of Dr. Hornig's office, [redacted] of DIA and myself for CIA. I believe your expressed concerns over the security aspects of the feasibility study and the possible diversion of considerable NPIC resources have been met by the provisions of the proposal. 25X1

[redacted] 25X1

Chief
DDI/Collection Guidance Staff

Attachments: a/s

25X1 DDI/CGS/[redacted]2/8/67)

Distribution:
#1 & #2 - DCI
#3 - DDI
#4 - Hornig File
#5 - CGS Chrono
25X1 #6 - [redacted]
#7 - [redacted]

25X1

[redacted]

[redacted] 25X1

Copy No. ~~10~~ 11

3 January 1967

MEMORANDUM FOR: Mr. Bross

SUBJECT : Report on Meeting with Dr. Donald Steininger, 29 December 1966

1. On 29 December I met with Dr. Donald Steininger and [redacted] of DIA to discuss a draft reply by Dr. Hornig to Mr. Helms' and Mr. Vance's responses of early December to Hornig's initial proposal for a civilian review of [redacted] material. Steininger's reply is an attempt to bridge the gap between our answer which sought to involve NPIC, at least in the initial stages, and the DIA-Vance answer which offered [redacted] and the Army Engineers. A text of the draft Hornig reply is attached. There follows below explanations and comments keyed by number to points in the draft text:

(1) General background: The initial purpose of the civilian review is to enable certain cleared people in Interior, Agriculture, Commerce, NASA and AID to examine [redacted] photography to determine whether or not this photography would be useful for the purposes of their respective organizations. They are to make a general case for the economical use of this photography for peaceful purposes. They are to prepare a report on their findings on the basis of which a decision will be made by the Government (NASA and BOB?) as to whether or not the US should develop a "white", overt photo-satellite program for civilian purposes. While it is generally agreed that NASA would have the responsibility for launching such satellites (in the role of NRO), there is wide difference of opinion as to who should exploit that photography (in the role of NPIC). NASA obviously wants it but many believe US Geological Survey and Interior (the Aeros Project) might be better suited, and still others feel the Engineers and AMS--who have considerable experience--should be the exploiters. In any case, decision on this point is down the road; the immediate problem is how to handle the civilian "feasibility" review.

25X1 [redacted]

25X1 [redacted]

(2) NPIC has indicated that it would be willing to provide facilities for about ten "civilian" reviewers for four to six weeks i[redacted] but would be unable to house or support any effort larger than that or for a longer period of time. For his part, [redacted] indicated that AMS was not at all anxious to house and support this pilot review but, like NPIC, would be willing to provide continuing liaison in supporting services as needed if the review were to be housed elsewhere. Thus we agree that the [redacted] facility would be a good compromise. [redacted] has [redacted] containing 6,000 square feet of space which has been approved by [redacted] for [redacted] and it develops that they have done a considerable amount of work there on the [redacted] We have agreed that first exposures, initial indoctrination and a broad "overview" of the undertaking could be carried out at NPIC and if necessary at AMS too, but that the bulk of the review would be conducted [redacted] 25X1 25X1 25X1 25X1 25X1 25X1 25X1 25X1

(3) This sentence touched off a long discussion of the role that [redacted] might play. Our three-man understanding at the end of it is that we should avoid letting the civilian agencies individually approach NPIC or DIA and request films. Therefore, an agreed single intermediary should be the contact for the civilian agencies and should in turn be the only identity to approach NPIC or DIA. It is not yet decided whether it should be [redacted] a ~~corporation~~ [Army (Engineer) element] now holding the contract with [redacted] for the AMS and serving as a mapping research laboratory for ~~AMS~~ OCE. Our discussion settled on the following chain of functions: 25X1 25X1 25X1

NPIC - controls release of all films and materials

[redacted] 25X1 as sponsor and day-by-day administrator and house-[redacted]per

[redacted] provides facility and physical needs

[redacted] Agric Commerce NASA (status in doubt)

In the light of the above, we have a choice of accepting as the interface contact point either [redacted] more appropriately [redacted] or more efficiently an NPIC designee. DIA and Steininger would prefer the NPIC designee, but I have reserved on this until we can find out how much would be involved. It is understood with [redacted] that requests on DIA for film and material would also channel through the agreed interface point. In any case, Steininger fully accepts the right and responsibility of NPIC and DIA to withhold whatever they must for whatever reasons. 25X1 25X1 25X1

TOP SECRET [redacted] 25X1

(4) I have reserved on [redacted] photography although I believe that given the kind of security controls we and DIA are free to exercise there would be little risk involved. The big problem of course is that once the civilian agencies discover what they can see [redacted] films they will exert great pressure for the inclusion of these materials in whatever study they make. 25X1 25X1

(5) I see no problem with this until the time comes to release the material. And then we will be confronted with all the doubts and arguments that have plagued the NSAM 156 deliberations. In any event, the responsibility at this point is ours and we could perhaps force the excision of whatever we see security problems with. Naturally, this will be difficult at best since it will effect some of their conclusions. Perhaps the answer lies in not letting them have [redacted] first place (see item 4 above). 25X1

(6) The concept of sponsor, Steininger admitted, was a bureaucratic convenience and the job description for the sponsor in this paragraph is quite arbitrary. The sponsor is intended as the interface between NPIC-DIA and the civilian agencies. While an NPIC designee could serve as the release point for materials (see 3 above), I do not believe NPIC would be interested in fulfilling other sponsor tasks. Accordingly, I would see the sponsor carrying out tasks a. and b. NPIC and DIA, and AMS too in some cases, should carry out c. although the sponsor might make the arrangements as in d. In any case, d. needs further definition. Again, it is up to us pretty much to choose between [redacted]or this role. The logic o[redacted]s present functions argue strongly for it to serve as sponsor. 25X1 25X1

(7) No problem here, and Art Lundahl has already offered a very extensive panorama of services to help this fledgeling effort get off the ground.

(8) It is a matter for further discussion how big an effort in terms of people NPIC and DIA will want to give over to us. In any event, it should be on a case-by-case rather than a day-to-day basis. At some point in this paragraph we should work in some language about the length of time we expect this initial civilian review to occupy.

this?

2. CIA and DIA will be asked by Hornig to advise the sponsor and civilian agencies on the form the report should take. Inasmuch as this is an effort to determine what overhead photography can do for a number of physical sciences, the three of us have generally agreed that the civilian team should attempt to come up with a resources inventory type of study for a single geographical area in Latin America--say Central America or Venezuela-Colombia. We have not talked much beyond this, but I will be seeking guidance from OBI, ORR and others on this point.

3. Sorry to be so wordy in this initial report, but for the sake of avoiding confusion in the future I feel that it is important that you all have a full understanding of these first talks. I will be canvassing you for your views in the near future. I must say that the whole undertaking contains the fullest potential for a fascinating bureaucratic hassle.

25X1

Chief
DDI/Collection Guidance Staff

Attachment

SECRET

[redacted] 25X1

DRAFT
DSS/eac
12-28-66

25X1 MEMORANDUM FOR [redacted]

I would like to thank you for your considered responses to my memorandum of 7 November proposing a mechanism by which the civilian agencies can review the usefulness of [redacted] for non-intelligence 25X1 purposes. Based on the comments you have made, I would now like to suggest a detailed set of guidelines which I believe will conform to your wishes and provide a framework within which we can approach the civil agencies.(1)

I propose that our guidelines cover the following points and in the manner indicated:

1. The designation of the organization and facility which will provide space, viewing and measuring equipment and technical services such as photo reproduction, drafting, report reproduction, etc. I believe that you both agree on the [redacted] facility for this purpose.(2) 25X1

2. The organizations to monitor and approve from a security standpoint the photography that the agency teams can review and the disposition of the resulting information. Since the agency teams, using [redacted] as their agent, will have to request the film from both CIA 25X1

and DOD depositories, I would propose that DIA and NPIC monitor all these requests and approve each on a case by case basis. (3) As a general rule, I hope we can agree now that these teams can review [redacted] photography of non-hostile areas; however, I assume that either NPIC or DIA would make whatever exceptions are appropriate as the situation arises. (4) In addition, I believe we should agree that all information, data and reports resulting from this evaluation shall be classified [redacted] (5) specifically released from that classification by the DCI.

25X1

3. The organization to act as a CIA-DOD sponsor for the agency teams. (6) I would envisage the sponsor assuming the following responsibilities:

a. Coordinating the team's administrative needs;

b. Arranging the details of financial reimbursement;

c. Organizing and acting as host for the initial indoctrination of the teams to the techniques of photo interpretation and for in-process seminars in which the teams can, on a fully classified basis, present their progress and results to interested people from the intelligence community, the civilian agencies and the Executive Offices.

d. Coordinating with NPIC and the DIA for their participation in the indoctrination and the seminars.

25X1

I propose that [redacted] who is the custodian of the [redacted] contract, be this sponsor.

4. The mechansim by which the experience and expertise of NPIC and DIA can be fully exploited in support of the evaluation. In addition to providing for NPIC and DIA participation in the indoctrination and seminars, I would like to see a continuous interaction between the agency teams and experts from the intelligence community.[7] To insure this, I suggest that both NPIC and DIA assign individuals from their organizations who are expert in each of the technical areas of interest to the agency teams to work with these teams on a day to day basis, providing advice and guidance in the formulation of the teams' evaluation plan and in the interpretation of the data.[8] Among the areas to be covered by this evaluation are geography, geology, hydrology, oceanography, agriculture and forestry.

If these proposals are agreeable to you, I will seek the participation of the civilian agencies on this basis.

25X1

[redacted]

2 February 1967

MEMORANDUM FOR: [redacted] 25X1

SUBJECT: Orthophotography as a Possible Method of Sanitization, and Some Comments on the UNIMACE

My exploration during the last few days has led up several by-ways of interest. Since you are going to ACIC next week, you should know, and may already, that the ACIC has a new AS-11-BC costing approximately $700,000 plus (I assume when and if ordered in some quanitity) which does about the same job as the UNIMACE, which costs about $1,000,000. Probably at DIA's request, the AMS is currently running a comparative evaluation test on the two in order to determine the pros and cons of each.

After some thought, I doubt that the application of orthophotographic techniques can be of much use in the sanitization of
25X1 [redacted] photography to the unclassified level. It's expensive and time-consuming. It would do a rather good job of concealing the height factor; but the really important point, in terms of AID use, is the diplomatic/political problem vis-a-vis foreign governments. The orthophotography may not be too degraded by the scanning lines for detailed examination by scientists, but without negotiated contracts with foreign governments for conventional mapping, the source of the orthophotography would be rather obvious.

So I suggest that downgrading of original frame (I must say the scale seems to favor this at an early date) and [redacted] photography 25X1
at some future date - say to SECRET or CONFIDENTIAL - would appear practical for non-denied areas. The use of the orthophotographic planimetric and associated contouring, produced for mapping purposes, should also be made available for the construction of controlled mosaics of selected areas for the use of scientists and AID resource inventory studies, with whatever security controls are deemed essential. The coverage for mapping purposes, however, will probably not correspond in area or time with the needs of AID and civilian scientists. So there would still be real problems of programming support to the civil agencies.

This is a layman's understanding of what goes on in evaluating, processing, and reducing data for use in making maps, and I am undoubtedly making some errors in the following description.

I shall not spend many words on the method of determining the geodetic control but the results appear as specific points on frame photography [redacted] 25X1

25X1 After the [redacted] photos have been very roughly evaluated for general quality, and amount and type of cloud cover (reportedly done for NPIC), an index layout of a portion of a run is constructed by matching points along the edges of adjacent selected photos. This product is a working reference index, giving a gross unadjusted mosaic from prints of the photos without alteration of scale.

The geodetic and associated points on the frame photos must
25X1 be transferred to [redacted] photos. This is done by a Veri-Scale Point Marking Instrument. The operator sits at a console, with a
25X1 [redacted] photo and a marked frame photo displayed in front of him. By manipulating controls, the operator brings the x-y position on the frame photo directly over the identical point on the [redacted] The 25X1
position is recorded on an IBM card to an accuracy of .1 mm. As many points as needed for each photo are thus established.

The resultant data are then introduced, with detailed data regarding the ephemeris positions at time of exposure, atitudes, and orientations of the exposure stations, into the Semi-Automatic Exposure Coordinate Reader, where, with the use of a photo-multiplier tube, the x-y position can be located to within 1 micron. Again there is an IBM card for each position. It is through this process that the mass of controlling data stored in the UNIMACE computers is obtained.

The UNIMACE is made up of computers, a console with an operator to monitor and aid the scanning if a problem arises, and four tables within which are the scanning mechanisms (the scanning light provided by a cathode ray tube active in two of the tables). As the scanning proceeds, the mechanisms move the glass plates which
25X1 measure 9" by 18" [redacted] segment occupies the middle of the plate) containing the image through the x, the y, and the z (vertical) axes on command of the computers. Two scanning tables contain what are essentially a stereo model. The results of the scanning are recorded on negative films in the other two tables. The films are then taken to the lab for developing. One film will have the orthophotographic, rectified, planimetric image constructed

[redacted] 25X1

constructed through the scanning process. The other will have the drop-line image of vertical change, similarly rectified so that it fits the planimetric image. Currently a draftsman must construct the contours from the drop-line image, but a new computerized method is being designed or is under construction which will permit contours to be scribed directly on plates.

The scanning segments on the x axis can vary from 250 microns to 1000 microns. 500 micron segments are normally used. The segments on the y axis are 250 microns. The resolution is about 40 lines/mm. Enlargement of the original allows better resolution still at 40 lines/mm. The planimetric image is thus made up of a mass of very small segments. These are clearly visible when the
25X1 [redacted] original scale photography is enlarged by 10 to 20 times.
25X1 For [redacted] material, it takes about two hours per model to finish the UNIMACE operation when x axis segments are 250 microns. For 9' x 9' frame images, it takes about 45 minutes. This is a big argument, in terms of time and cost, for good frame photography for the construction of the basic map, with [redacted] photography for 25X1
use in filling in the details. These large orthophotographic and contour segments are then fitted together with proper control in constructing the map sheet.

Another machine, the V 8 Stereomat, is older and smaller, but is being improved. It costs about $110,000. The same computerized data are needed for it, but it can only use 6" focal length material. Of course 3" material could be enlarged prior to input. I don't know the details regarding its scanning segments, but it takes 3 hours per 9" x 9" model to produce the results. At the moment it must be run twice to obtain the planimetric and the contours separately. A request for introduction of an improvement to have the drop-line run simultaneously is in the works. Quite a bit of work is done on this machine for the Air Force to determine best routes for flight to targets in Vietnam. The information for the x, y, and z is on tape and the computers can be programmed for any solution desired by the Air Force.

[redacted] 25X1

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 25X1

[redacted]

11 January 1967

25X1

MEMORANDUM FOR: [redacted]

SUBJECT: Problems Relating to the Feasibility of the Use of [redacted] Photography by Civilian Agencies 25X1 25X1

REFERENCES: [redacted]

1. The report of July 1966 of the NSAM 156 Committee on "Political and Security Aspects of non-Military Applications of Satellite Earth Sensing" contained a discussion of many possibilities for using [redacted] photography for civil purposes. In August 1966, reference a, the USIB approved COMOR's recommendation that NASA

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[redacted]

25X1

[redacted]

establish a panel representing those scientific and technical disciplines of interest to NASA in order to examine the potential [redacted] photography 25X1 in meeting its requirements and to make recommendations concerning the desirability of increased NASA participation in the [redacted] program. 25X1 To date no action appears to have been taken by NASA except for the selection and clearance of a number of appropriate scientists and technical personnel.

2. Dr. Hornig in reference b took action to get the ball rolling by proposing to the DCI and to Secretary Vance a method for providing cleared teams from several agencies including NASA and 25X1 AID to review the potential [redacted] photography for meeting the needs of U.S. civil mapping agencies (USGS, USC&GS, SCS, FS, etc.), NASA (with respect to its earth resources survey), and AID (with respect to surveys for developmental projects in its foreign aid program).

3. A feasibility review by cleared teams of scientists, technicians, economists, and geographers representing the interests of NASA, AID, and other civil agencies (as proposed by Dr. Hornig) could profit from technical and advisory support available from NPIC's expertise on photo interpretation in several disciplinary areas. Such a review, however, would be primarily oriented toward mapping and charting at various scales and toward determining the distribution of significant environmental and physical phenomena. This type of work has fallen broadly within the MC&G field and has been investigated 25X1 with the use [redacted] photography in a carefully controlled PI and analytic environment where collateral data were not used except in the evaluation phase as described in reference d. [redacted] 25X1 25X1 [redacted] conducted this work under Task 25 of a contract with the U.S. Army Engineers' GIMRADA. Task 25 included the construction and use for analytic purposes of mosaics covering all of Africa. The evaluation of the PI and analytical work indicated many inadequacies in using photography of such short focal length. It is quite clear in the evaluation [redacted] and, in some specific instances 25X1 25X1 [redacted] photography would greatly increase the utility of presently classified satellite photography for determining the patterns and descriptions of not only military environmental factors but also of many other phenomena of interest to NASA, AID, and other civil agencies. For the above reasons, I suggest that AMS primarily, and NPIC secondarily, should cooperate in the indoctrination and guidance of the teams conducting the review.

[redacted] 25X1

 25X1

[redacted]

4. Since NASA apparently did not pick up the ball in establishing a review panel as approved by USIB, I must concur in general with the agreements as reached between [redacted] 25X1 Dr. Steininger, and [redacted] 25X1 as set forth in reference c. However, I do feel that the interface contact point mentioned in this memorandum should be [redacted] 25X1 and that GIMRADA should function solely as the administrative and housekeeping link in the setup.

5. Many problems will arise in any operational phase that might be established subsequent to the review by the cleared teams operating within a structure still to be decided between Dr. Hornig, the DCI, and Secretary Vance:

a. An essential problem is of course that of classification of the photography, the extent to which clearances would have to be given, the manner in which the information on the photography could be used on an unclassified basis (partially already established in the Sanitization Manual) and the possibility of declassifying actual photos by orthophoto methods. This latter point raises questions of cost, time, and certain additional unresolved technical peculiarities of orthophotography based on satellite photography.

b. The majority of the interests of the scientists, economists, geographers, and those in other disciplines would require extensive analysis of the photographs themselves. Large cadres of interested professionals in these many disciplines would have to be 25X1 cleared to utilize [redacted] photography or the photography would have to be declassified, either directly or by some method of sanitization. The many interested men in these disciplines would not be satisfied with being given only the information derived from the photography, along lines analogous to selection of the information derived from [redacted] 25X1 photography that is included on an unclassified basis by the USGS as well as by military mapping services in medium and small scale map compilations.

c. In an operational stage of utilizing [redacted] 25X1 photography in the interests of a variety of disciplines and for the most part for presentation in map form, we run up against the need for specialized and

[redacted] 25X1

[redacted]

presently classified and expensive equipment to handle the photography. In December 1965 DIAMC reported in reference e on the findings of a working group which was asked to examine the feasibility, methods, and costs of having civil agencies [redacted] photography in their map compilations and map revisions. This group noted that the most efficient arrangement would be to establish a central secure facility with special equipment and other capabilities in the USGS. This facility would serve the requirements of other civil mapping agencies. It is my feeling that a photo interpretation and analytical facility to meet the requirements of various disciplines as noted in previous paragraphs could be associated with the USGS facility or be served by it. Such a facility would, of course, not meet the desire of all who are interested in obtaining satellite photography for earth resource studies. In other words, I do not feel that a quick decision should be made for [redacted] to become the site for an operational facility for the purposes described in previous paragraphs without careful consideration of the findings of the working group which prepared the report that was submitted to the Bureau of the Budget in December 1965.

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5. Somewhat along these lines, it is interesting to know that the Association of American Geographers is intending to establish a commission on remote sensing and that this commission will undoubtedly discuss and take actions to develop at least a summer institute to train younger professional geographers in utilizing data obtained from remote sensors which the Association expects to have available from EROS and APOLLO vehicles possibly as early as 1969 or certainly in the very early 1970s. It is my feeling that commissions will be established, if they have not already, within other disciplines and that similar training will be undertaken on an unclassified basis in those disciplines. In other words, we can look forward to a large number of especially trained professionals in a variety of disciplines to be impatiently awaiting satellite photography and data from other sensors.

[redacted] 25X1

14 November 1966

MEMORANDUM FOR: Chairman, Committee on Overhead Reconnaissance

SUBJECT: Briefing Note on the Potential Use of Remote Sensors for Studying and Recording Data on the Earth's Resources.

1. The following observations arise from my attendance at a two-day meeting (October 7 and 8, 1966) of the National Academy of Sciences - National Research Council (NAS/NRC) Committee Advisory to the U.S. Geological Survey's Geographic Applications Program. No classified information could be discussed and the following account is written in that vein.

2. From the intelligence community's point of view, the two most significant aspects of the NASA Earth Resources Surveys Program (NERSP) and the associated U.S. Geological Survey's Space Applications Programs, in my judgment, are:

a. The expressed intent to use high-resolution cameras and other advanced sensors to observe the earth from orbiting space vehicles within the time period of roughly 1969-1972 and onwards (resolutions greater than 20 meters are needed to fulfill some listed requirements); and

b. The expectation that the results of the orbital surveys of the earth will be made available to members of the United Nations. NASA's head of the NERSP is preparing a presentation to be given to the U.N. Committee of Space Research some time next year. (See memo from [redacted] OBI, of 2 November, 1966, forwarded to the DD/I, entitled

"The NASA National Earth Resource Program.")
Two Latin American countries have already indicated an interest in the potential of the programs as described at a Pan American Institute meeting in Mexico City this summer.

Not to be overlooked, however, are the immeasurable benefits from the results of such surveys and scientific findings to our own military interests, to the economic and cultural planning of industrialized nations, and to the orderly development of the emerging, less-developed nations. Rapid coverage of extensive areas (many of which have previously been relatively inaccessible and unmapped), would provide a new dimension in area planning and development -- which would be greatly benefited, incidentally, if up-to-date map bases of large to small scale were available for use in portraying the distribution of the results of the surveys.

3. The high degree of interest in remote sensors among scientists and planners from educational institutions, government departments, and industry was evidenced by the large attendance at a series of Symposia on Remote Sensing of the Environment at Ann Arbor and arranged by the Institute of Science and Technology at the University of Michigan. The first Symposium was held in February 1962; the second in October 1962; the third in October 1964; and the fourth in April 1966. During this same period, the NAS/NRC Committee on Remote Sensing of the Environment was formed and is now promising to become quite active. A separate NAS/NRC Advisory Committee to the U.S. Geological Survey on the Space Program for Earth Observation was also established and presently has three subcommittees under it. One is the Advisory Committee for Geography noted in paragraph 1 of the memorandum; another is for geology/hydrology; and a third for oceanography. A fourth is under consideration for cartography (mapping), although this may be included with the Committee for Geography. Another separate NAS/NRC Advisory Committee on Remote Sensing exists for agriculture.

4. A variety of studies proposed by men (most of whom, to the best of my knowledge, have little or no clearance for handling classified information) working in the above fields have been sponsored by the Department of Interior (William A. Fischer, who does have clearances, is Research Coordinator for the Earth Orbiter Program

for the U.S. Geological Survey), Agriculture, and the Navy, with funding provided by NASA's Office of Space Science and Applications (SAR) (see Tabs A and B). Proposals for additional feasibility studies are being actively sought. Many studies are under way, programmed, or under consideration. Test sites are chosen and so-called "ground truth" studies are undertaken at these sites. NASA normally provides the aircraft and sensors needed for responding to specified requirements formulated by the researchers (see Tabs C and D). A typical study is a proposal for a $45,000 project submitted by the Kansas University to determine the utility of radar and other remote imagery for thematic land use mapping. Under a contract with the University of California (Riverside/UCLA) test sites have been established in the Southern California/Salton Sea area for defining the scientific and economic benefits of remote sensing as a means for examing the resources of a region and for developing skilled scientists in using imagery and other data from the sensors. Another proposal from Northwestern University has been submitted for examining the potential of remote sensing from orbital spacecraft as a data source for urban and transportation analyses. Test sites suggested are Phoenix and Chicago.

5. The NASA funding for the Geographic Applications Program, conducted as part of the U.S. Geological Survey's program, was nearly $615,000 for the period from May 1966 to the end of January 1967. To date $276,000 have been obligated, of which $100,000 are for overhead, staff, travel, and committee expenditures. Funds can be carried over. The current contract with Northwestern University amounts to roughly $50,000 and that with the University of California, $64,000. Additional NASA funding is expected as the program advances. I do not have data on funding in the other disciplinary fields, but I am sure it is substantially greater because studies in those areas are more advanced.

6. Gemini photography, at least some of which was taken by hand-held Hasselblad cameras (with 250 mm focal length lenses and 70 mm interchangeable color and black/white film packs), produced startlingly clear imagery and dramatic color contrast, as you know. The viewing of this photography has whetted the appetites of men who have been interested in exploring the effectiveness of various sensors for obtaining data required for analyzing a host of problems relating to physical and cultural resources (see Tab E).

Geodesists at Ohio State University are devising a coordinate grid system to make Gemini photography more useful for broad interpretation. A mosaic of northern South America will be made from Gemini photography.

7. A representative of the OAS noted the tremendous lack of data on Latin America and the interest of OAS in coverage by remote sensing. (As an illustration of what is needed, he exhibited a group of maps printed at 1:250,000 scale, based on AMS photomaps of 1:60,000 scale constructed from aircraft photography. These materials were subjected to analysis by 30 photo interpreters. The final maps are excellent portrayals of the distribution of hydrology, transportation, rainfall, soils, land capability, land use, geology, and population distribution for Santo Domingo. The magnitude of the effort for this small country must have been very great, considering the conventional means that had to be used.)

8. At the October meeting for the Advisory Committee of Geographic Applications, information was provided by NASA representatives regarding the possible inclusion of several sensors in the Apollo and possible other oncoming NASA vehicles. The potentials excited those present and they are looking forward to great improvements in image resolution and in other data from orbiting sensors (see Tab F -- AAP refers to Apollo Applications Program and ERS to the EROS concept). It was stated that the Apollo vehicles might reach 50 degrees north and south latitude. It was further recognized that many of the proposed sensors for inclusion are only in the R&D stage. Any sensors, if installed, would be greatly subordinated to the main objectives of the Apollo missions, at least until primary Apollo objectives are totally achieved. Also for future inclusion, 24" panoramic cameras with ~~74~~ 41 degree scan associated with 12" frame cameras were discussed (see Tab G).

9. There was some discussion of direct dollar benefits that might be realized from use of remote sensor data. It was pointed out that, for 1:250,000 scale mapping of the United States alone, 130,000 stereo-photo models would be needed if obtained from aircraft coverage and only 1,200 such models would be required if obtained from orbiting satellites. Annual savings in maintaining the U.S. Geological Survey's 1:24,000 map series of the U.S. by use of orbital photography would amount to $2,000,000, and the annual benefit to user groups in the many

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sectors of the U.S. economy which depend on such maps would approximate $136,000,000 at the present time. It was felt that orbital stereo photography for mapping could save three to five years time in up-to-date map maintenance and production for U.S. coverage.

10. Concern was expressed over the magnitude of the task for processing, storing, and retrieving the information to be obtained from the orbiting sensors. It was recognized that automation must play a larger role in the handling and analysis of the data and that all possible assistance should be sought from government agencies now facing similar problems in information processing and maintenance of data banks.

11. Obviously there is some wishful and naive thinking and vaguely formulated planning inherent in the discussions at the two-day meeting I attended as an observer. It seems essential that those officials involved in managing overhead reconnaissance do whatever they can to guide and cooperate with those responsible for the Earth Resources Programs in order that unnecessary duplication in hardware design and development is avoided, and that maximum use of data from orbital sensors (admittedly involving appropriate sanitization and declassification) can be ensured in fulfilling the important objectives of earth resource surveys for military, economic, and political purposes. Future configurations of earth orbiting vehicles may be able to fulfill efficiently (with proper safeguards for the handling of sensitive material) a greatly broadened, all-inclusive set of requirements for earth observation from space -- both for intelligence and for all other users dependent upon improved knowledge of their countries' resources.

25X1

4

NASA'S EARTH RESOURCES SURVEY PROGRAMS WITH OTHER AGENCIES IN AGRICULTURE, FORESTRY, GEOGRAPHY, GEOLOGY, HYDROLOGY, AND OCEANOGRAPHY

OUTLINE OF SOME OF THE FUNCTIONS OF THE DEPTS. OF AGRICULTURE, INTERIOR AND NAVY:

1. DEFINE THE OBJECTIVES OF EACH DISCIPLINE FOR THE FEASIBILITY, SPACEFLIGHT TESTING, AND OPERATIONAL PHASES OF NASA'S EARTH RESOURCES SURVEY PROGRAM
2. ESTABLISH THE FEASIBILITY OF COLLECTING USEFUL EARTH RESOURCES DATA FROM SPACECRAFT
3. STUDY AND DOCUMENT THE ECONOMIC JUSTIFICATION FOR EARTH RESOURCES SURVEYING AND DATA COLLECTION FROM SPACE
4. ESTABLISH INSTRUMENT REQUIREMENTS AND SPECIFICATIONS FOR EARTH RESOURCES SURVEYING FROM SPACE
5. DOCUMENT THE DATA ACQUISITION PRIORITIES AND REQUIREMENTS (AREAL COVERAGE, TIMING, FREQUENCY OF COVERAGE) FOR EARTH RESOURCES SURVEYS DURING AIRCRAFT, SPACEFLIGHT TESTING AND OPERATIONAL PHASES
6. PERIODICALLY DOCUMENT SCIENTIFIC ACHIEVEMENTS MADE BY EACH DISCIPLINE DURING THE AIR AND SPACEBORNE PHASES OF THE PROGRAM
7. DEVELOP METHODS FOR UTILIZING EARTH RESOURCES DATA COLLECTED FROM SPACE

NASA SA66-15795
7-26-66

B

EARTH RESOURCES SURVEY PROGRAM

OBJECTIVES

1. TO DETERMINE THOSE NATURAL AND CULTURAL RESOURCE PHENOMENA WHICH CAN BE BEST ACQUIRED FROM SPACE FOR THE ECONOMIC BENEFIT OF THE NATION AND MANKIND.

2. TO DEVELOP THE BEST COMBINATION OF SPACE FLIGHT INSTRUMENTS, SUB-SYSTEMS, OBSERVATIONAL PROCEDURES, AND INTERPRETATIONAL TECHNIQUES FOR GATHERING NATURAL AND CULTURAL RESOURCE DATA AND TO TEST THESE WITH AN EVOLUTIONARY SERIES OF EXPERIMENTAL MANNED AND UNMANNED SPACECRAFT.

APPLICATIONS

AGRICULTURE AND FORESTRY PRODUCTION
GATHER DATA ON PLANT VIGOR AND DISEASE IN ORDER TO AID IN THE INCREASE OF AGRICULTURE AND FOREST PRODUCTION.

GEOGRAPHY, CARTOGRAPHY, CULTURAL RESOURCES
GATHER DATA TO PERMIT BETTER USE OF RURAL AND METRO-POLITIAN LAND AREAS AND TO UPDATE TOPOGRAPHIC BASE MAPS AND CENSUS INVENTORIES.

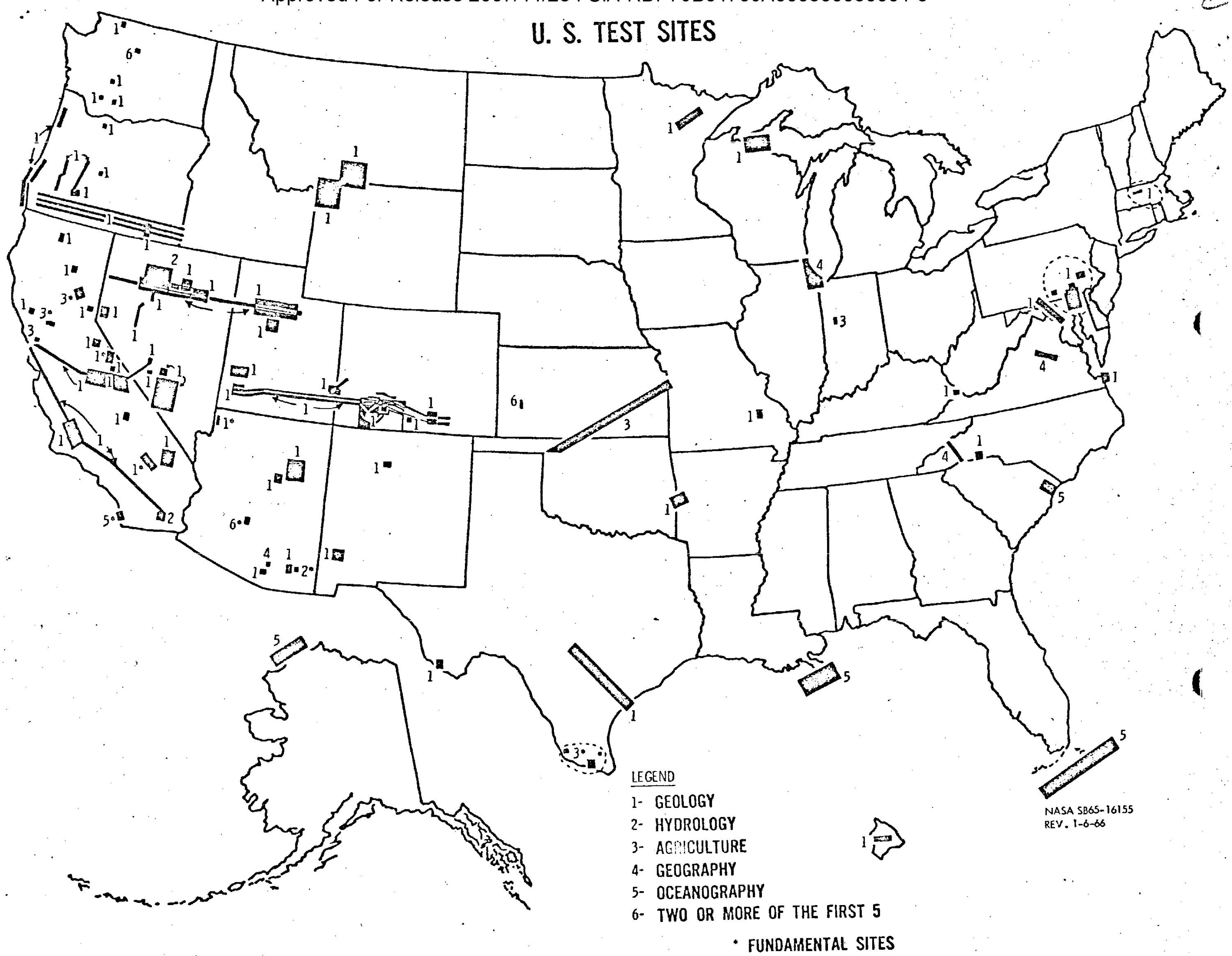
GEOLOGY AND MINERAL RESOURCES
GATHER DATA TO AID IN 1) THE DISCOVERY AND EXPLOITATION OF MINERAL AND PETROLEUM RESOURCES; 2) THE PREDICTION OF NATURAL DISASTERS.

HYDROLOGY AND WATER RESOURCES
GATHER DATA TO AID IN THE LOCATION AND BETTER USAGE OF WATER RESOURCES.

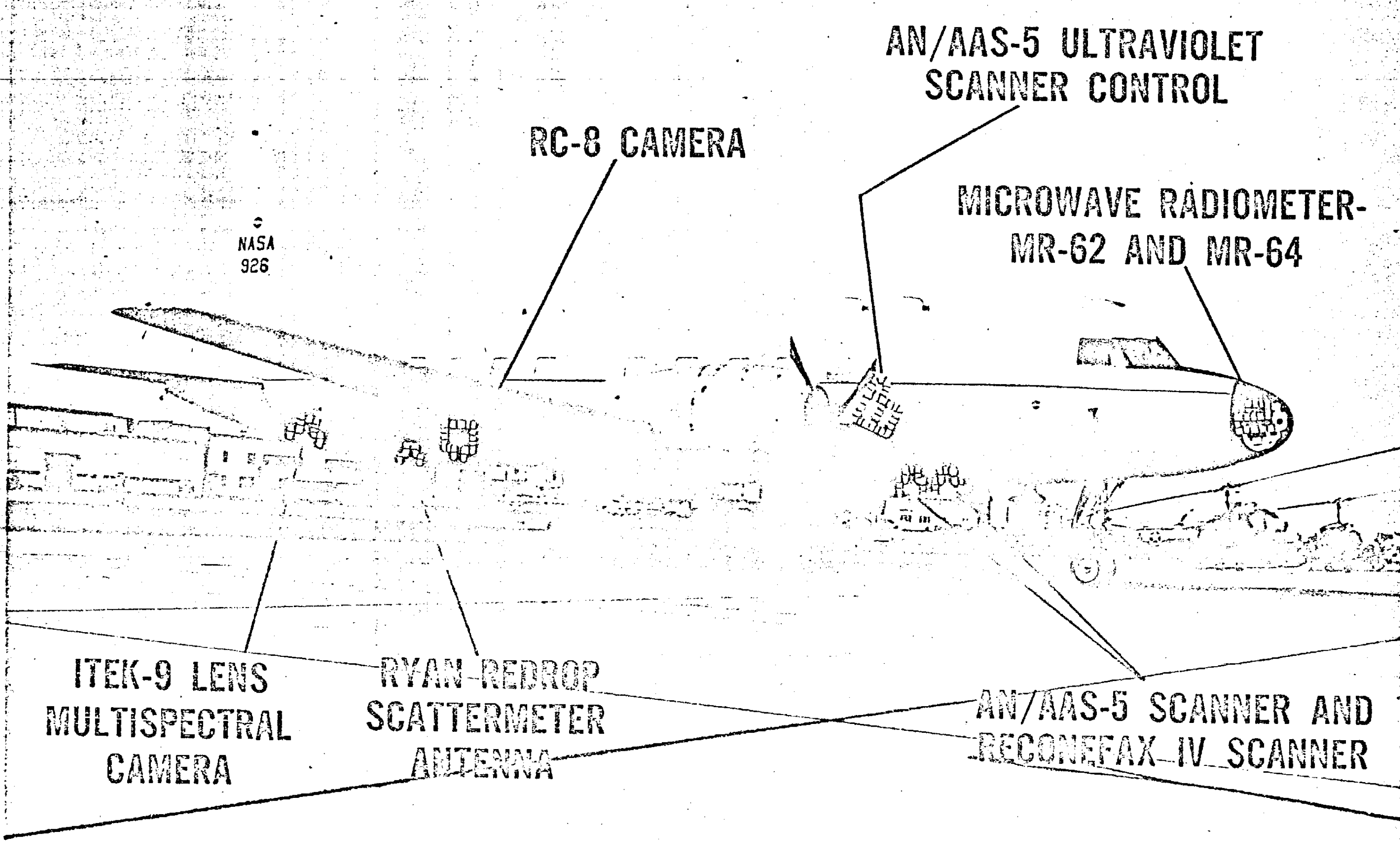
OCEANOGRAPHY AND MARINE RESOURCES
GATHER DATA TO AID IN OCEAN TRANSPORTATION AND TO AID IN BETTER UTILIZATION OF FISHERIES.

NASA HQ SA67-15106
10-5-66

U. S. TEST SITES



NASA EARTH RESOURCES SURVEY AIRCRAFT CONVAIR 240-A SHOWING INSTRUMENT LOCATIONS



[redacted] NASA HQ SA67-15152 10-13-66

E

TABLE I

ANTICIPATED APPLICATIONS OF EARTH RESOURCES DATA GATHERING SYSTEMS

AGRICULTURAL GEOGRAPHIC GEOLOGIC HYDROLOGIC OCEANOGRAPHIC

	VEGETATION DENSITY	GRASS-BRUSH-TIMBERLAND INTERFACES	PLANT SPECIES AND VIGOR	SOIL SERIES, TEMP., & MOISTURE	IRRIGATION WATER	FIRE DETECTION	LAND USE	TRANSPORTATION & LINKAGES	SETTLE & POPULATION MOVEMENTS	RESOURCES UTILIZATION	CLIMATIC CONDITIONS	TOPO. MAPPING & GEOMORPHOLOGY	COMPOSITION	STRUCTURE	STRATIGRAPHY--SEDIMENTATION	MINERAL DEPOSITS	ENGINEERING	CRUSTAL-MANTLE STUDIES	EVAPOTRANSPIRATION	RAIN DISTRIBUTION & INFILTRATION	GROUND WATER DISCHARGE	WATER POLLUTION	SNOW SURVEYING & GLACIOLOGY	EFFLUENTS OF MAJOR RIVERS	THERMAL CONDITIONS	SEA SURFACE ROUGHNESS	SHOALS & COASTAL MAPPING	BIOLOGICAL PHENOMENA	ICE SURVEILLANCE	SUBSURFACE STRUCTURE
METRIC CAMERA	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X			X	X	X	X	X	X	X	
PANORAMIC CAMERA	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	
MULTISPECTRAL TRACKING TELESCOPE	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	
MULTIBAND SYNOPTIC CAMERA	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
RADAR IMAGER	X	X		X	X	X	X	X		X	?	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	
RADAR ALTIMETER/SCATTEROMETER							?	?								X	X			X			X			X		X	X	
WIDE RANGE SPECTRAL SCANNER*	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
IR RADIOMETER/SPECTROMETER	X		X	X		X	X	X					X		X	X	X	X	X			X	X	X	X		X	X	X	
MICROWAVE IMAGER				X	X		X	?					X	X	X			X		X	X	X	X	X	X	X	X		X	
MICROWAVE RADIOMETER				X	X	X	?	?					X					X	X	X		X	X	X	X	X	X		X	
LASER ALTIMETER/SCATTEROMETER												X		X	X	X	X	X					X	X		X	X		X	
MAGNETOMETER										X						X		X									X			X
GRAVITY GRADIOMETER																X		X							X		X	X		X
ABSORPTION SPECTROSCOPY													X				X											X		
RADIO FREQUENCY REFLECTIVITY																			X	X				X	X			X	X	
VIEWFINDER **						X		X		X	X			X	X			X		X		X	X	X			X	X	X	
ULTRAVIOLET SPECTROMETER-IMAGER													X	X	X	X														
EARTH BASED SENSORS***				X	X	X	X	X	X		X	X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X

* 0.32 - 14.0 microns

** This instrument augments an astronaut's vision with opitcal power and directional data. The astronaut can utilize the viewfinder by itself or in conjunction with other directional type sensors.

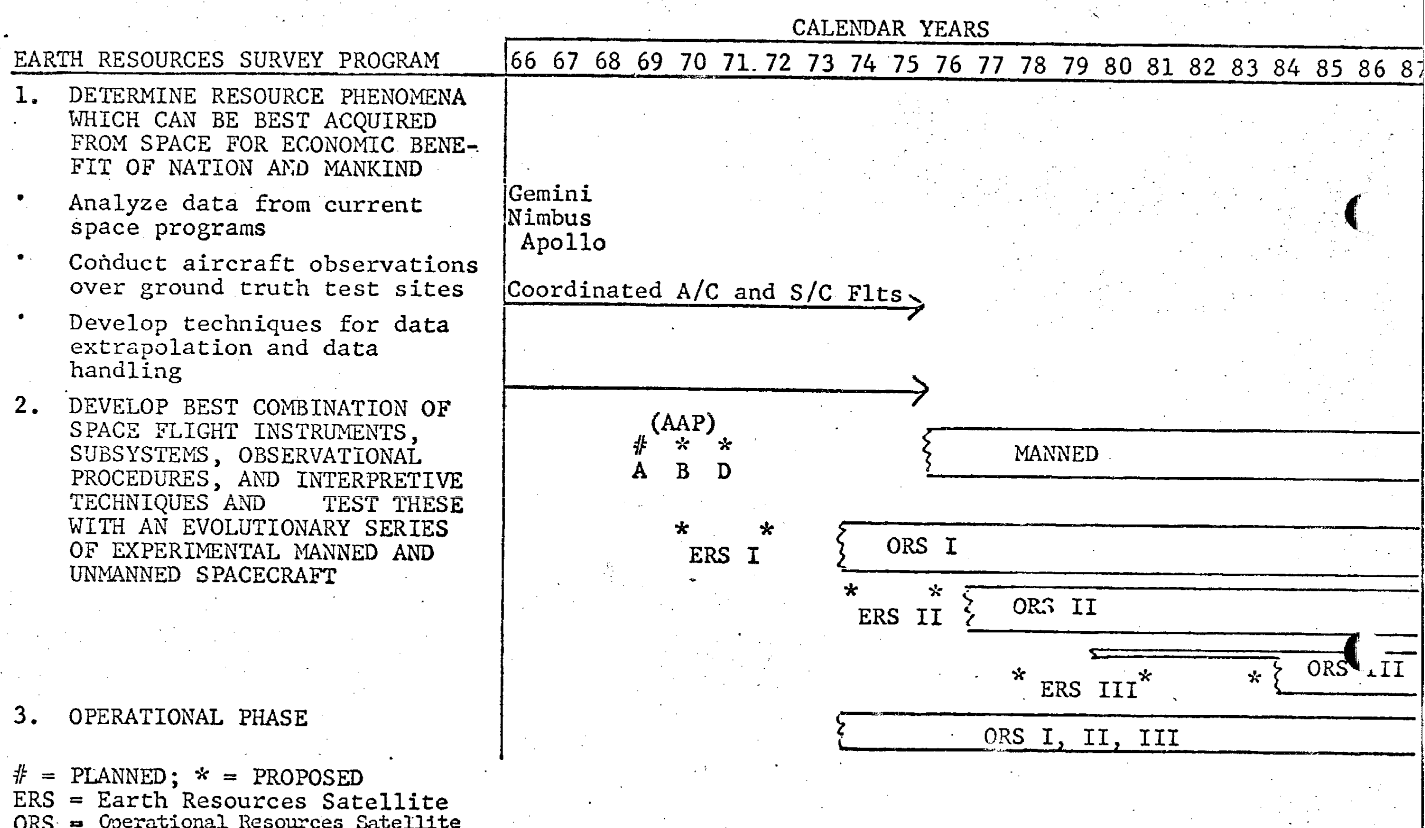
*** These earth-based sensors may include a number of fixed and mobile instruments, such as buoys, seismographs, stream gauges, and so forth, placed on or near the earth's surface for detecting, recording, and transmitting a variety of earth resources phenomena of interest to a large number of users.

NASA SA66-15248
REV. 7-29-66

This table has been summarized from more detailed tables for each discipline and therefore does not include all the anticipated applications which have been identified to date.

F

MILESTONE CHART



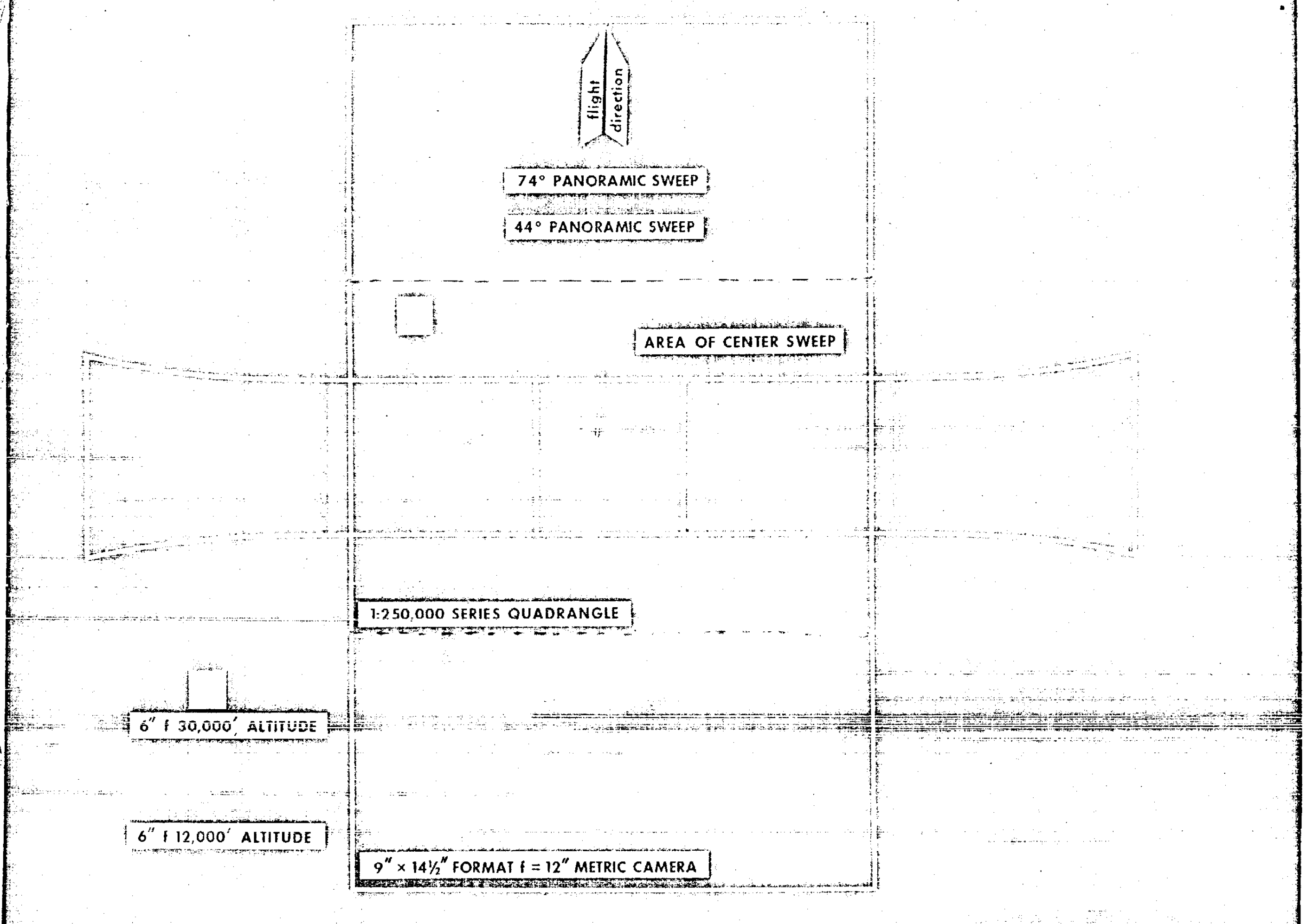
NASA HQ SA67-15162 10/16/66

USER REQUIREMENTS AND STATUS OF SPACE SYSTEMS FOR EARTH RESOURCE SURVEYS

SAMPLES OF REQUIREMENTS IN TERMS OF RESOLUTION RANGES	ASSOCIATED MAPPING LIMITATIONS		INSTRUMENTS AVAILABLE TO COLLECT DATA FROM 200 NM		AVAILABILITY AND TIMING OF SPACECRAFT TO MEET REQUIREMENTS	
	PRODUCTION	REVISION	INSTRUMENT TYPE	RESOLUTION	SPACECRAFT	YEAR
LESS THAN 20 METERS: CROP & TIMBER SPECIES BUILDINGS, STREETS, ETC. DETAILED CENSUS SMALL FAULTS, AND FRACTURES LOCAL WATER LEVELS, POLLUTION AND SEDIMENTATION SPECIFIC SEA STATE	1:100,000	1:20,000	95" TRACKING TELESCOPE 24" PANORAMIC CONVERGENT CAMERAS 12" METRIC CAMERA SYSTEM	2-3 METERS 6-15 METERS 18-30 METERS	AAP-B, D MAN FOLLOW-ON ERS-III ORS-III	1970-71 POST '72 1978 1985
20 TO 100 METERS: CROP AND FOREST TYPES URBANIZATION & LAND USE SYNOPTIC CENSUS GENERAL GEOLOGIC ANALYSIS WATER SNOW AND ICE INVENTORY GROSS SEA STATE	1:250,000 (LIMITED CULTURE)	1:100,000 (LIMITED CULTURE)	12" METRIC CAMERA SYSTEM 6" MULTIBAND SYNOPTIC CAMERA SYSTEM SIDE-LOOKING RADAR ADVANCED TV* SYSTEM	18-30 METERS 30-50 METERS 20-40 METERS 30-100 METERS	AAP-A, B, D MAN FOLLOW-ON ERS-II ORS-II ERS-III ORS-III ERS-I ORS-I	1969-71 POST '72 1974 1977 1978 1985 1970 1974
100 TO 300 METERS: PRIMARY LAND USE (FORESTRY, AGRICULTURE, BARREN) REGIONAL GEOLOGY WATER, SNOW, AND ICE LINES	1:1,000,000 (LESS CULTURE)	1:250,000 (LESS CULTURE)	3" HASSELBALD & MAURER CAMERAS 35mm OR 70mm DIELECTRIC TAPE CAMERA NIMBUS TYPE TV MULTISPECTRAL SCANNER	100-200 METERS 100-200 METERS 200-400 METERS 200-300 METERS	GEMINI NIMBUS APOLLO ERS-I ORS-I	1966 1966 1967 1970 1974

NOTE: AN ADVANCED TV SYSTEM WITH 30-100 METERS RESOLUTION MAY BE AVAILABLE FOR SPACE USE BY 1970.
THE ERS-I AND ORS-I SPACECRAFT COULD NOT HANDLE THE FILM TYPE CAMERAS OR SIDE LOOKING IMAGING RADAR.

NASA HQ SA67-15115
10-6-65



COMPARISON OF PHOTO COVERAGE FROM 125 NAUTICAL MILES ALTITUDE

PREPARED IN COOPERATION WITH US GEOLOGICAL SURVEY

[redacted]

Approved For Release 2007/11/28 : CIA-RDP79B01709A000300050001-3

COMPARISON OF PHOTO COVERAGE FROM 125 NAUTICAL MILE ALTITUDE

THE ILLUSTRATION COMPARES GROUND COVERAGE AFFORDED BY A 24-INCH FOCAL LENGTH, 12 DEGREE LENS CONE PANORAMIC CAMERA EXPOSURE, WITH A 12-INCH FOCAL LENGTH, 72 DEGREE LENS CONE FRAME CAMERA EXPOSURE. THEIR FORMAT COVERAGE IS SHOWN PLOTTED ON THE OUTLINE OF AN AVERAGE 1:250,000 SCALE (1 INCH = 4 MILES) MAP.

FOR FURTHER COMPARISON A BLOCK SYMBOL IS USED TO ILLUSTRATE GROUND COVERAGE AFFORDED BY 6-INCH FOCAL LENGTH, 90 DEGREE LENS CONE, FRAME CAMERA PHOTOGRAPHY FROM 30,000- AND 12,000-FOOT ALTITUDES. SUCH PHOTOGRAPHY FLOWN AT 30,000-FOOT ALTITUDE WAS NORMALLY USED TO COMPILE THE 1:250,000 SCALE MAP SERIES OF THE UNITED STATES.