NATURAL RESOURCES PROGRAM

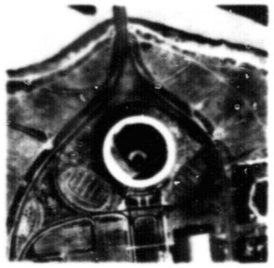
SPACE APPLICATIONS PROGRAMS

TECHNICAL LETTER NASA-51

[redacted]

U.S. Geological Survey
Department of the Interior

HIGH RESOLUTION PHOTOGRAPHY



THIS PORTION AT NEGATIVE SCALE

ENLARGEMENTS SHOW THE HIGHLY RESOLVED DETAIL FROM PANORAMIC PHOTOGRAPHY

EXPOSURE OF WASHINGTON, D.C. STADIUM
WITH PERKIN–ELMER CAMERA
f=18 INCHES   5 INCH FILM FORMAT
FLYING HEIGHT APPROX. 40,000 FEET

10× ENLARGEMENT

20× ENLARGEMENT

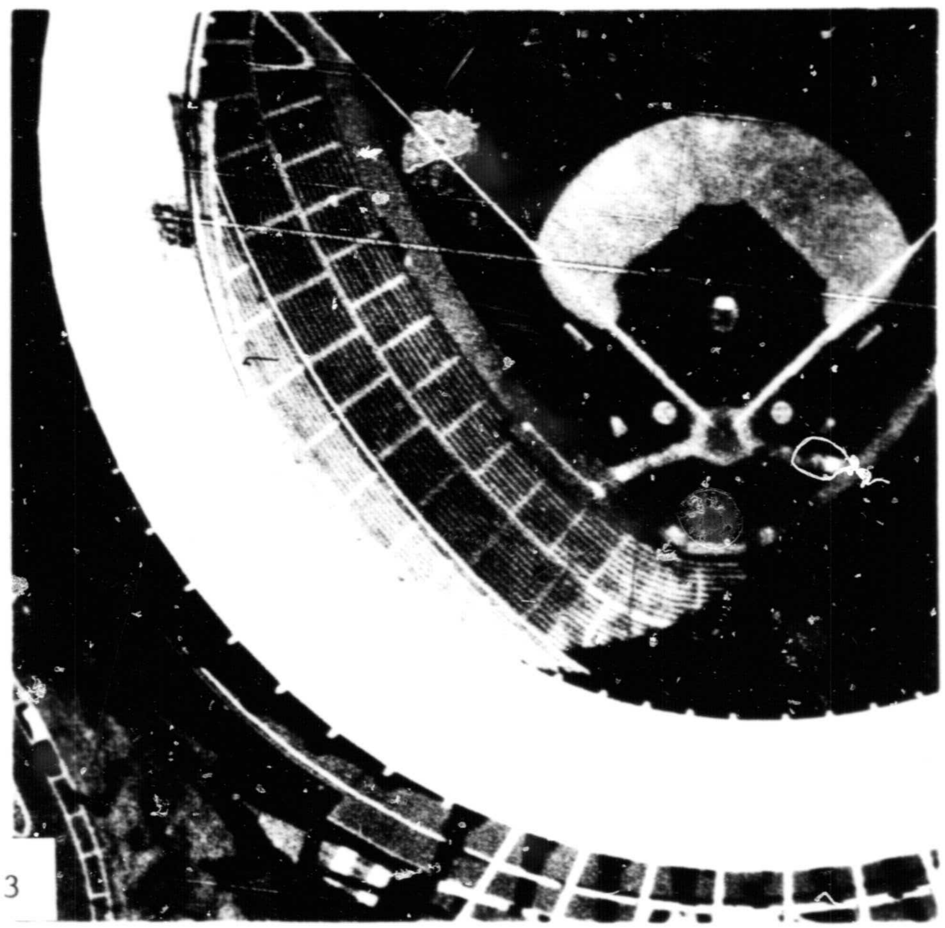
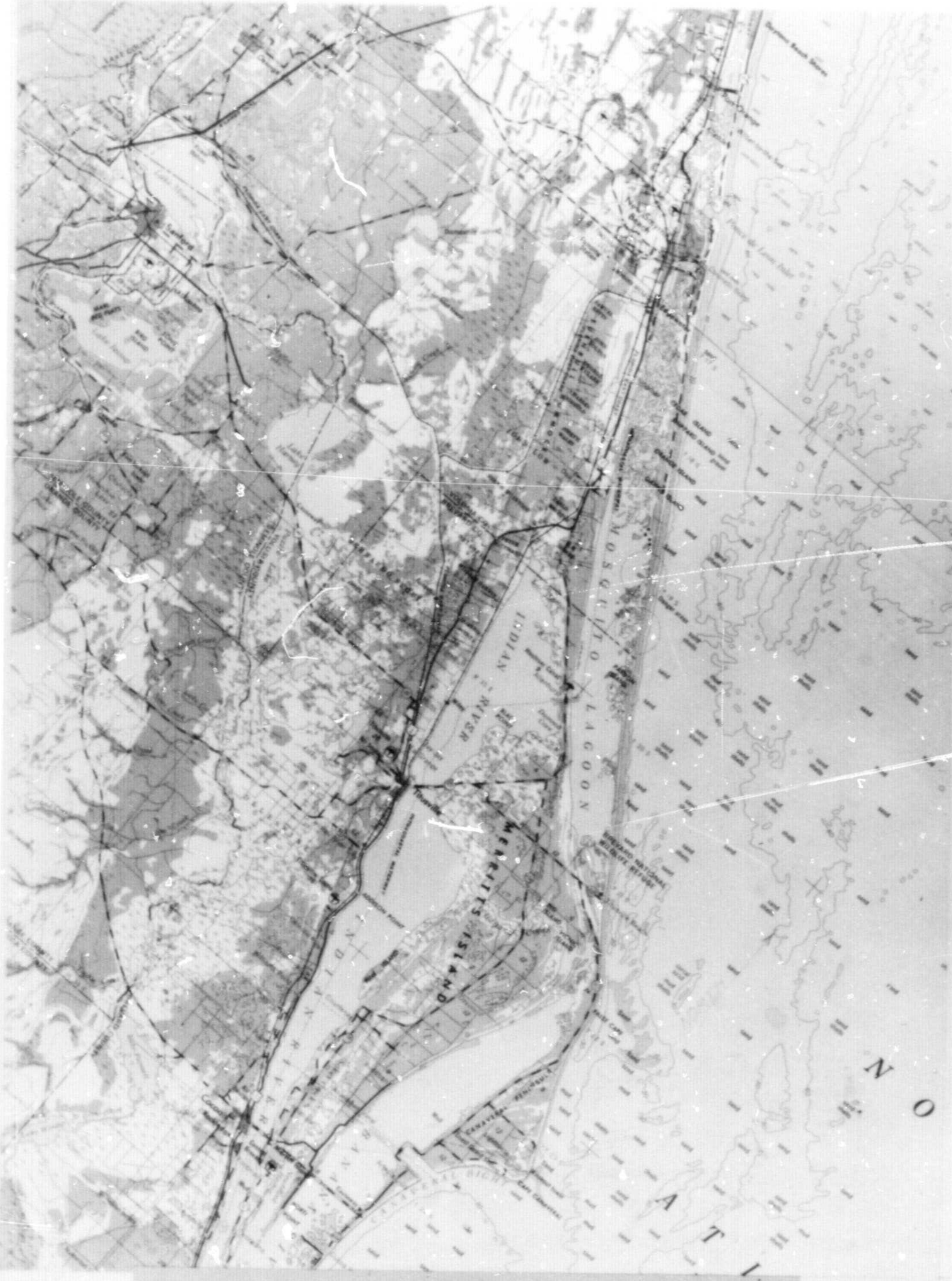
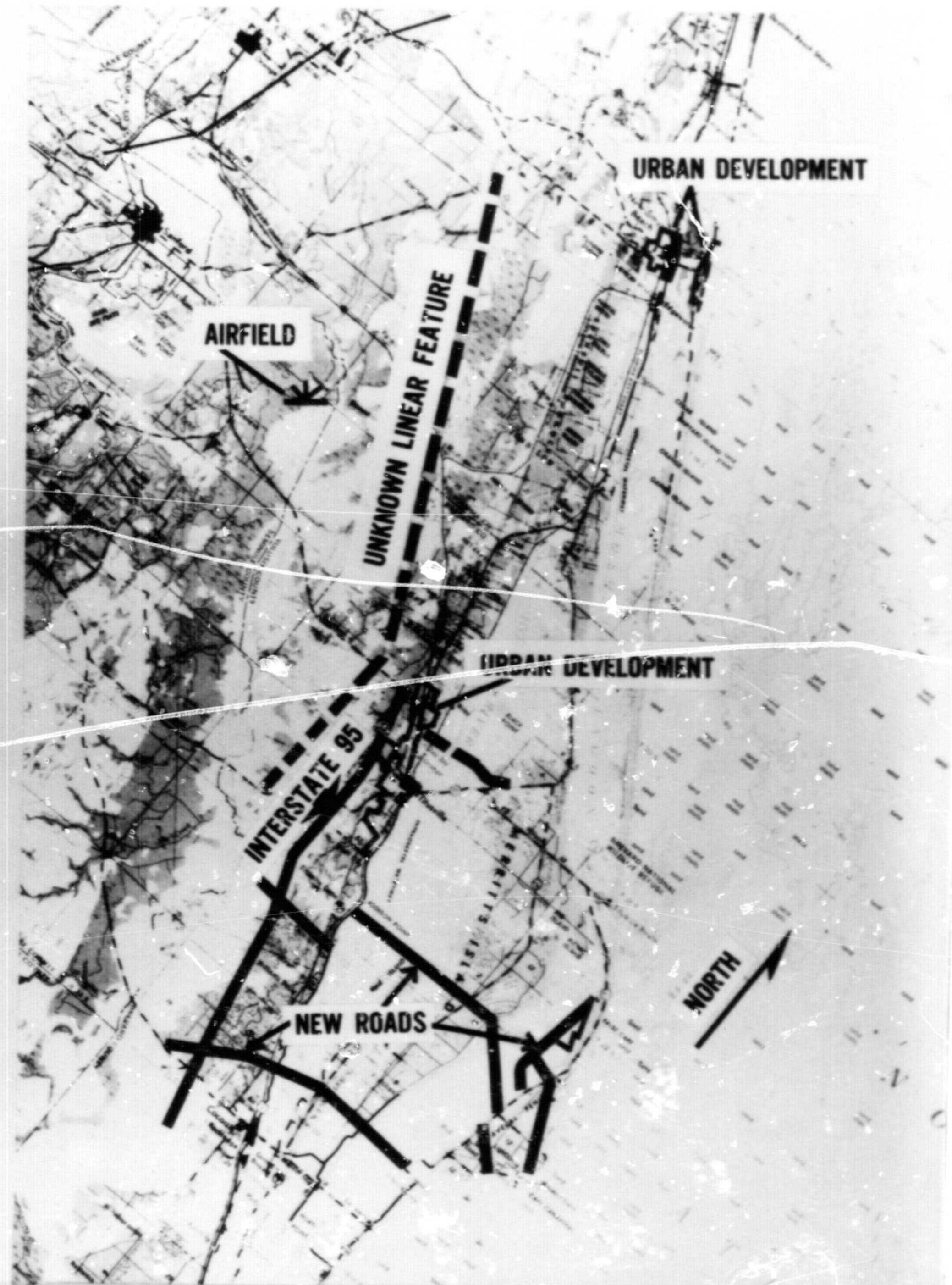


ILLUSTRATION 3



PORTION OF ORLANDO, FLORIDA 1:250,000 SCALE MAP– PUBLISHED 1955. REVISED 1962



MAJOR CULTURE CHANGES IDENTIFIED FROM GEMINI 7 PHOTOGRAPHY– DECEMBER 1965 HASSELBLAD CAMERA–250MM F/L

NASA SA66-15185 3-3-66

ILLUSTRATION 2

GEMINI 7 PHOTOGRAPH OF CAPE KENNEDY, DECEMBER 1965

ALTITUDE: 165 NM
250 mm FOCAL LENGTH
HASSELBLAD CAMERA
ORIGINAL PHOTO
SCALE 1:1,200,000

NASA SA66-15186

ILLUSTRATION 1

1.

UNITED STATES
DEPARTMENT OF THE INTERIOR
Geological Survey
Washington, D. C. 20242

Technical Letter
NASA-51
August 1966

Dr. Peter C. Badgley
Chief, Natural Resources Program
Office of Space Science and Applications
Code SAR, NASA Headquarters
Washington, D.C. 20546

Dear Peter:

In accordance with your request for submission of Significant Scientific Achievement Documents, I am transmitting herewith 2 copies of:

TECHNICAL LETTER NASA-51

APPLICATIONS OF REMOTE SENSOR DATA TO CARTOGRAPHIC PROGRAMS *

by

W. Sibert **

Sincerely yours,

William A. Fischer
Research Coordinator
Earth Orbiter Program

*Work performed under NASA Contract No. R-09-020-024
**U.S. Geological Survey, Topographic Division, McLean, Virginia

[redacted]

2

UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TECHNICAL LETTER NASA-51

APPLICATION OF REMOTE SENSOR DATA TO CARTOGRAPHIC PROGRAMS*

by

W. Sibert**

July 1966

These data are preliminary and should not be quoted without permission

Prepared by the Geological Survey for the National Aeronautics and Space Administration (NASA)

*Work performed under NASA Contract No. R-09-020-024
**U.S. Geological Survey, Topographic Division, McLean, Virginia

Photo copies of illustrations are available for viewing at the following places:

Author(s); Discipline Coordinators; NASA Data Bank (Houston); Remote Sensing Evaluation and Coordination Staff (RESECS) and the U.S. Geological Survey Libraries (Denver, Menlo, Washington).

CONTENTS

APPLICATION OF REMOTE SENSOR DATA TO CARTOGRAPHIC PROGRAMS

by

W. Sibert

History of Natural Resources Surveys in the United States

In the first half of the 19th century, the Pacific Railway Survey and the expeditions led by Schoolcraft, Lewis and Clark, Pike, Long, Walker, and Fremont were conducted by the Federal Government in the western part of the country. These early Western surveys were aimed chiefly at exploration. Increased migration westward after the Civil War emphasized the need for more thorough exploration of the vast area, and in 1867 Congress authorized the establishment of four surveys which included the study of the geology and geography of the territories. These were known as the King, Hayden, Powell, and Wheeler Surveys, after their respective leaders. Then, in 1879, the 45th Congress, following recommendations of the National Academy of Sciences, consolidated the scientific surveys and created a new agency, the U.S. Geological Survey, to carry out all such surveys in the future. A growing population and an expanding economy have emphasized the wisdom of Congress in this decision. During the ensuing 87 years, the publication of topographic maps has provided a means of cataloging our Nation's natural resources and of assuring wise use of them.

As the population grows, the consumption of raw materials and energy grows. Because the Nation holds continued economic growth as one of its cardinal aims, resource exploration and development must be improved to meet increased requirements. To this end, more knowledge must be acquired. More sensitive instruments and techniques must be brought to bear, and scientific theory must be extended. Truly, the Nation is more and more "living by its wits"; more effort must be put into sharpening those wits if economic growth is to continue.

The relatively crude and time-consuming practices of early exploration ground surveys have now been replaced by the use of aerial photographs in precision photogrammetric plotting instruments. Most topographic mapping is now being done in offices remote from the areas being mapped. Ground surveys are needed only to establish basic ground control, to obtain or confirm name information, and to complete ground detail that is obscured on the photographs by shadow or vegetation cover.

Advanced satellite technology and analytical phototriangulation concepts now being developed hold promise of further reducing the requirement for ground surveys insofar as establishment of basic control is concerned. And now, with the concept of earth-orbiting remote-sensor satellites collecting photographs of great precision and resolution, it may be possible to survey the country's land resources and to keep data current on published topographic maps within a time frame that is meaningful in today's context. Also, space photography offers a unique and realistic potential for compiling topographic maps at scales of 1:24,000 through 1:250,000 on a selected area basis, and at scales of 1:1,000,000 and smaller on a global basis.

Application of Remote Sensor Data to Topographic Mapping

As an example of the potential use of earth-orbital photographs, reference is made to photographs recently obtained during the Gemini VII flight over the Cape Kennedy, Fla., area. (See Illustration 1) These photographs, exposed on 70mm film in a Hasselblad camera having a lens of 250mm focal length, at an orbital height of approximately 165 nautical miles, produced rather startling clarity of imagery. The film image resolution is approximately 12 lines per millimeter, and, although the original photo scale is approximately 1:1,200,000, the density of planimetric detail compares favorably with that shown on the published 1:250,000-scale topographic map. As shown by Illustration 2, many major cultural changes can be identified, indicating the potential use of orbital-height photographs for map revision operations. This single photograph covers approximately 1,600 square miles, whereas conventional photography at an altitude of 30,000 feet would require approximately 21 exposures to cover the equivalent area.

Inasmuch as the Gemini photographs indicate the potential application of orbital photography to cartographic programs, it is interesting to speculate on application of orbital photographs acquired by optimum camera systems. In this regard, large scale and maximum resolution would be desirable if they could be obtained without great loss of coverage. Consideration therefore is given to panoramic cameras. These cameras provide the basic means for meeting otherwise incompatible requirements through the use of a long-focal-length lens, through use of only that portion of the lens field which are on or near the optical axis, and through inclusion of mechanism for scanning the lens through large angles across the direction of flight. As a result, panoramic cameras can maintain the inherently high resolution of the center of the lens field over the total angle scanned, with central field resolutions exceeding 100 lines being common with state-of-the-art cameras. By employing two such cameras in a convergent mode, stereoscopic capability can be provided. Illustration 3 indicates the enlargement capabilities of panoramic camera photographs. The original negative resolution is rated at 90 lines per millimeter. As can be seen, a 20X enlargement does not show any appreciable loss of image definition.

Commercially available panoramic cameras, employing a 24-inch-focal-length lens, provide negative resolutions of approximately 120 lines per millimeter. It is interesting to consider employing such cameras at earth-orbital heights of approximately 125 nautical miles. Original negative scale would be 1:380,000; a 10X enlargement would provide 1:38,000-scale source material, and a 20X enlargement would provide 1:19,000-scale source material. Ground targets as small as 12 feet in diameter would be resolved. When one considers, in retrospect, that photo scales of 1:60,000 were used for compilation of the U.S. 1:250,000-scale series maps and that, to date, the average photo scale for compilation of 1:24,000-scale topographic maps is approximately 1:20,000, it is evident that orbital-height photography can be suitable for map construction and revision.

Time-Cost Benefit Considerations

The use of spacecraft as remote sensor platforms offers the unique advantage of permitting cartographic data to be collected on a national and global basis within a time frame and with coverage per data-bit never before conceived. Therein lies the prime value of remote sensor systems. They thus pave the way for a great step forward in the production and maintenance of map products on a national and global extent, with potential for significant cost savings and increased production rates.

It is estimated that benefits to the U.S. economy, resulting from the availability of topographic maps, will be approximately $680 million annually by 1981--when the topographic mapping program is completed. Maintenance of the topographic map series within the shortest possible time lapse, particularly with regard to cultural features, is essential if we are to realize continuing annual dollar benefits. Conventional, present-day techniques generally restrict map maintenance to intervals of from 5 to 10 years for urban areas and from 10 to 15 years for farming areas, whereas the potential of remote sensor data is such that map maintenance intervals of from 1 to 2 years and 2 to 3 years, respectively, is anticipated. Thus, through the use of remote sensors, conditions may be established that would realistically permit continuing annual dollar benefits and, more importantly, provide a basis for keeping pace with the Nation's rapidly expanding economy.

Direct dollar benefits that may be realized from use of remote sensor data in cartographic programs are as follows:

A. $136 million annually, or 20% of the total U.S. dollar benefits resulting from availability of topographic maps, through more responsive map-maintenance capabilities.

B. $2 million annually through savings in production operations for maintenance of the U.S. 1:24,000-scale topographic map series.

C. $320,000 annually through savings in production operations for maintenance of the U.S. 1:250,000-scale topographic map series.

D. Based on an extrapolation of the data derived for the U.S., which is only 1/18 of the total land area of the world, the global dollar benefits could exceed a billion dollars annually.