NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

EARTH RESOURCES SURVEY PROGRAM

TECHNICAL LETTER NASA-69

GEMINI PHOTOGRAPHY EVALUATION

By

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and
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U.S. Geological Survey, Topographic Division,
Washington, D.C.

March 1967

Prepared by the Geological Survey for the National Aeronautics and Space Administration (NASA) under NASA Contract No. R-09-020-024 (Geography and Cartography Program)

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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

Technical Letter
NASA-69
March 1967

Dr. Peter C. Badgley
Program Chief,
Earth Resources Survey
Code SAR, NASA Headquarters
Washington, D.C. 20546

Dear Peter:

Transmitted herewith **is one copy of:**

TECHNICAL LETTER NASA -69

GEMINI PHOTOGRAPHY EVALUATION*

by

Robert H. Nugent**
and
Lowell E. Starr**

Sincerely yours,

William A. Fischer
Research Coordinator
Earth Orbiter Program

*Work performed under NASA Contract No. R-09-020-024
(Geography and Cartography Program)
**U.S. Geological Survey, Topographic Division, Washington, D.C.

UNITED STATES
DEPARTMENT OF THE INTERIOR
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These data are preliminary and should not be quoted without permission

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INTRODUCTION

Photography from space offers unique opportunities for recording elements of the terrestrial environment and provides the various earth sciences with advantages never before possible. The usefulness of space photographs for cartographic applications and natural and cultural resources study programs will increase when these photographs are taken with calibrated cameras designed for high resolution. As an initial effort to demonstrate a potential use of space photography, selected photographs from the Gemini IV and VII spaceflights were evaluated with respect to basic cartographic requirements.

1.0 GEMINI IV PHOTOGRAPHS

1.1 Stereoplotter analysis

A stereomodel of Gemini IV photographs (fig. 1 and 2) covering the general area of Willcox, Ariz., was analyzed to determine ground and film resolution and geometric qualities. The photographs were exposed with a hand-held Hasselblad camera (focal length, 80-mm; film format, 70-mm; Ektachrome color film MS, 50-217; negative scale, approximately 1:250,000) from an orbital altitude of 110 nautical miles during orbit 13, June 4, 1965.

1.1.1 Procedure

Positive color transparencies, enlarged 2.6X, were prepared by a commercial laboratory from duplicates of the original color film. Also, positive panchromatic (black-and-white) transparencies were prepared from the duplicate color film by using a Geological Survey ER-55 reduction printer in reverse to preserve the existing geometry and obtain a 2.7X enlargement with a principal distance of approximately 216-mm.

A Wild A5 plotter was selected for analysis of the stereomodel. The A5 is a mechanical-projection stereoplotter which will accommodate aerial photographs of focal lengths ranging from 98-mm to 215-mm, either near-vertical photographs or low-oblique photographs with tilts up to 25° from the vertical.

1.1.2 Results

Relative orientation, (that is, reconstructing the perspective conditions between a pair of photographs which existed at the moment the photographs were taken):

Color model -- successful.

Panchromatic model -- not successful, because the principal distance of the transparencies exceeded the limitations of the plotter and because the transparencies were several generations removed from the original exposures.

<u>Absolute orientation</u>, (that is, fixing the scale, position, and attitude of the model with reference to ground positions):

Not successful for both the color and panchromatic models because the tilt of the camera at the instants of exposure exceeded the limits of the A5 plotter, that is, 25°.

<u>Model appearance</u>:

Color model -- Soft, that is, corresponding images did not appear to lie in the plane of sharpest focus. This softness also could be caused by the degradation of imagery which occurs as photo imagery is processed through several generations from the original exposure.

Panchromatic model -- Extremely soft. These transparencies were two generations further removed from the original color exposures than the color transparencies.

<u>Model resolution</u>:

Color model -- Areas approximately 1 acre in size (210 x 210 feet) could be resolved but not interpreted. Linear features, such as railroads or roads, could be seen but not positively identified. Timbered areas and wooded drains could not be delineated but could be identified by observing color contrasts.

The standard error for a single elevation reading was approximately 65 feet; and, based on minimum line separation, the least interval for a form line drawn at model scale was approximately 540 feet.

Panchromatic model -- Linear features, such as roads or railroads, were visible but not identifiable. Quarter-mile square fields were not easily discernible. Degradation of resolution as compared with that of the color model undoubtedly resulted from the necessary additional processing of the transparencies.

<u>Geometric fidelity</u>:

Inability to achieve absolute orientation and the poor resolution of both the color and panchromatic models prohibited meaningful analysis of geometric qualities.

1.1.3 Conclusions

Space photographs of such small scale and poor resolution, lacking geometric controls (that is, fiducial marks and reseau) and reasonable verticality, are not adaptable to use for stereometric operations. However, the feasibility of using space photographs for stereometric operations demonstrated; photographs taken with properly designed cameras and data-reduction systems could probably be used for medium-scale mapping adequate for many needs.

1.2 Resolution Analysis

In addition to the stereoplotter analysis, a study was made of the resolution capabilities of the Hasselblad camera as exhibited on the duplicate color transparencies.

1.2.1 Procedure

Resolution was measured by microdensitometer traces of test targets and discrete image edges. The traces were made with a Jarrell-Ash microdensitometer. Measurement of images on the transparency, such as air strips and fields, was limited to those of a dimension which could be scanned by a densitometer slit of sufficient dimension to give recognizable edges permitting computations. The slit dimensions were 25 microns by 450 microns at a chart scale of 300:1. With the white background of the laboratory target indicated on the lead end of the film roll taken as 100 percent transmission, a maximum-density reading of (0) could be used for the color film. Relative brightness of the imagery could then be correlated to the limits of the film density. The method used to evaluate resolution required extrapolation of edge gradients to determine a useful linespread factor. Computations were further complicated by distortions introduced in the printing process.

1.2.2 Results

Film resolution based on measurements on resolvable National Bureau of Standards targets is limited to 25 lines/mm. These targets were copies at a magnification of 2.7X to insure valid interpretation of resolution values.

Using a scale factor based on measurement of 1-mile sections, the smallest area discernible with the microdensitometer was 200 feet square.

The color copy transparency appeared to give faithful duplication of the color test chart indicated at the lead end of the film roll.

1.2.3 Conclusions

The resolution is not suitable for most cartographic purposes since a minimum of 50 lines/mm AWAR and a ground resolution of approximately 12 meters is required.

2.0 GEMINI VII PHOTOGRAPHS

2.1 Revision Study

A Gemini VII photograph of the Cape Kennedy, Florida, area (fig. 3) exposed with a lens of 250-mm focal length in a Hasselblad camera from an altitude of 165 nautical miles was studied to determine the feasibility of using earth-orbital photographs for map revision.

2.1.1 Procedure

A duplicate copy of the original Gemini VII color transparency was used to produce enlarged black-and-white paper prints. The paper prints were enlarged 4.85X to approximately 1:250,000 scale to facilitate a direct comparision of photo imagery with published map imagery. The Orlando, Florida, sheet of the 1:240,000 Series, published in 1955 and revised in 1962, was used for the comparison.

2.1.2 Results

Linear features, such as roads, railroads, and airport runways, were readily identifiable, as were areas of urban development and industrial complexes. Shoreline features were clearly outlined. As shown in figure 4, new highways, airfields, and outlines of urban areas could be delineated quite readily. Close inspection revealed also that large individual buildings, small water bodies, and street patterns could be identified.

2.1.3 Conclusions

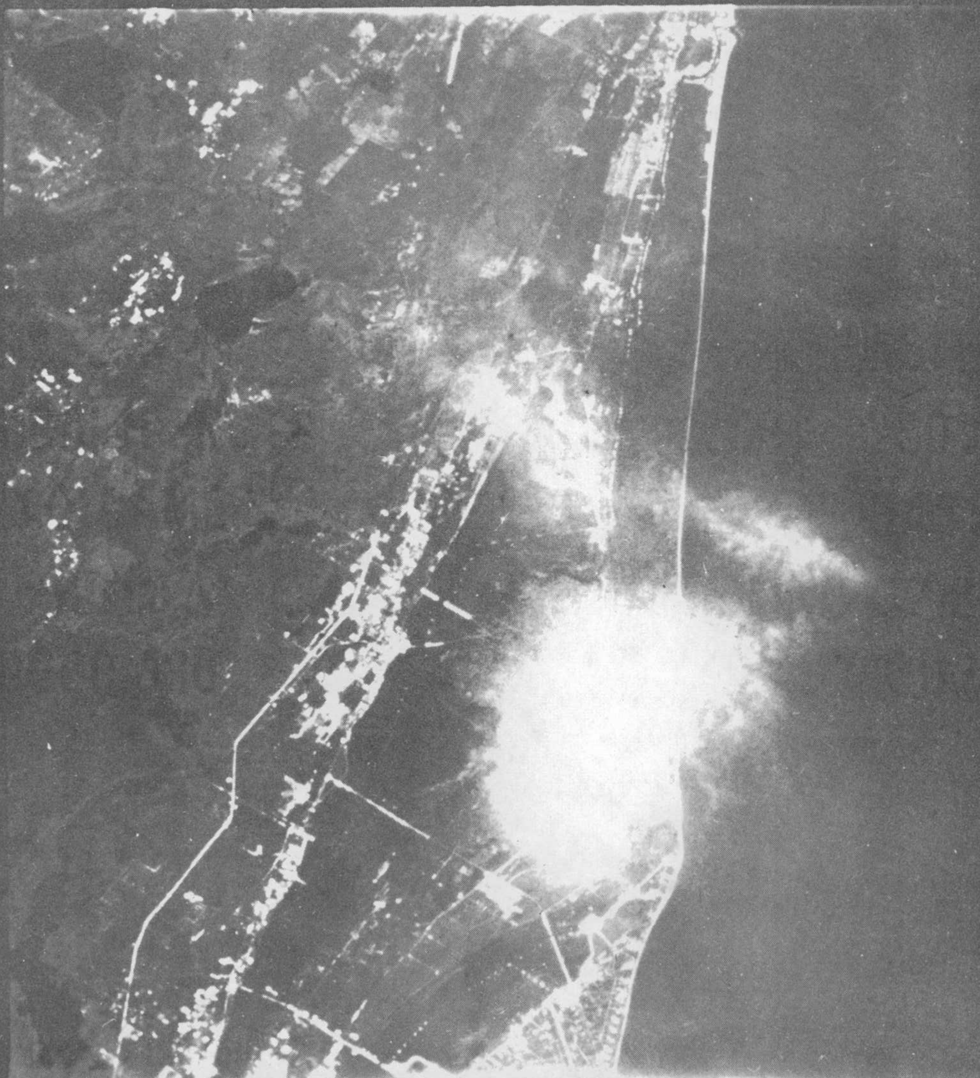
Although the Gemini photograph was not of optimum quality for cartographic applications, the comparison demonstrated the potential use of orbital photographs for updating the planimetric features of published maps. In addition orbital photographs would be useful in evaluating need for revision of maps at many scales as well as estimating the cost of revision. As a result of these observations, greater promise is expected of future space photographs obtained and processed with systems especially designed for cartographic applications.

Illustrations

Figure 1

Figure 2

GEMINI 7 PHOTOGRAPH OF CAPE KENNEDY, DECEMBER 1965



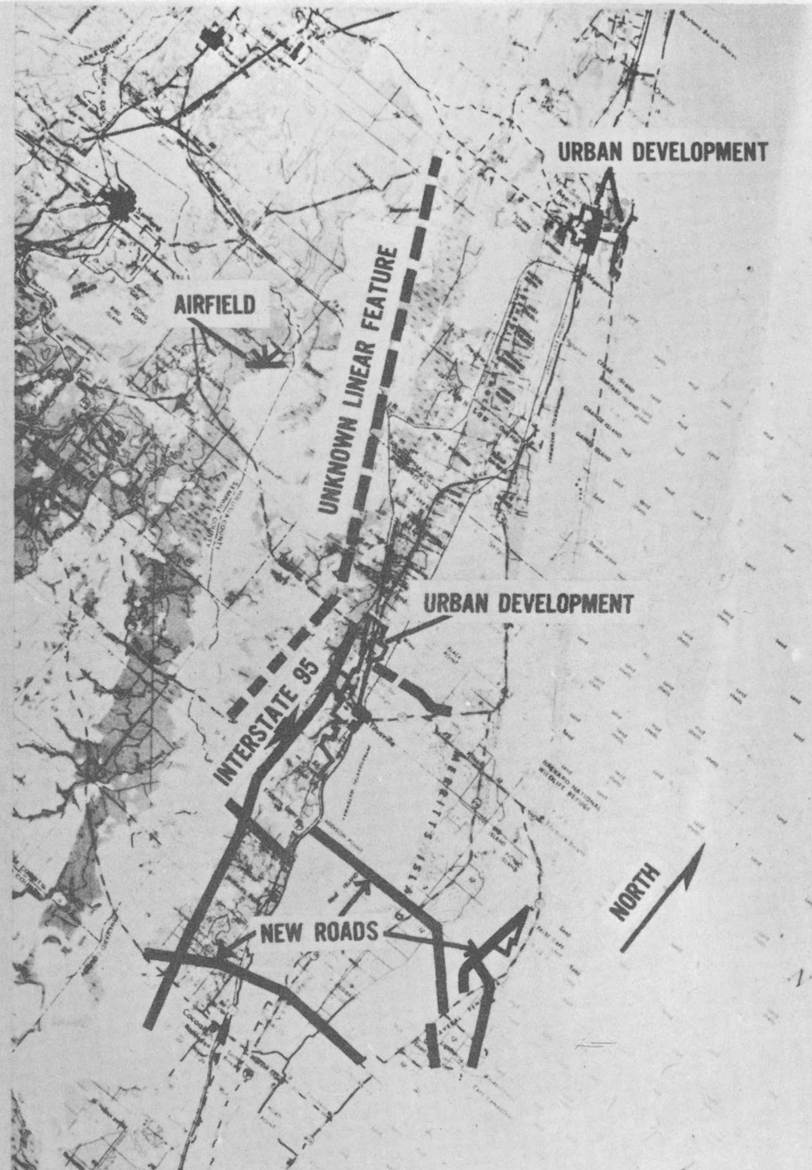
ALTITUDE: 165 NM
250 mm FOCAL LENGTH
HASSELBLAD CAMERA
ORIGINAL PHOTO
SCALE 1:1,200,000

NASA SA66-15186

FIG. 3

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

FIG. 4a



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

NASA SA66-15185 3-3-66

FIG. 4b