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Section Two: Study A

INTERPRETATION OF GEOGRAPHIC PATTERNS IN SIMULATED ORBITAL TELEVISION IMAGERY OF EARTH RESOURCES

by

James P. Latham, with Interpretation and Analysis
by Clark I. Cross, William H. Kuyper,
and Richard E. Witmer

INTRODUCTION

The spatial variations and often complex inter-relationships that are displayed by geographic phenomena on earth surface always provide both a challenge and a partial answer to the interpreter of remote sensing imagery. The spatial variations of the patterns that are present in most regions increases the difficulty of the task when one desires to identify and isolate a particular geographic phenomenon. However, both detection and evaluation of the significance of a surface type or category may depend upon perceiving complex inter-relationships that are present in a synoptic image.

The photo-interpreter is both advantaged and disadvantaged by changes in the scale of the image acquisition program. Larger scale imagery may make it possible to interpret greater range of detail, but it also multiplies greatly the data which must be processed to extract specific elements of information. Consequently, for many purposes of geographic analysis the smallest possible scale which still resolves the patterns of interest should be preferred. This means that increasing the generalizing function by photographic scale reduction to the maximum permissible for the purpose of the investigation increases the efficiency of the interpretation process, and reduces the number of images that must be acquired and processed. Of course it also means that there is a limit placed on the minimum size of phenomena occurrances that can be resolved, and consequently some surface patterns will not be recorded.

Additional considerations are associated with the interpretation of scan-line imagery which is generated by television sensors. As emphasized in previous reports of this investigation, the scan line sensor is a sampling system and regardless of its resolving capability, it does not scan or record all of the surface within the area crossed by the pattern of scan lines. Also the degree to which details of the surface patterns are resolved now is dependent not only upon the scale of the imagery but also upon: (1) The number of systematic sampling scan lines that traverse the observed area; (2) the width of the individual scan lines that sense the patterns of phenomena perceived by the lens; and (3) the orientation of the parallel scan lines relative to the orientation of linear features in the mix of surface phenomena.

In order to better determine the effects of the above television imagery characteristics upon the interpretation of geographic patterns obtainable from orbital television sensors, and in order to better evaluate the influences of alternative sensor system parameters such as changes in orbital altitudes or scan line rates, this investigation designed the following experimental series of interpretation studies. A team of three professional interpreters independently mapped thematically the selected geographic phenomena that they could detect in orbital television imagery produced in the Remote Sensing and Interpretation Laboratory at Florida Atlantic University on a fourteen inch monitor and recorded photographically for analysis.

To minimize and test interpretation bias resulting from the differences among interpreters, three interpreters were used. The following two interpreters were geographers: Clark Cross who is particularly experienced with forestry photo-interpretation, and Richard Witmer, a physical geographer with interest in remote sensing. The third interpreter, research associate William Kuyper, has completed 23 years of photo-interpretation and research with the Air Force. Each interpreter was expected to have a general knowledge of the nature of the region but was also expected to avoid applying any specific knowledge not clearly discernible in the image. In each experiment, the smaller scale or grosser scan-line pattern was interpreted before viewing the next higher level of image refinement. The patterns separately interpreted included transportation routes, land use, and physical regions. Areas, imagery scale, and scan-line patterns were varied.

In selecting the photography to be used in simulating orbital television from the available images recorded by Gemini crews, the areas of consideration were limited to tropical or subtropical zones. Although the availability of good quality images were limited, particularly when a near vertical perspective was desired, sixteen images were secured in super-slide format from the NASA Applications Technology Center in New Mexico, and five were selected for this experiment. They are as follows:

CREW NO.	NASA/MCS NO	SCALE	LENS FOCAL LENGTH	ALTITUDE N.M.	LOCATION
VII	65-63806	1:2M	250mm	120	Cape Kennedy
VII	65-68807	1:2M	250mm	120	Cape Kennedy-DeLand
VII	65-82824	1:4M	80mm	120	Jacksonville
	65-45748	1:6M	80mm	140	Salton Sea
XII	66-63034	1:10M	38mm	140	Houston, Tex.

None of these photos were direct vertical views, although the Cape Kennedy image obliqueness was minor. No rectification of the images was attempted for this interpretation experiment, and the researchers were able to make some interesting evaluations of the influence of obliqueness upon the discrimination of phenomena. In estimating the scale of the images, a horizonal line through the mid-point of the slide was used as a basis for measurement. This estimated film scale is indicated on the thematic maps resulting from the interpretation studies.

The equipment system and procedures followed in simulating television observation of earth surfaces via means of the space photography have been described in the preceding Section One of this report. The resulting TV monitor image was carefully photographed by the most effective technique that resulted from a series of photographic systems test. The monitor image was then enlarged at actual size - 14 inches - and glossy prints on a medium weight paper were provided each of the interpreters.

To increase objectivity and maintain experimental controls, designed in part to reveal any differences in perception that might result from the previous experiences of the three scientists, the principal investigator established the following guidelines for the initial phase of the process:

1. No additional sources of data - such as maps or documented studies of the photo area- would be used by the interpreter.

2. Interpretation will proceed from the smallest to the largest scale imagery for an image series with a particular scan line rate, and changing image scale.

3. Interpretation will proceed from the least to the greatest scan line rate when image series are evaluated with different scan line intensities.

4. The interpreter may, as usual, draw upon his general background knowledge of physical geography, hydrology, agriculture, settlement patterns or other fields. His interpretation of the geographic patterns are expected to be rational assumptions based on his experience and understanding of the general character of the regions and the season of the photography. However, he should try to avoid prejudicing the process due to any specific knowledge of phenomena locations in the area based on other study or fieldwork. Decisions should be "read out" of the image.

5. Each interpreter should independently prepare a written summary of his observations on his interpretation experience and conclusions relative to the types of images processed as each phase of the study is completed.

PHASE I - INTERPRETING FOUR ENVIRONMENTS IMAGED AT VARIOUS SCALES AND TV SCAN LINE RATES

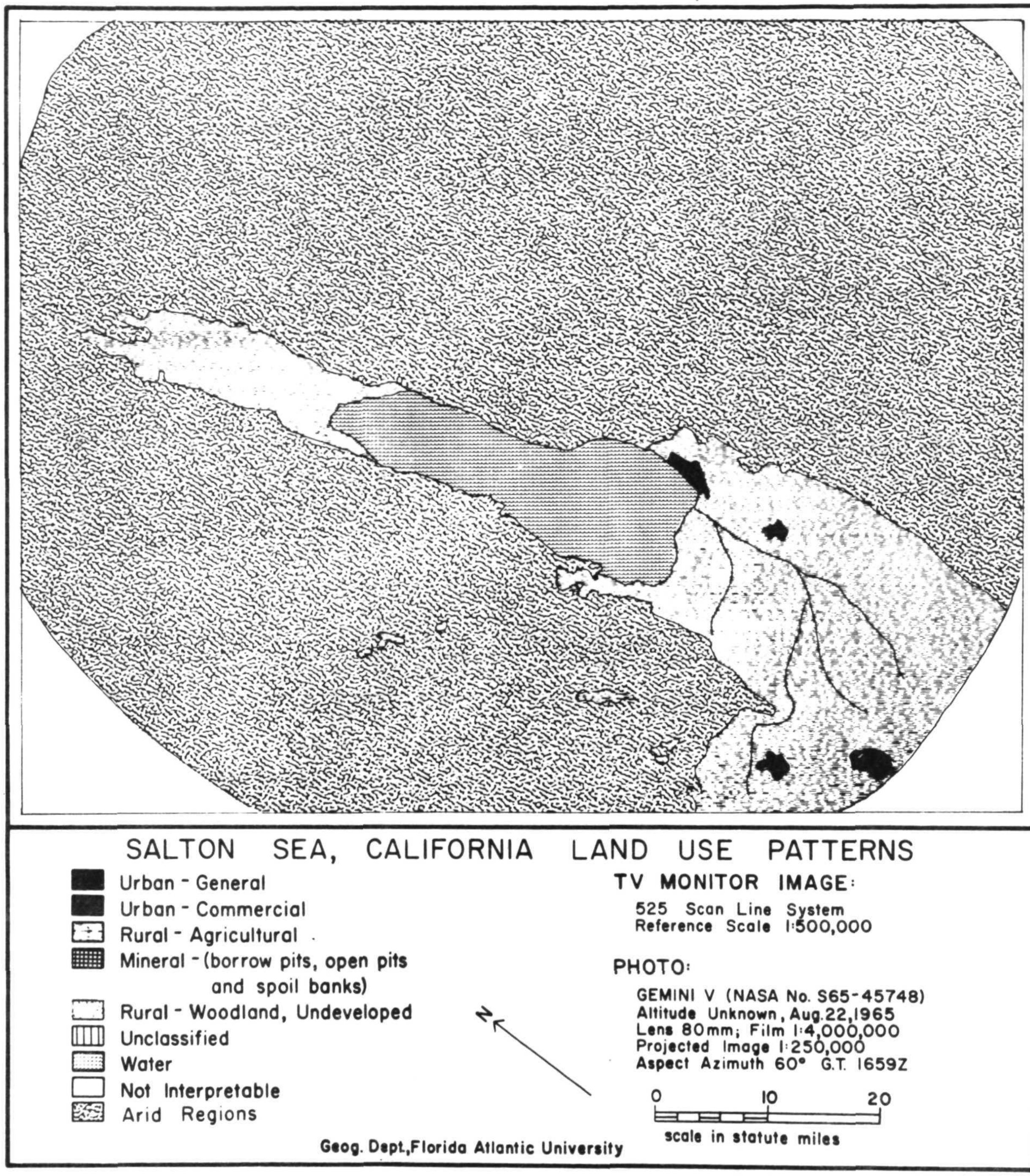
The interpretation studies were initiated with the evaluation of simulated imageries which were variously scaled on the monitor and presented with alternatives in scan line sampling intensity: either the 525 or 945 line systems. A famous view of the Imperial Valley, California-Mexico, was first interpreted, Figure 12 presents 525 scan line view of this area. The initial photography was taken with an 80 mm. lens from a relatively high orbit of 140 N.M. and at an oblique angle.

Figure 13 presents a thematic map of land use interpretation for the Salton Sea area which resulted from evaluation of the 525 image. In this and all the subsequent maps of this report, the scale of the map itself is indicated by the bar scale on the map. The term "Reference Scale" refers to the scale at which the region was viewed on the face of the TV monitor tube. The scale of the photography is indicated in two ways: (1) The scale of the film image which is being projected; and (2) the "projected image" scale as it appears on the rear view screen which simulates the earth surface viewed by the TV camera. This latter scale for a real orbital television system would be a function of the orbital altitude and the focal length of the camera lens.

In commenting upon interpretation of the 525 image, the following comments were made by the investigators: transportation patterns were not discernable - Airfield was annotated as I could see runway pattern - Agricultural patterns were pronounced in shape as sectional squares, but I could not identify types - I could not identify any particular portion of the urban area; only general outline- No linements (other than waterways) can be seen as transportation - Urban areas are differentiated from surrounding agricultural patterns by lighter tones and finer texture - Rudimentary suggestions of canal patterns seen.

Since all three interpreters agreed that the linear patterns associated with transportation routes were not evident - except for the airport runways - no attempt was

Figure 12. Simulated 525 scan line rate television image of Imperial Valley, California.



SALTON SEA, CALIFORNIA LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
Arid Regions
N
TV MONITOR IMAGE:
525 Scan Line System
Reference Scale 1:500,000
PHOTO:
GEMINI V (NASA No. S65-45748)
Altitude Unknown, Aug. 22, 1965
Lens 80mm; Film 1:4,000,000
Projected Image 1:250,000
Aspect Azimuth 60° G.T. 1659Z
0 10 20
scale in statute miles
Geog. Dept, Florida Atlantic University

Figure 13.

made to prepare a map of transportation for this area. It is apparent that both the scale of the imagery,and hence the resulting ground width for the scan lines,would make it impossible to resolve most routes. The obliqueness of the image may also contribute to the masking of roadways, since in irrigated areas they are apt to be lined with bushes or occasional trees. However, analyzing the 945 scan line rate image shown in Figure 14, one interpreter concluded that "increased resolution permits discrimination of several transportation lineaments.

As Figure 15 illustrates, the 945 image suggested only limited change in the land use patterns in this case; however, this map was not entirely representative. One geographer indicated that," It allows much greater detail to be interpreted concerning hydrologic patterns, especially surface streams and canals in the agricultural sections. Part of the image warranted an attempt to make large scale speculations concerning the patterns with light areas being considered land used for fruit and truck crops and the areas labeled as hay, pasture, and fallow." It is probable that some of the restriction upon the level of improvement from the increase to 945 scan lines is due to the fact that due to technical difficulties associated with the manufacture of the 945 monitor tube, it was yielding a "soft" image which reduced contrast and resolution. However the principal constraint upon the Imperial Valley television imagery was the considerable obliqueness in the photographic angle and the relatively high orbit.

Orbital television observation of the Houston-Galveston area of the East Coast of Texas was simulated with both the 525 and 945 scan line rates, but with the 525 system monitor scale at 1:350,000 while a smaller scale of 1:500,000 was studied with the 945 rate. The original photography was taken at the same 140 N.M. orbital altitude as the previous Salton Sea picture, but with a shorter focal length of 38mm. However, when the projected image viewed by the TV camera was at the same 1:500,000 scale as for the previously viewed image.

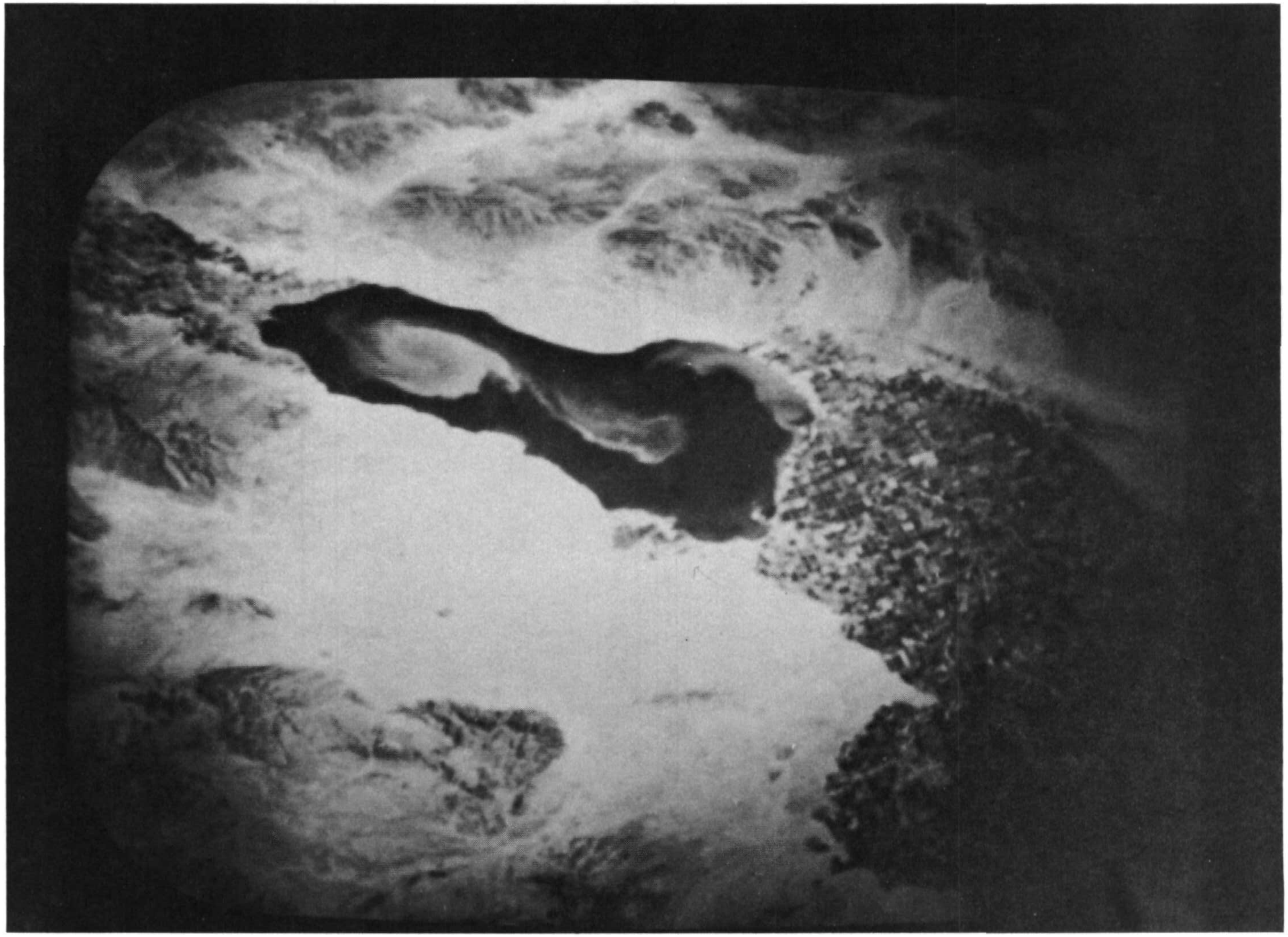


Figure 14. A 945 scan line rate simulated television image of Imperial Valley, California - Mexico - as imaged on 14 inch monitor.

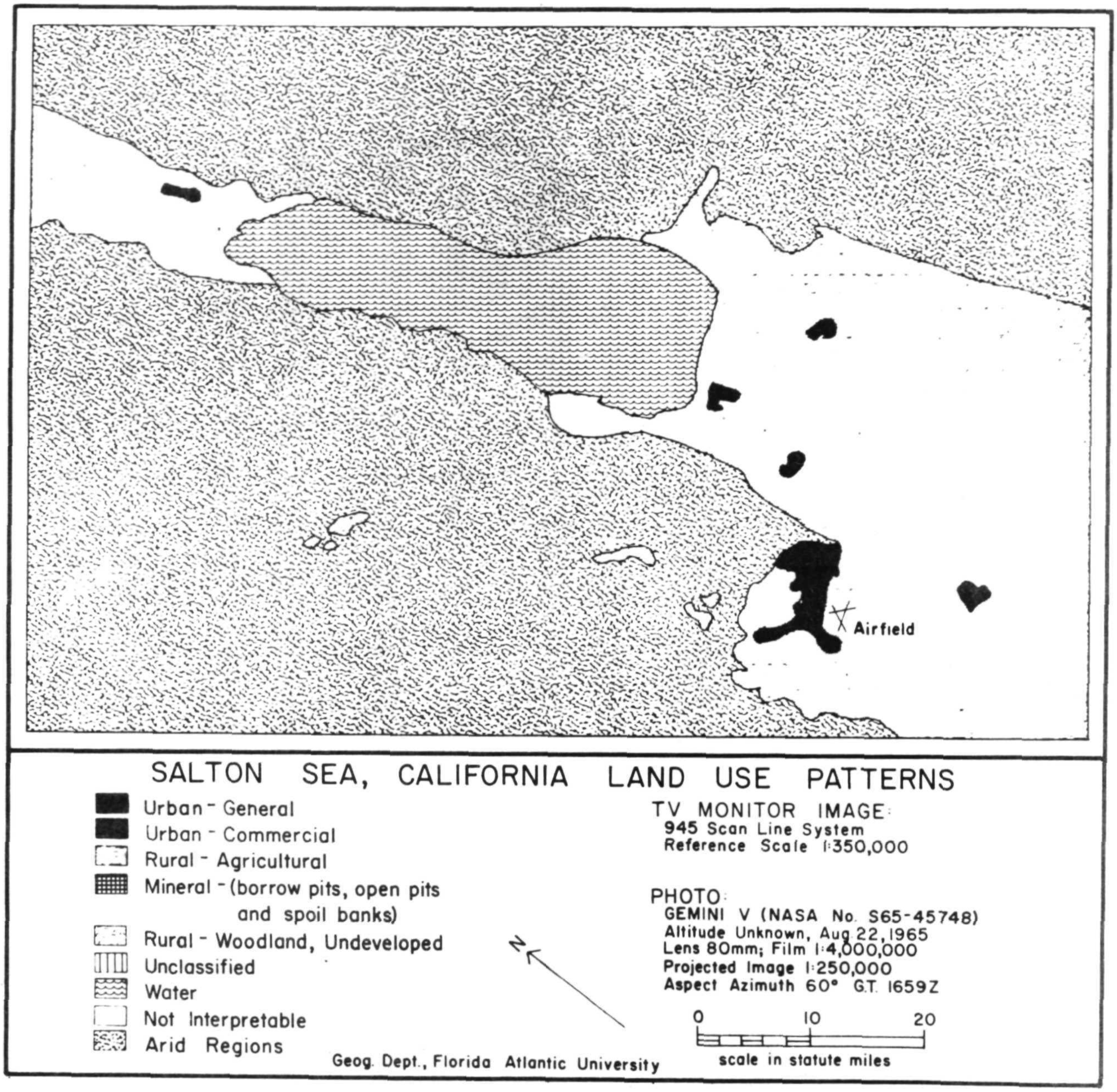
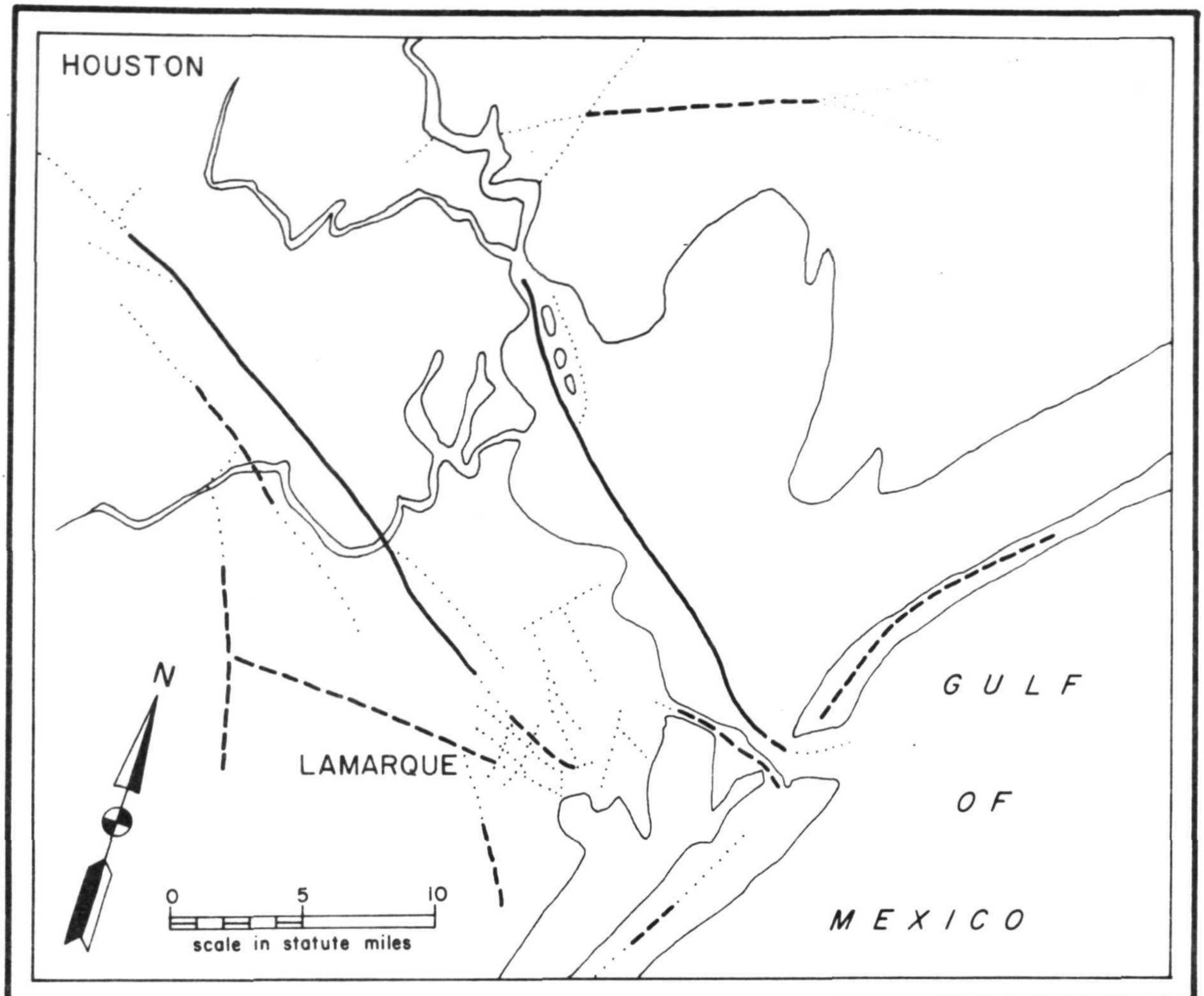

Airfield
SALTON SEA, CALIFORNIA LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
Arid Regions
N
TV MONITOR IMAGE:
945 Scan Line System
Reference Scale 1:350,000
PHOTO:
GEMINI V (NASA No. S65-45748)
Altitude Unknown, Aug 22, 1965
Lens 80mm; Film 1:4,000,000
Projected Image 1:250,000
Aspect Azimuth 60° G.T. 1659Z
0
10
20
scale in statute miles
Geog. Dept., Florida Atlantic University

Figure 15.

As Figure 16 indicates, significant elements of the transportation routes were discernable in the 1:350,000 image, even with only 525 lines, although only major route segments were seen by all three interpreters. The ship channel was interpreted by all since prominent spoil banks recorded strongly in even the TV image and a "darkened stripe" was "cutting almost striaght across the bay and exiting through the inlet."

Land use patterns are generalized into principal types in the Figure 17 map from the 525 line image interpretation. However, the analyst complained that in this image the "loss of information is tremendous and only very general patterns could be interpreted," consequently differentiations mapped were principally limited to a rural-urban difference and urban bounding was not very confident.Apparently this lack of definition is principally explained by the high orbit and short 38mm focal length for the orginal photography, and it demonstrates the disadvantages of short focal length for any imagery of earth resources.

Figure 18 images the Houston-Galveston area with 945 lines. The bright tones associated with urban area, beaches, and spoil banks are readily seen although this is a smaller scale image at 1:500,000 on the monitor. Figure 19 demonstrates that although monitor image scale has been reduced, the analysts discern more transportation pattern with this 945 line image, which has both more and narrower lines of scan. However, the increase in routes seen and agreed upon is not great, and may be limited by the fact that although scan line rate almost doubled, the imagery scale was reduced by more than one third. Similarly, the land use map of Figure 20 indicates a continuing inability to differentiate rural areas, which may reflect both the focal length limitations of the photography and the topography of the area. The 945 system however did encourage differentiating the "urban-commercial", since the lighter but coarser texture of the reflectance from congested structures of varying heights encouraged their separation from the other light gray urban tones.



EAST COAST OF TEXAS TRANSPORT PATTERNS

INTERPRETED AS TRANSPORT ROUTE BY:

.... Some 1 Analyst

– – – – – – 2 of the Analysts

———— All 3 Analysts

TV MONITOR IMAGE:

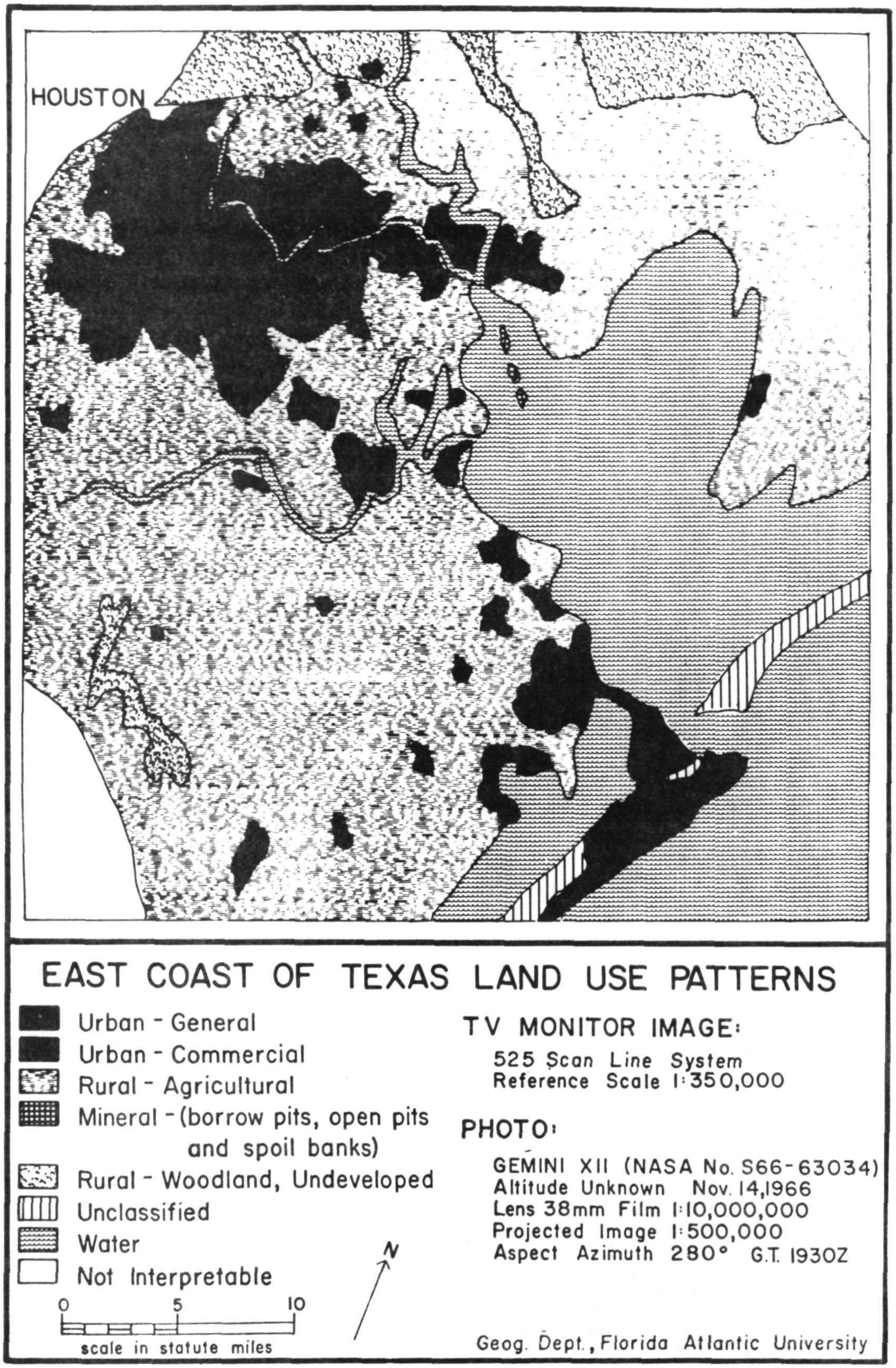
525 Scan Line System
Reference Scale 1:350,000

PHOTO:

GEMINI XII (NASA No. S66-63034)
Altitude Unknown Nov. 14, 1966 G.T. 1930Z
Lens 38mm Film 1:10,000,000
Projected Image 1:500,000
Aspect Azimuth 280°

Geog. Dept., Florida Atlantic University

Figure 16.



HOUSTON
EAST COAST OF TEXAS LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
0
5
10
scale in statute miles
N
TV MONITOR IMAGE:
525 Scan Line System
Reference Scale 1:350,000
PHOTO:
GEMINI XII (NASA No. S66-63034)
Altitude Unknown Nov. 14,1966
Lens 38mm Film 1:10,000,000
Projected Image 1:500,000
Aspect Azimuth 280° G.T. 1930Z
Geog. Dept., Florida Atlantic University

Figure 17.

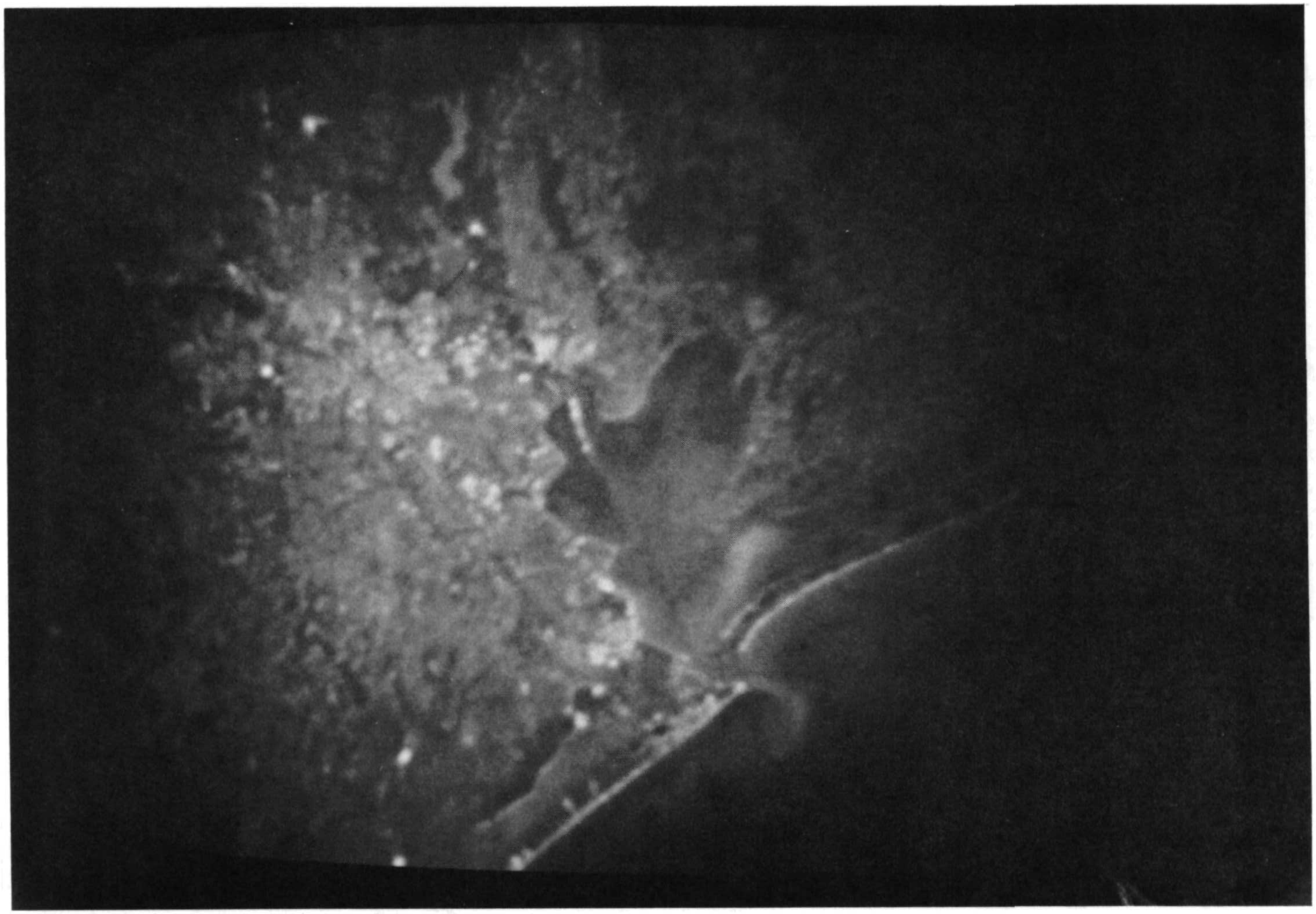


Figure 18. Simulated 945 scan line rate television image of the Houston-Galveston area of the East Coast of Texas, as imaged on the 14 inch monitor.

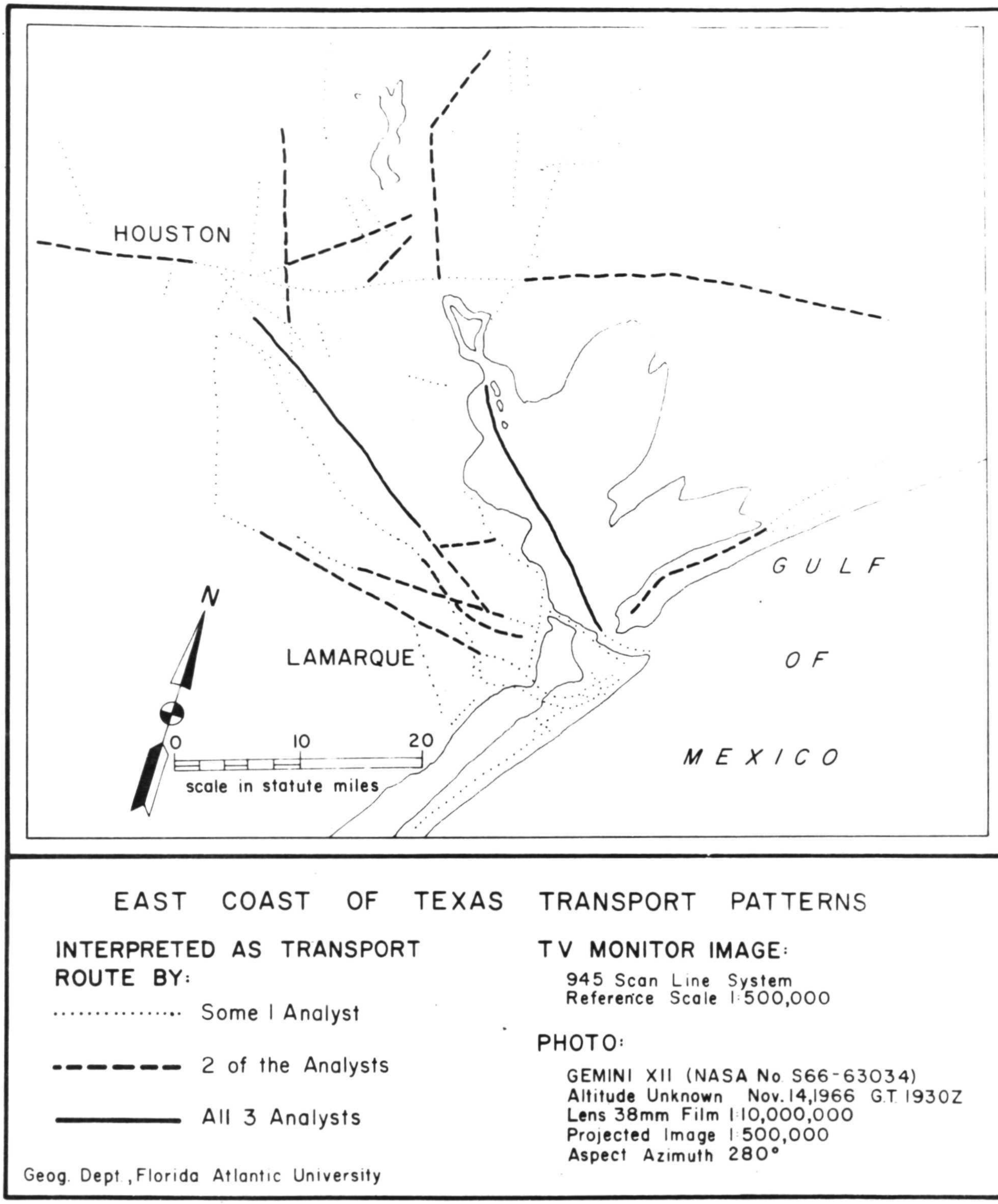

HOUSTON
LAMARQUE
GULF
OF
MEXICO
N
0
10
20
scale in statute miles
EAST COAST OF TEXAS TRANSPORT PATTERNS
INTERPRETED AS TRANSPORT ROUTE BY:
Some I Analyst
2 of the Analysts
All 3 Analysts
TV MONITOR IMAGE:
945 Scan Line System
Reference Scale 1:500,000
PHOTO:
GEMINI XII (NASA No. S66-63034)
Altitude Unknown Nov. 14, 1966 G.T. 1930Z
Lens 38mm Film 1:10,000,000
Projected Image 1:500,000
Aspect Azimuth 280°
Geog. Dept., Florida Atlantic University

Figure 19.

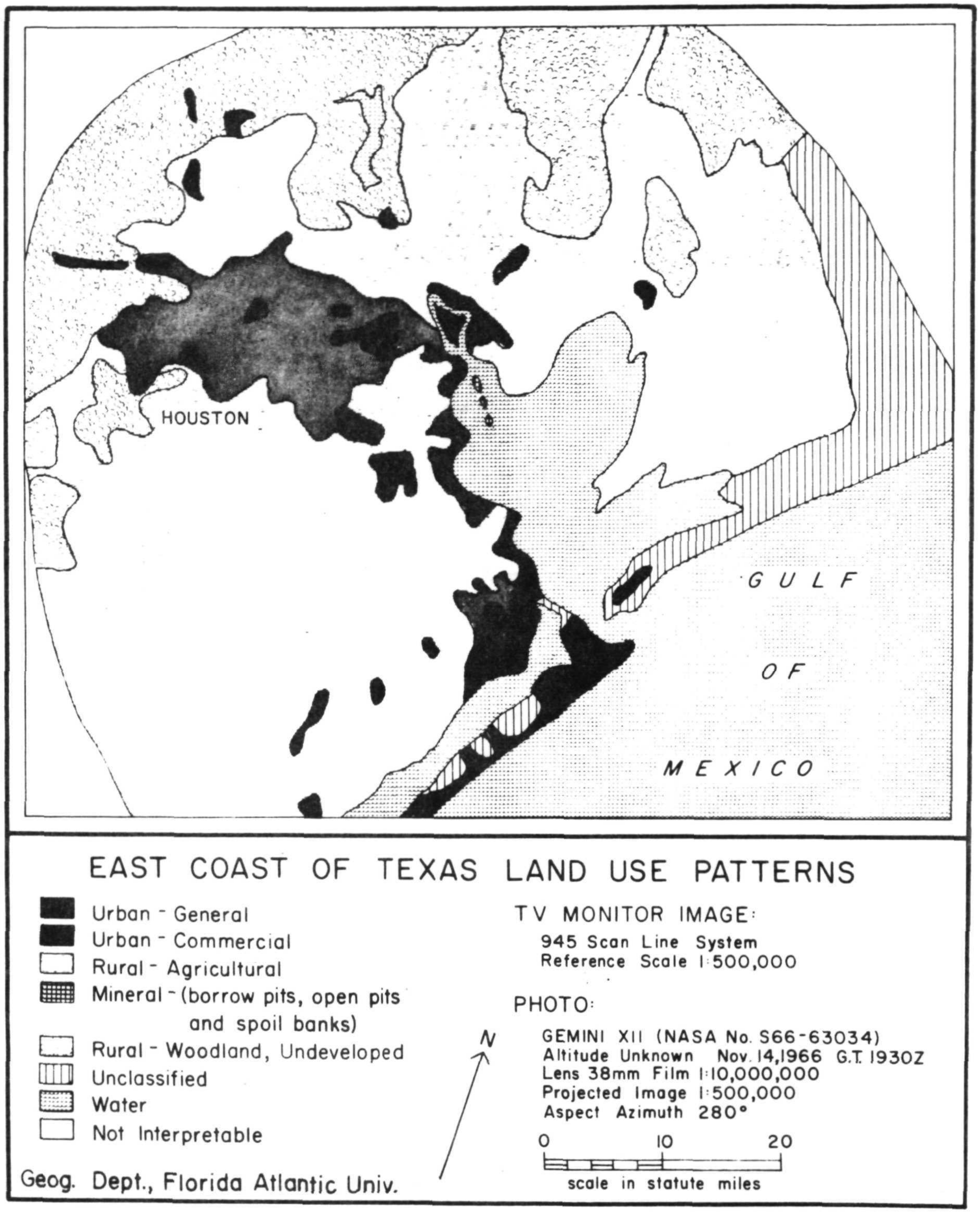

HOUSTON
GULF
OF
MEXICO
EAST COAST OF TEXAS LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
Geog. Dept., Florida Atlantic Univ.
N
TV MONITOR IMAGE:
945 Scan Line System
Reference Scale 1:500,000
PHOTO:
GEMINI XII (NASA No. S66-63034)
Altitude Unknown Nov. 14,1966 G.T. 1930Z
Lens 38mm Film 1:10,000,000
Projected Image 1:500,000
Aspect Azimuth 280°
0 10 20
scale in statute miles

Figure 20.

Northeast Florida's Jacksonville region is the third study area. Its mixed terrain types of woodland, fields, waterway, and urban uses provide an interesting pattern in Figure 21, which presents the 525 line image at a rather small 1:830,000 monitor scale. However, the original photograph was taken at almost a zero degree aspect azimuth from approximately 120 N.M. with an 80mm lens; and then scanned via a larger projected image scale of 1:400,000. It should be noted that the north-south orientation of the scan line pattern applied to this image relates closely to the overall orientation of both major natural features (e.g.: the coastline, beaches, and St. John River), and major cultural features (e.g.: highways and coastal settlements).

Although the monitor reference scale is smaller, the transportation mapping achieved in the 525 line interpretation presented as Figure 22 exhibits more detail than either of the preceding area studies. One interpreter explains that, "This image is somewhat of an anamoly. The fringe areas of the image are very dark and obscured, the central part of the image has a whitish obscured area, but the remainder is unusually clear and defined." There seems to be some evidence in this interpretation of linear features that the scan line azimuth adds significantly to the emphasizing of highways and other features with a comparable azimuth. Figure 23 maps land use patterns observed in the 525 line image. Separations of cropland and woodland were observed by the interpreters despite the small scale of the monitor image and the limits of the 525 line rate. However, they expressed some concern over the brightly generalized and exaggerated blooms that seem to show from the clearing of surface areas. In some cases these show a close relationship to highways and are probably large construction sites - as for the new shopping centers known to be developing south of the city. In other cases, they may be the open-pit mining of sands and other minerals that occurs here on old beach ridges.

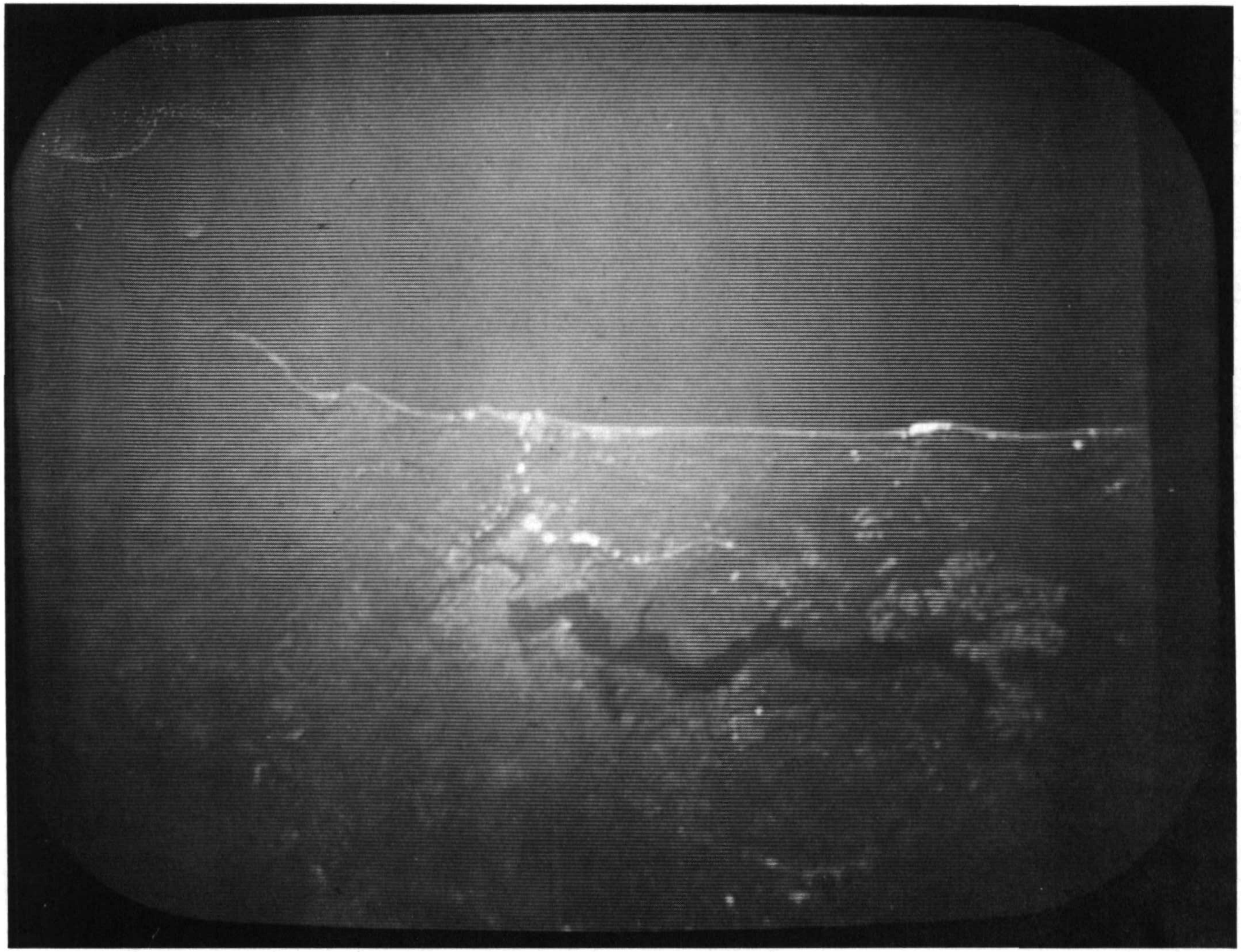
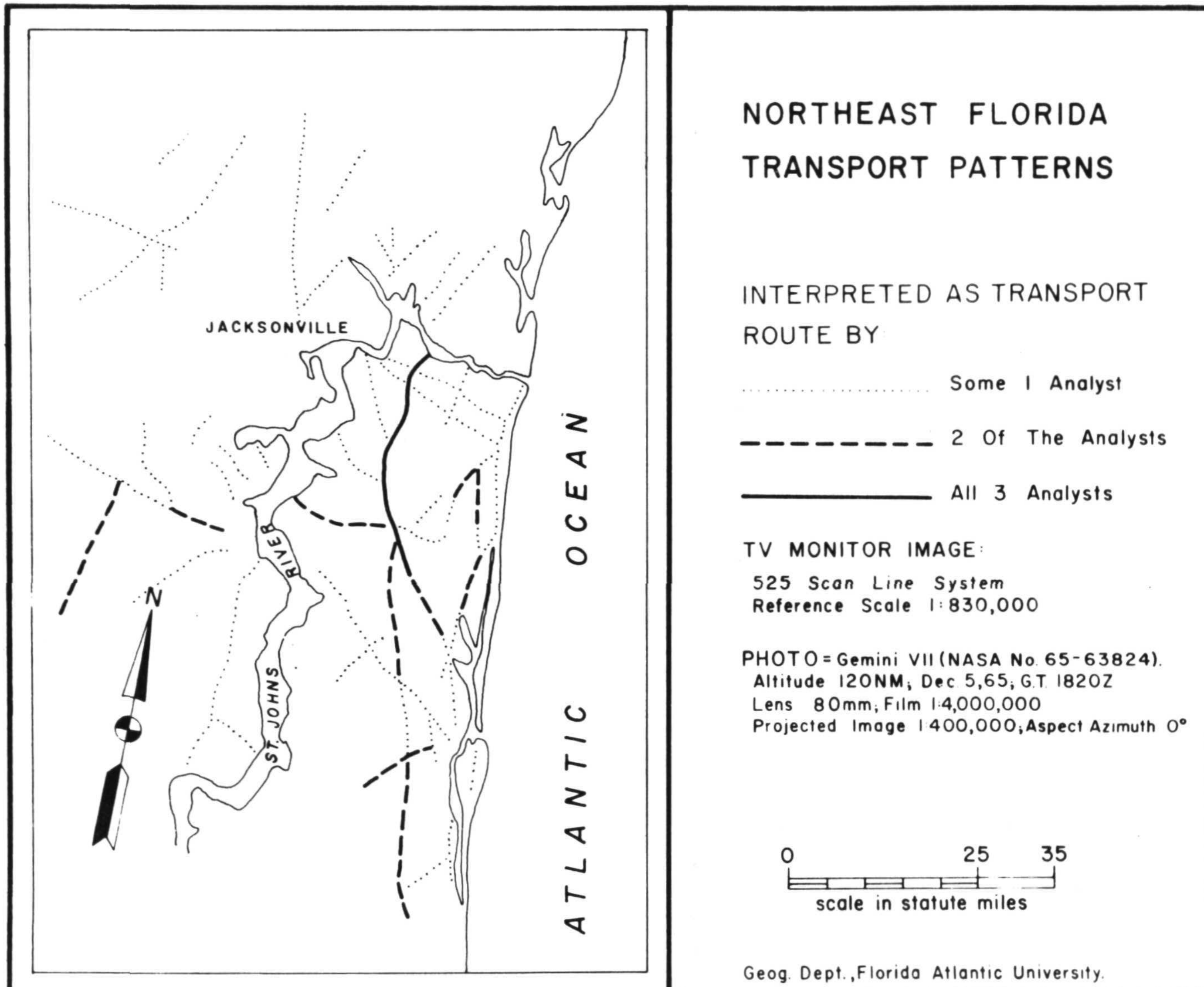


Figure 21. Simulated 525 scan line rate television image of Northeast Florida's Jacksonville area, as imaged on the 14 inch monitor.



JACKSONVILLE
ST. JOHNS
RIVER
N
ATLANTIC
OCEAN
NORTHEAST FLORIDA
TRANSPORT PATTERNS
INTERPRETED AS TRANSPORT
ROUTE BY
Some 1 Analyst
2 Of The Analysts
All 3 Analysts
TV MONITOR IMAGE:
525 Scan Line System
Reference Scale 1:830,000
PHOTO = Gemini VII (NASA No. 65-63824).
Altitude 120NM; Dec. 5,65; G.T. 1820Z
Lens 80mm; Film 1:4,000,000
Projected Image 1:400,000; Aspect Azimuth 0°
0
25
35
scale in statute miles
Geog. Dept., Florida Atlantic University.

Figure 22.

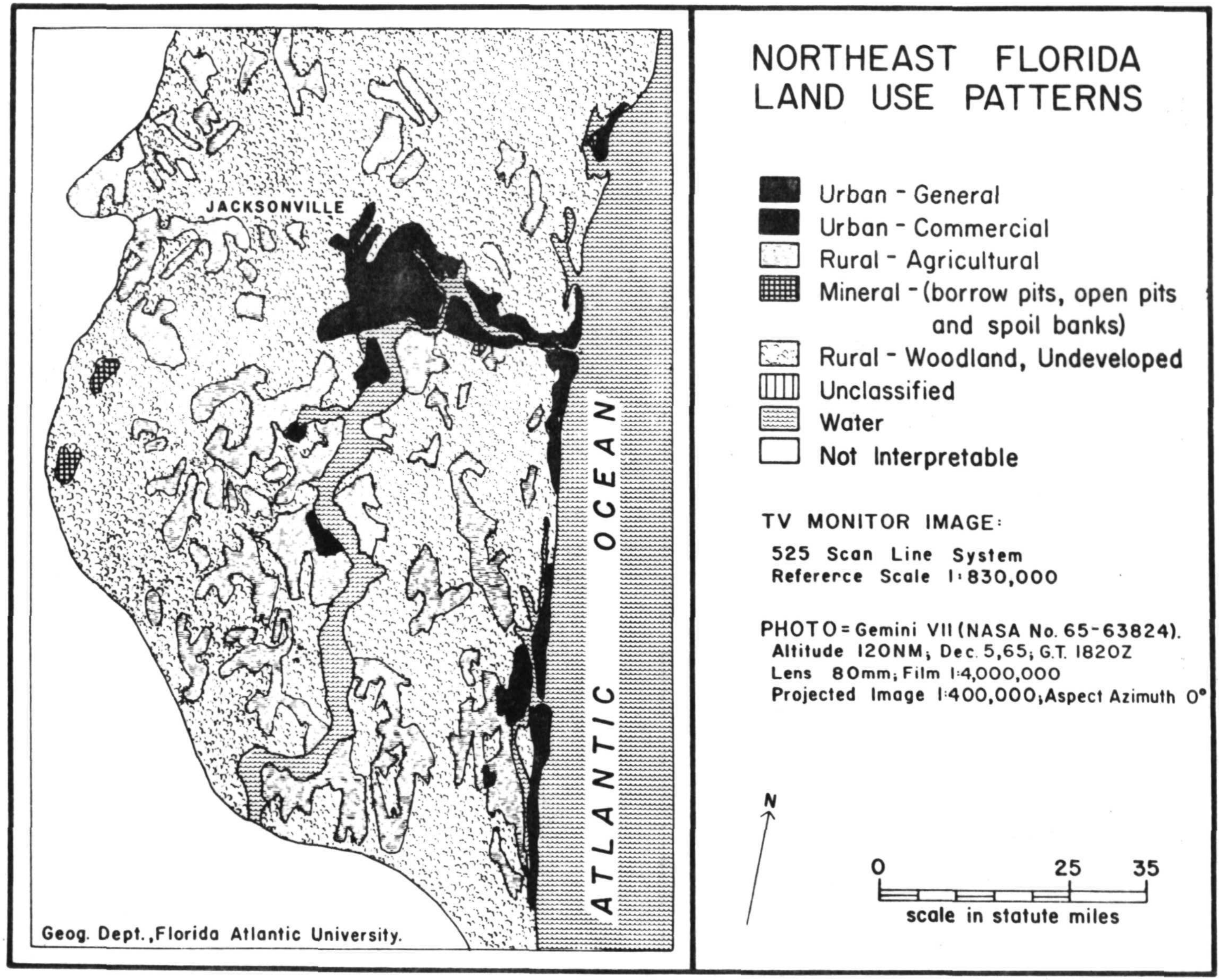

NORTHEAST FLORIDA
LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
TV MONITOR IMAGE:
525 Scan Line System
Refererce Scale 1:830,000
PHOTO = Gemini VII (NASA No. 65-63824).
Altitude 120NM; Dec. 5,65; G.T. 1820Z
Lens 80mm; Film 1:4,000,000
Projected Image 1:400,000; Aspect Azimuth 0°
N
0
25
35
scale in statute miles
JACKSONVILLE
ATLANTIC OCEAN
Geog. Dept., Florida Atlantic University.

Figure 23.

Figure 24 displays the 945 line image at a larger 1:500,000 scale on the monitor image. Since the original photography was partially covered by a slight haze, it represented a limitation that will be commonly experienced in orbital imagery of sub-tropical humid regions. The interpreter's remarks quoted in the above paragraph pointed out how this may create uneven definition of surface areas within one frame. It is noticeable in this monitor image that adjusting brightness to improve monitor sharpness in the area of principal interest may drop out imagery content from the monitor's other areas. Figure 25 presents the transportation patterns discerned on the 945 line tube face. There is a significant gain in detail, particularly as one moves further from image center. However, no interpreter claimed that the type of transport route could actually be interpreted from the scan line image. On flat terrain such as prevails here, one is deprived of clues that might separate roads from railroads, since the roads go as straight and are usually as gently curved as the railroads. Land use patterns determined with the 945 line image display somewhat more variety and precision in Figure 26. Both the larger reference scale and the increase in scan lines while decreasing scan line width contribute to this. Both urban and cleared agricultural areas were discriminated by their lighter tones in contrast to the general woodland background. Bright "blooms" earlier discussed were now often being classified as "Mineral". It is interesting that airports known to be in the area were not located by the interpreters in any of the Jacksonville imagery.

The physical geographer of the team also prepared a physical regions interpretation which is not illustrated here. He commented that, "The detail of the image was first interpreted for geomorphic and physiographic sub-regionalization, and categories arrayed in an inland (east to west) direction - i.e.: beach ridge, backwater, beach remnants, etc. The tonal and textural features which permit this sort of differentiation are, in this author's judgement, some of the most salient features to be found in imagery of this type.

Figure 24. Simulated 945 scan line rate television image of Northeastern Florida's Jacksonville area, as imaged on 14 inch monitor.

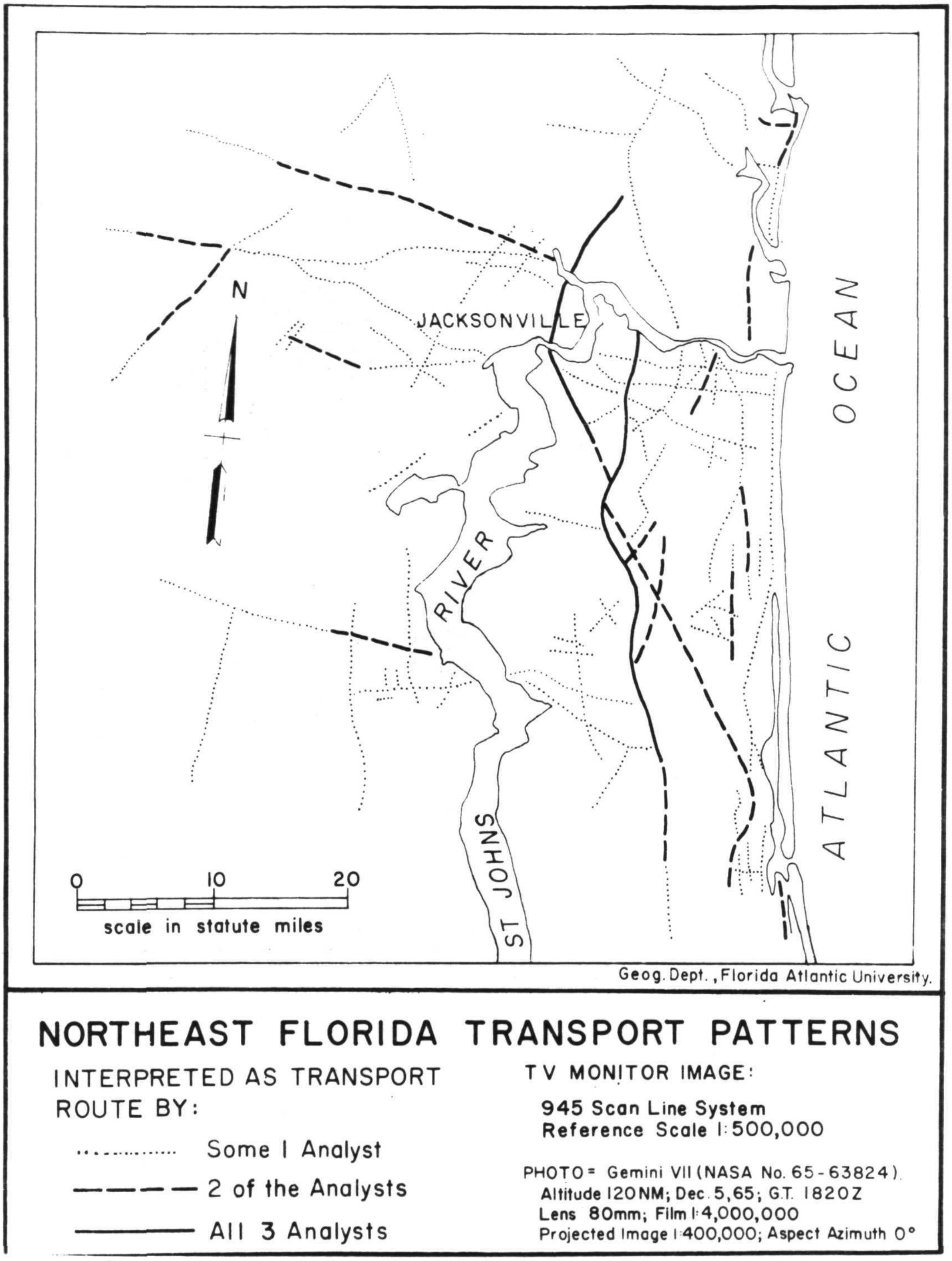

N
JACKSONVILLE
OCEAN
ATLANTIC
RIVER
ST JOHNS
0
10
20
scale in statute miles
Geog. Dept., Florida Atlantic University.
NORTHEAST FLORIDA TRANSPORT PATTERNS
INTERPRETED AS TRANSPORT ROUTE BY:
Some 1 Analyst
2 of the Analysts
All 3 Analysts
TV MONITOR IMAGE:
945 Scan Line System
Reference Scale 1:500,000
PHOTO = Gemini VII (NASA No. 65-63824).
Altitude 120NM; Dec. 5,65; G.T. 1820Z
Lens 80mm; Film 1:4,000,000
Projected Image 1:400,000; Aspect Azimuth 0°

Figure 25.

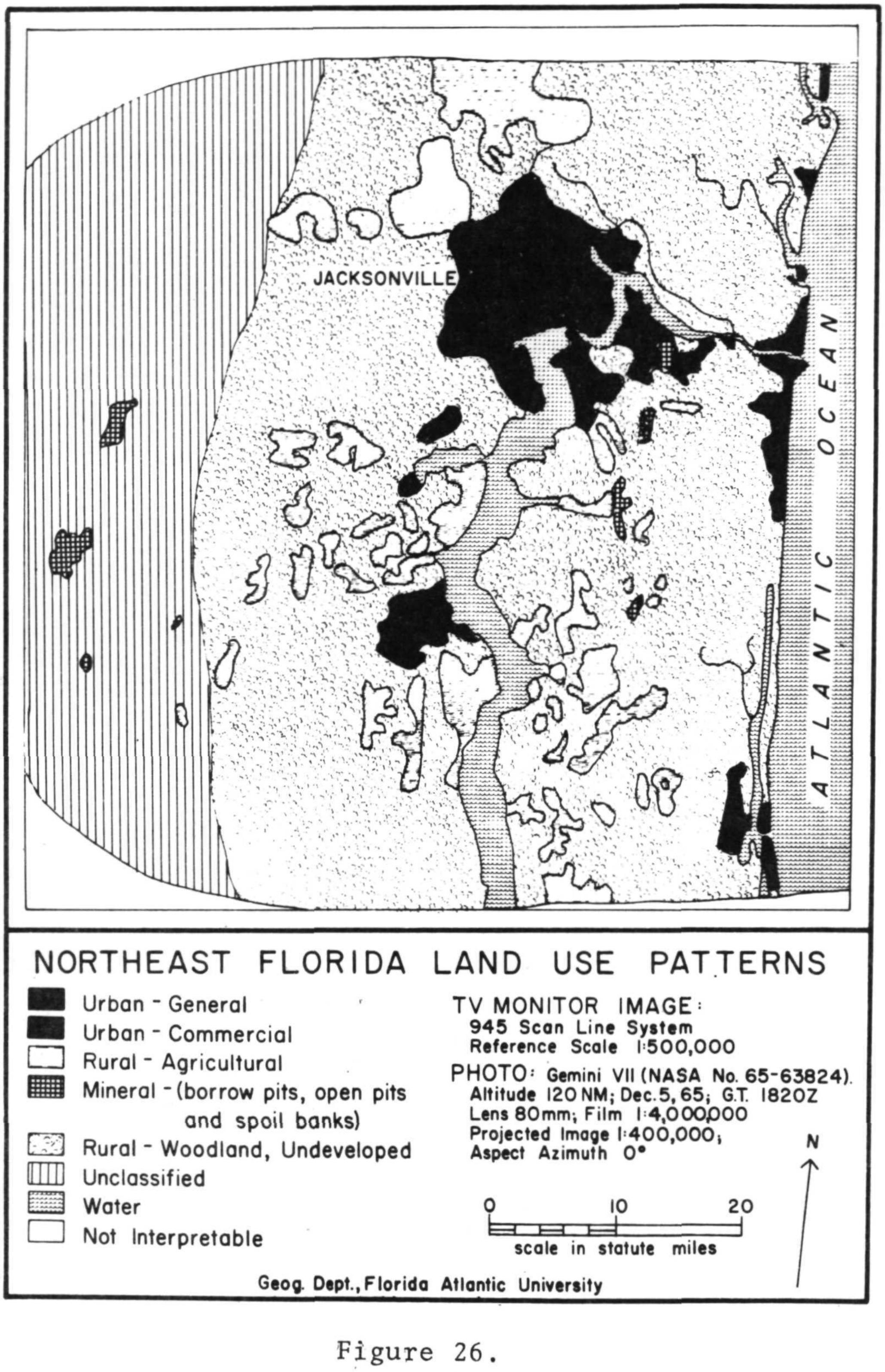

JACKSONVILLE
ATLANTIC OCEAN
NORTHEAST FLORIDA LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
TV MONITOR IMAGE:
945 Scan Line System
Reference Scale 1:500,000
PHOTO: Gemini VII (NASA No. 65-63824).
Altitude 120 NM; Dec. 5, 65; G.T. 1820Z
Lens 80mm; Film 1:4,000,000
Projected Image 1:400,000;
Aspect Azimuth 0°
N
0
10
20
scale in statute miles
Geog. Dept., Florida Atlantic University

Figure 26.

East Central Florida from Titusville to the Sanford and DeLand interior area was photographed with an oblique angle similar to the Imperial Valley scene, but this image was taken with the longer 250mm lens system and from a lower 120 N.M. orbit. Lines of transportation were more easily detected, as Figure 27 indicates for the analysis of 525 line imagery; and interpreters felt confident in actually identifying them as highways. It is interesting to note evidence that the oblique angle which centers the lens aspect angle on the Sanford-Deland region increases the road net detected in that area relative to the nearer Titusville area. Figure 28 indicates an interesting destribution of land use patterns but it is displayed on a background largely "unclassified" by the analyst working with the 525 line imagery. Once again the haze factor which inhibits humid coastal imagery is present, as indicated in the almost opaqueness that is generated as one moves toward Cape Kennedy.

Figure 29 makes the haze problem clear in this 945 line monitor image. It contributes to the difficulty of differentiating rural terrain types, and this image is also handicapped somewhat by the "soft" aspect of the 945 monitor tube. However, as Figure 30 displays, the longer lens and lower orbit did permit the interpreters to detect an interesting detail in transportation patterns with this 945 system, with a considerable network of roadways particularly observed in the Sanford vicinity. However, the 945 image still provides little basis for discriminating rural land use types, as Figure 31 indicates, although most of the previously "unidentified" category for the 525 image has now been generalized as "Rural-Woodland, Undeveloped." Near the coast some evidence of beach ridge and paralleling wet swales were observed in the pattern but their exact use was not clear.

All interpretation of the imaged environments analyzed above was accomplished without the use of any magnifying equipment on prints from photographs of the 14 inch television monitor tube which were at the same size as the monitor. Imagery resolution seemed to range between 100 to 200 feet at best with no individual buildings identifiable but linear features such as roads and bridges were detectable. Scale selection was extended to 1:250,000 on the screen if the imagery permitted enlargement to that scale. The Houston image was enlarged only to 350,000 because the scan line picture on the TV monitor actually lost detail at a larger reference scale.

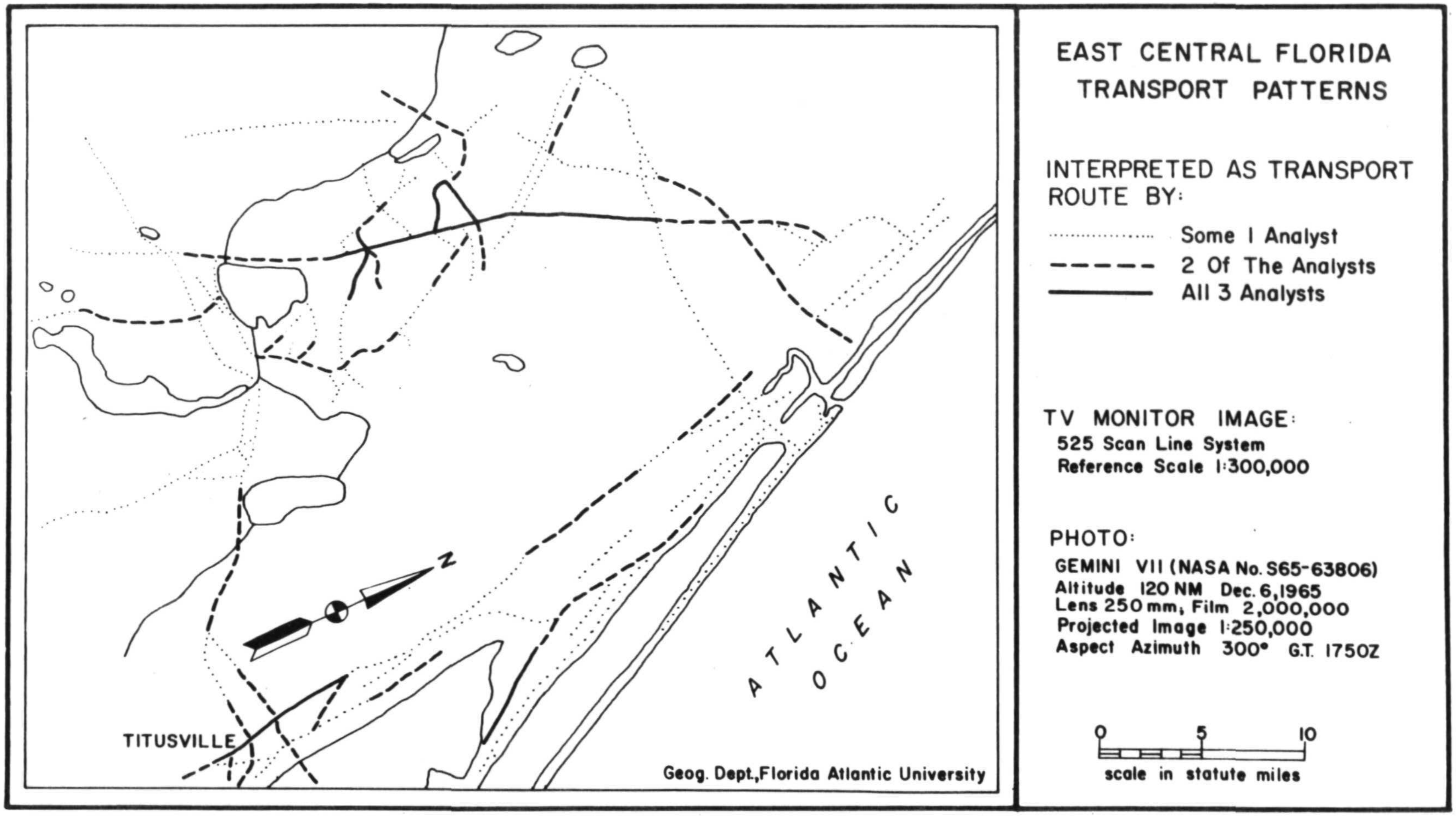
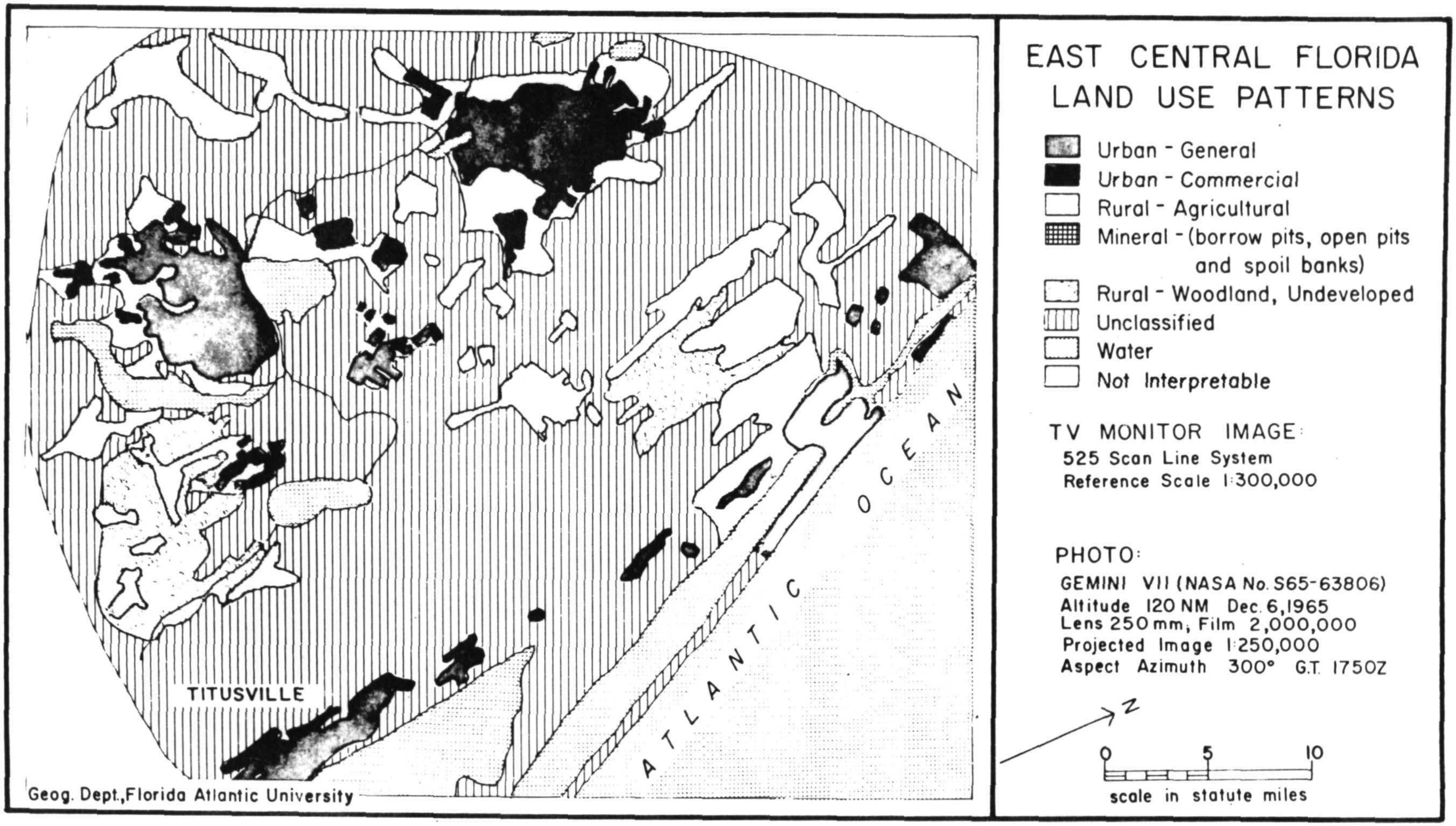

EAST CENTRAL FLORIDA
TRANSPORT PATTERNS
INTERPRETED AS TRANSPORT ROUTE BY:
Some I Analyst
2 Of The Analysts
All 3 Analysts
TV MONITOR IMAGE:
525 Scan Line System
Reference Scale 1:300,000
PHOTO:
GEMINI VII (NASA No. S65-63806)
Altitude 120 NM Dec. 6, 1965
Lens 250 mm; Film 2,000,000
Projected Image 1:250,000
Aspect Azimuth 300° G.T. 1750Z
0
5
10
scale in statute miles
N
TITUSVILLE
ATLANTIC
OCEAN
Geog. Dept., Florida Atlantic University

Figure 27.



EAST CENTRAL FLORIDA
LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
TV MONITOR IMAGE:
525 Scan Line System
Reference Scale 1:300,000
PHOTO:
GEMINI VII (NASA No. S65-63806)
Altitude 120 NM Dec. 6, 1965
Lens 250 mm, Film 2,000,000
Projected Image 1:250,000
Aspect Azimuth 300° G.T. 1750Z
N
0
5
10
scale in statute miles
TITUSVILLE
ATLANTIC OCEAN
Geog. Dept., Florida Atlantic University

Figure 28

Figure 29. Simulated 945 scan line rate television image of the East Central Florida area from Titusville to the Sanford-DeLand region as photographed from a 14 inch monitor.

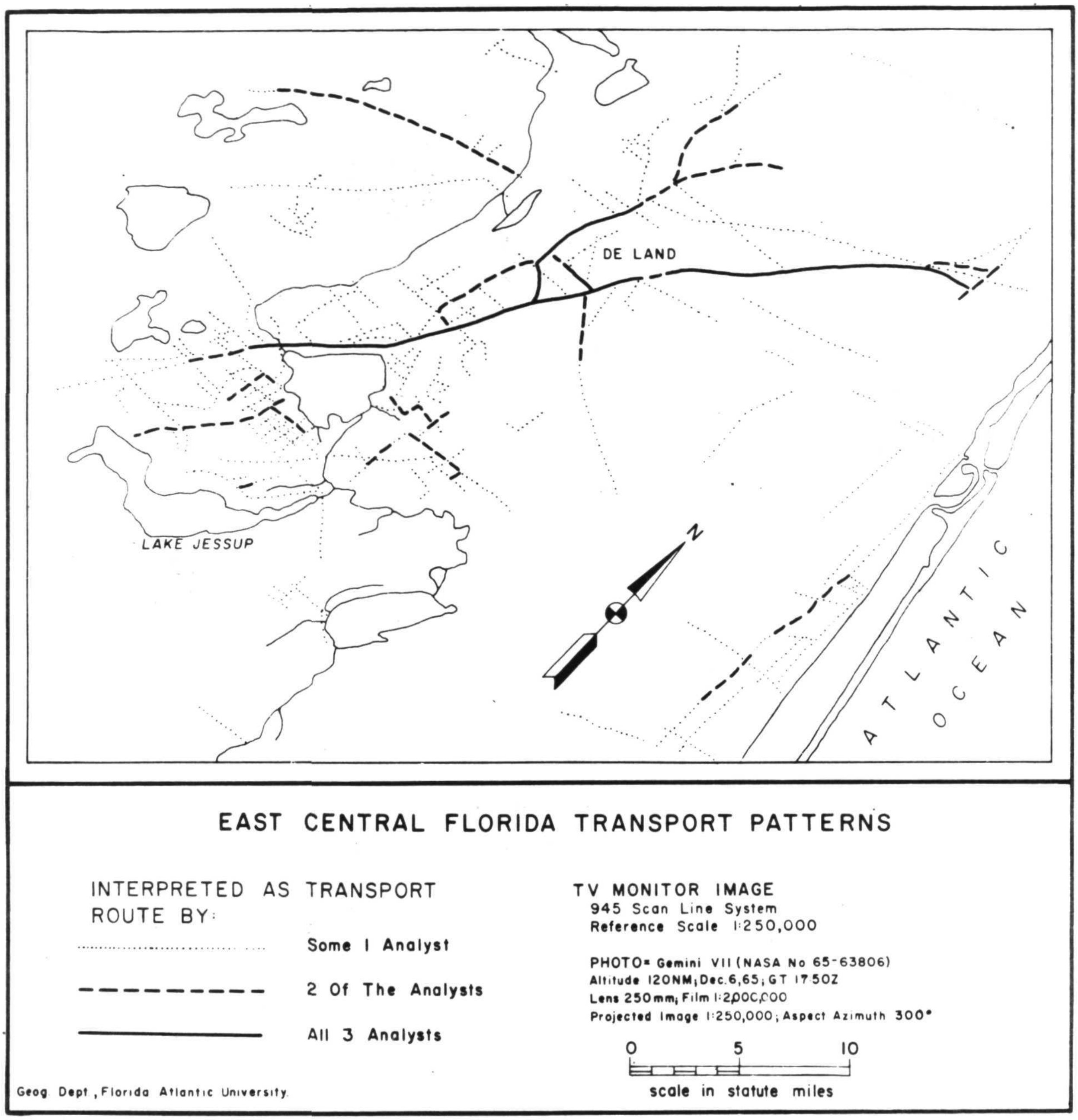

DE LAND
LAKE JESSUP
ATLANTIC OCEAN
N
EAST CENTRAL FLORIDA TRANSPORT PATTERNS
INTERPRETED AS TRANSPORT ROUTE BY:
Some 1 Analyst
2 Of The Analysts
All 3 Analysts
TV MONITOR IMAGE
945 Scan Line System
Reference Scale 1:250,000
PHOTO= Gemini VII (NASA No 65-63806)
Altitude 120NM; Dec. 6,65; GT 17.50Z
Lens 250mm; Film 1:2,000,000
Projected Image 1:250,000; Aspect Azimuth 300°
0 5 10
scale in statute miles
Geog. Dept., Florida Atlantic University

Figure 30.

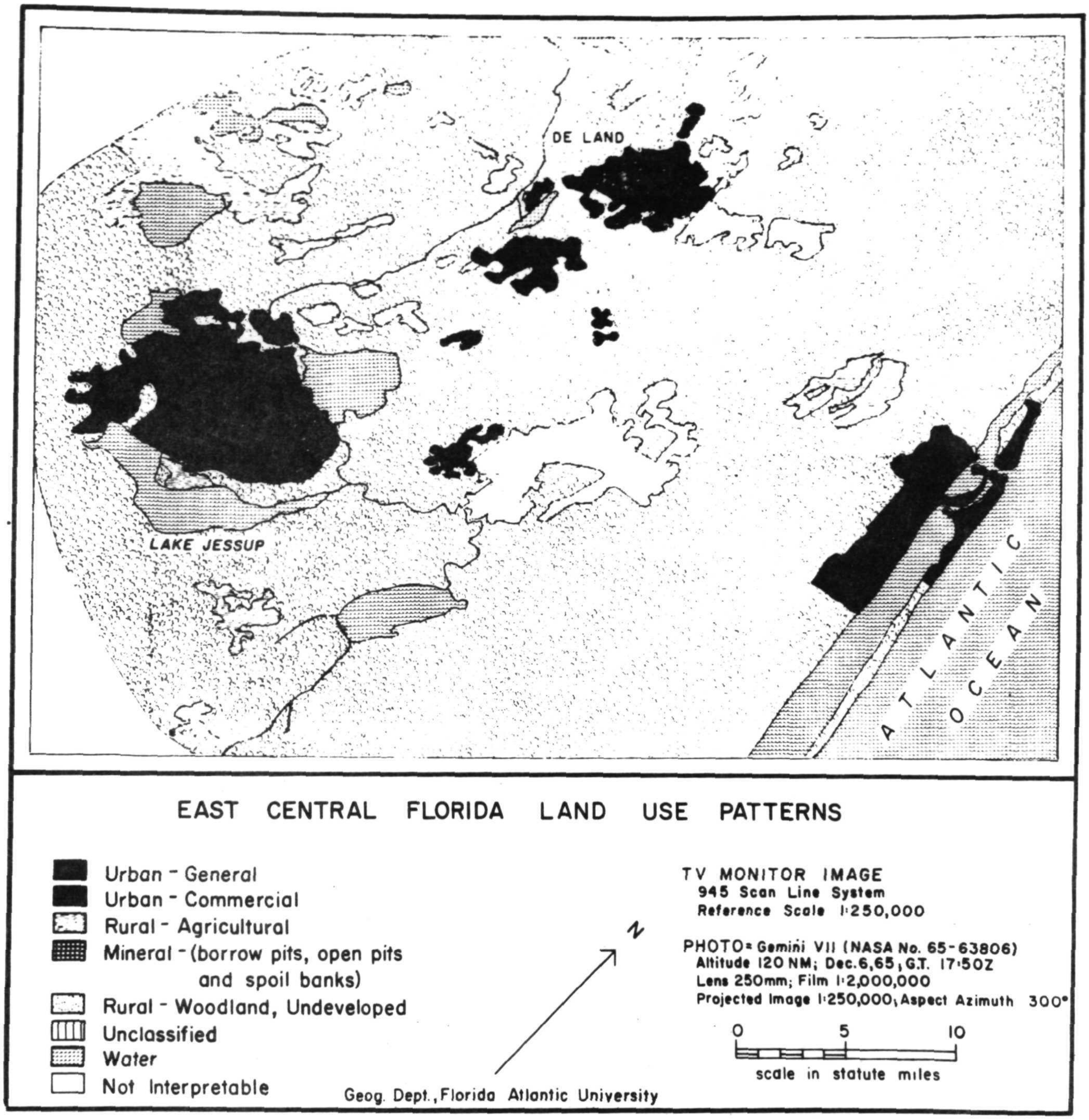

DE LAND
LAKE JESSUP
ATLANTIC
OCEAN
EAST CENTRAL FLORIDA LAND USE PATTERNS
Urban - General
Urban - Commercial
Rural - Agricultural
Mineral - (borrow pits, open pits and spoil banks)
Rural - Woodland, Undeveloped
Unclassified
Water
Not Interpretable
N
Geog. Dept., Florida Atlantic University
TV MONITOR IMAGE
945 Scan Line System
Reference Scale 1:250,000
PHOTO= Gemini VII (NASA No. 65-63806)
Altitude 120 NM; Dec.6,65; G.T. 17:50Z
Lens 250mm; Film 1:2,000,000
Projected Image 1:250,000; Aspect Azimuth 300°
0
5
10
scale in statute miles

Figure 31

PHASE II- INTERPRETING FOUR SCALE ALTERNATIVES IN SIMULATED TV IMAGERY WITH EITHER A 525 OR 945 SCAN LINE RATE

On the basis of the experience and perception gained in Phase I, the Principal Investigator and the three Interpretation Associates initiated a controlled experiment to more precisely evaluate how changes in the scale of television images, such as those that might result from alternate choices in orbital altitudes or optical focal length, would influence the detection and thematic mapping of transportation and land use patterns. The near vertical image of the Titusville area west of Cape Kennedy was chosen for the study since it was judged the best available at that time. It was taken with the 250mm. lens from an orbital altitude of 120 N.M. and contained good resolution and pattern definition. It included the partial cloud and haze attenuation that is typical in the humid coastal region, however this was a serious handicap only over the Cape area, and did not seriously handicap the mainland Titusville region in which the researchers were interested. Technical problems which the image attenuation presented when scanned in order to generate a television image with a good gray tone balance were present but manageable.

It was determined that systematic hierarchial scale changes in the television monitor image would be studied with the following scales examined in the sequence given: 1:1,000,000, 1:500,000, 1:250,000 and 1:125,000. Only the area which would be bounded by the full size monitor view at the 1:125,000 reference scale would be interpreted at each scale, even though the monitor image would contain more area at the smaller scales. To provide some uniformity among interpreters, a time limit of two weeks was placed on their interpretation of each set of four images provided.

The first set of four 525 scan line rate images were provided, with mylar overlays bounding the area to be interpreted, and the interpreter analyzed the alternate scales in ascending scale order. After completing the transportation and land use analysis on this set, he was provided similarly with a set of four 945 scan line rate photoprints of the monitor face. All prints were made at actual monitor size. It was assumed that all three interpreters knew the location of the area and the nature of its region. They were instructed to maximize the detail of the interpretation that could be based on the actual imagery patterns. Each man processed his assignment independent of the other interpreters. No maps or written materials on the area were to be used by the interpreters.

Figure 32 displays the 525 scan line rate image as displayed on the 14 inch monitor at the maximum 1:125,000 scale. It bounds the entire area to be evaluated by the researchers at any scale. Of course the glossy monitor-sized prints from which the interpreters worked were much better renditions of the actual monitor image than this reduced size report print. The reference scale on the monitor tube did of course vary with the four alternatives but original film scale, estimated at 1:2,000,000 for this image, was always projected on the rear view screen at the 1:250,000 ratio for viewing by the TV camera.

Figure 33 presents the transportation patterns interpreted from the 525 image at 1:1,000,000. In view of the fact that this image encompasses only about 50 scan lines each of which have considerable ground width at this scale, a rather surprising amount of information could be interpreted. The major turnpike route was observable, although this was undoubtably assisted by the recency of construction and the "bloom" effect of a cleared sandy surface, and might not be so obvious with a later more vegetated pathway. Major coastal waterways were seen, and several possible interior highways.

With the increase to the 1:500,000 scale mapped in Figure 34, much more detail is available. Many roadways are seen by the interpreters and the coastal waterways are seen as well as the bridges or causeways spaning them. Interpreters commented they could be confused in urban areas with a tone response from buildings but in the open country they could be interpreted with confidence.

The most noticeable increase is the amount of data that can be mapped occurs as one moves from the previous scale to the 1:250,000 presentation of Figure 35. Agreement among interpreters has increased as well as the number of routes each has discerned. In the words of one interpreter, "At this scale, faint photo traces appeared which could be interpreted as roads. At the scale previous, these traces were not evident. The better road net made delineation of the urban complex easier."

At the largest scale of 1:125,000 routes of transportation are quite extensive within the 525 raster scan lines image compiled in Figure 36. One analyst commented that, "Several more roads are visible on this image, but land/water contacts are poorly represented outside the central area." Another one concluded that, "at this scale road patterns will not be interpreted with appreciably greater accuracy than at the scale of 1:250,000."

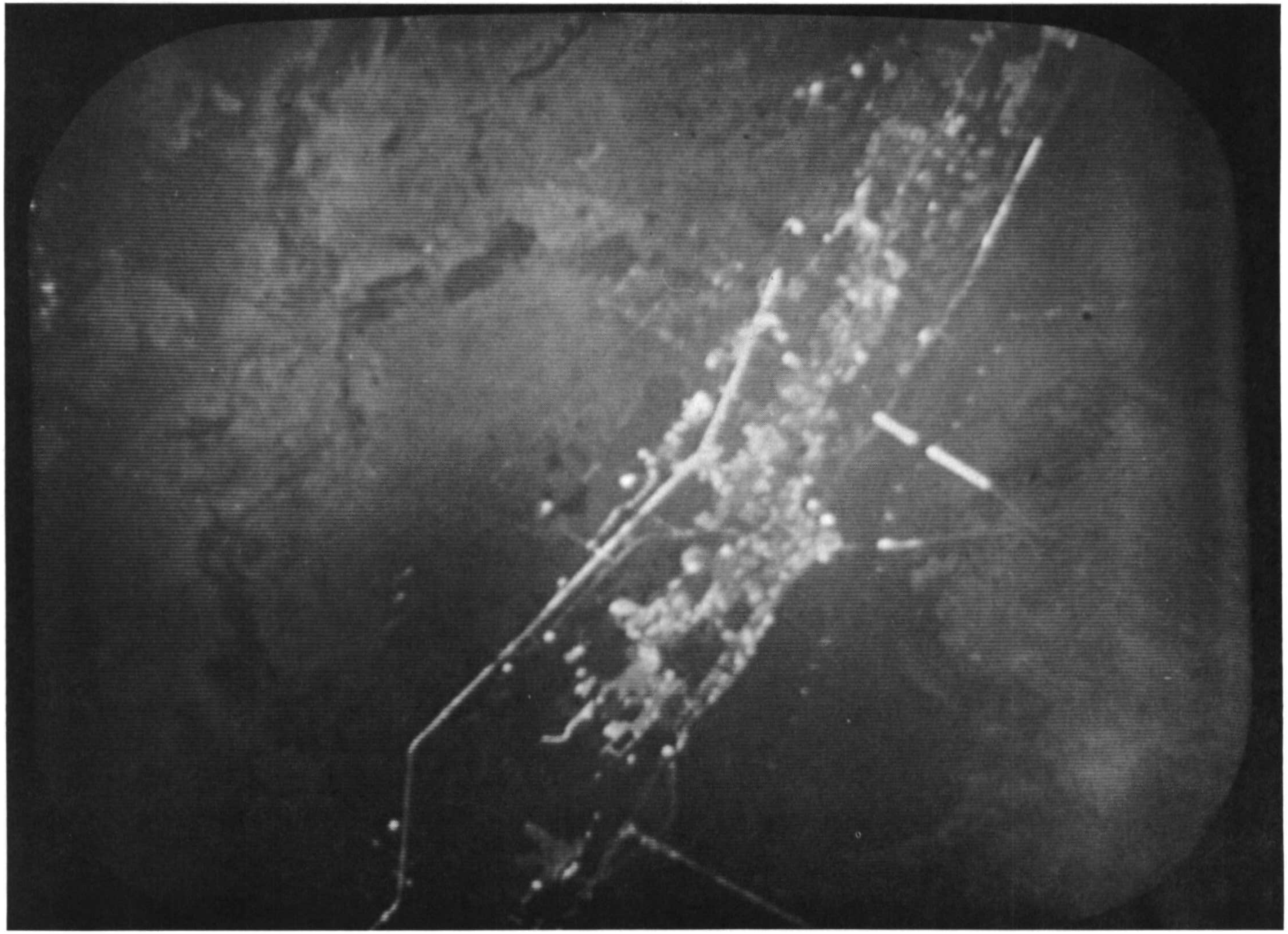


Figure 32. A 525 scan line rate simulated television image of the East Coast Florida Titusville area as displayed on a 14 inch monitor at a scale of 1:125,000.

EAST CENTRAL FLORIDA TRANSPORTATION PATTERNS

REFERENCE SCALE 1:1,000,000

INTERPRETED AS TRANSPORTATION ROUTE BY:

.... Some 1 Analyst
– – – 2 Of The Analysts
——— All 3 Analysts

TV MONITOR IMAGE

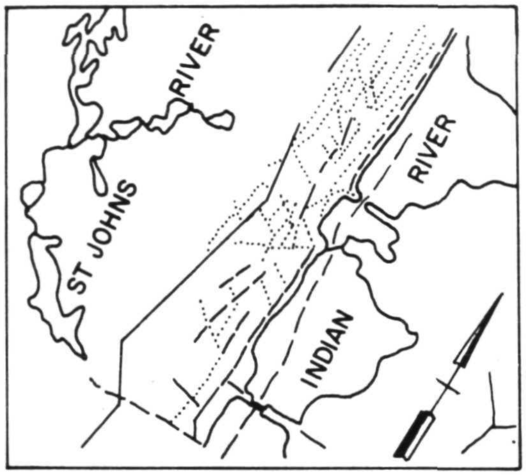
525 Scan Line System
Scale as Above

PHOTO= GEMINI VII (NASA No. 65-63806)
Altitude 120NM Dec 6, 1965
Lens 250mm, Film Scale=1:2,000,000
Projected Image Scale= 1:250,000
Aspect Azimuth 300° GT 1750Z

0 5 10 15 30
scale in statue miles

Geog. Dept., Florida Atlantic Univ.

Figure 33.



EAST CENTRAL FLORIDA TRANSPORTATION PATTERNS

REFERENCE SCALE 1:500,000

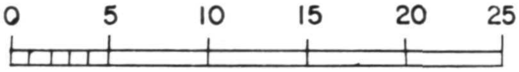
INTERPRETED AS TRANSPORTATION ROUTE BY

.... Some 1 Analyst
– – – – 2 Of The Analysts
———— All 3 Analysts

TV MONITOR IMAGE

525 Scan Line System
Scale as Above

PHOTO = GEMINI VII (NASA No. 65-63806)
Altitude 120 NM Dec 6, 1965
Lens 250mm, Film Scale 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT 1750 Z



scale in statute miles

Geog. Dept., Florida Atlantic University

Figure 34.

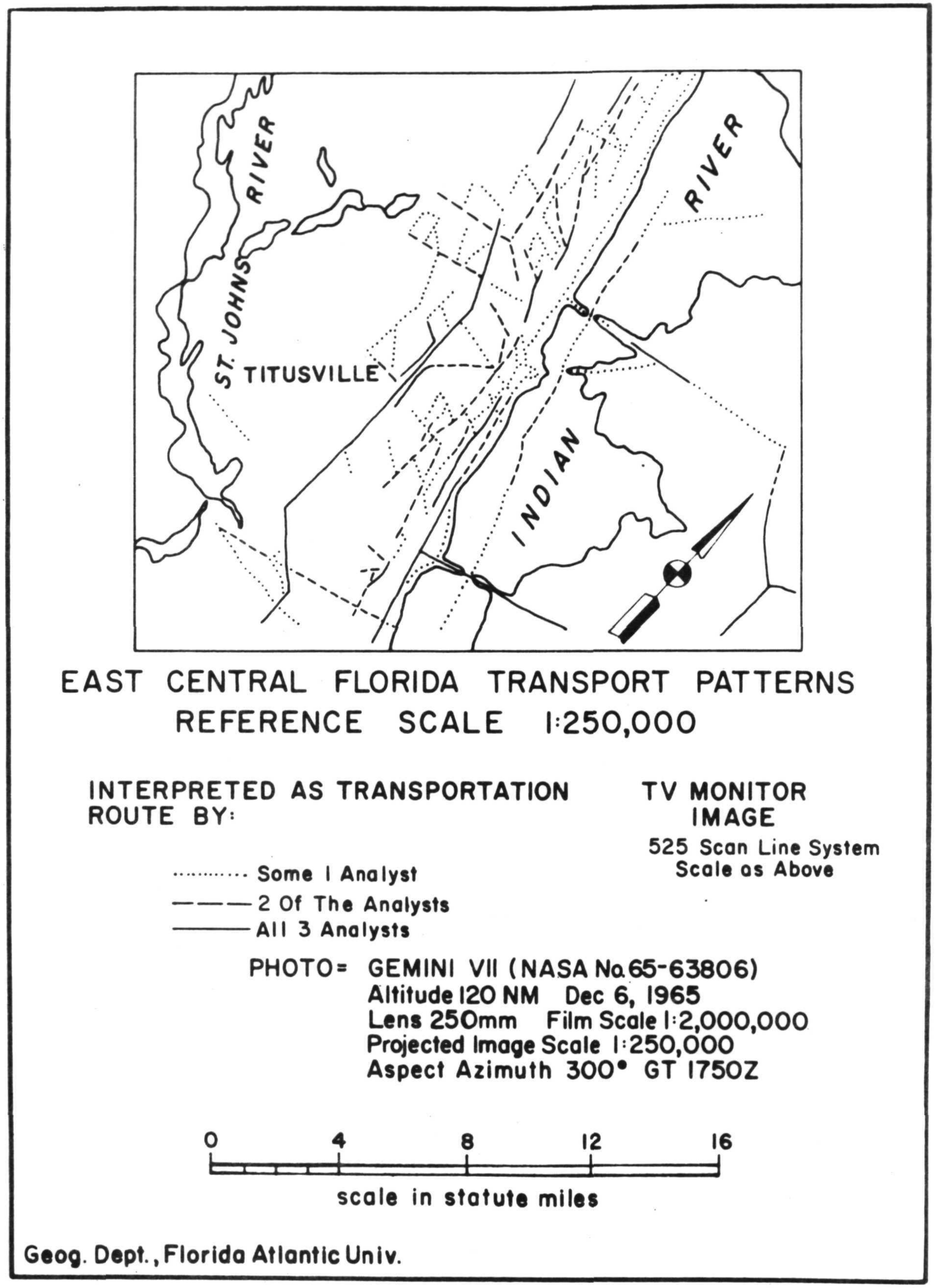
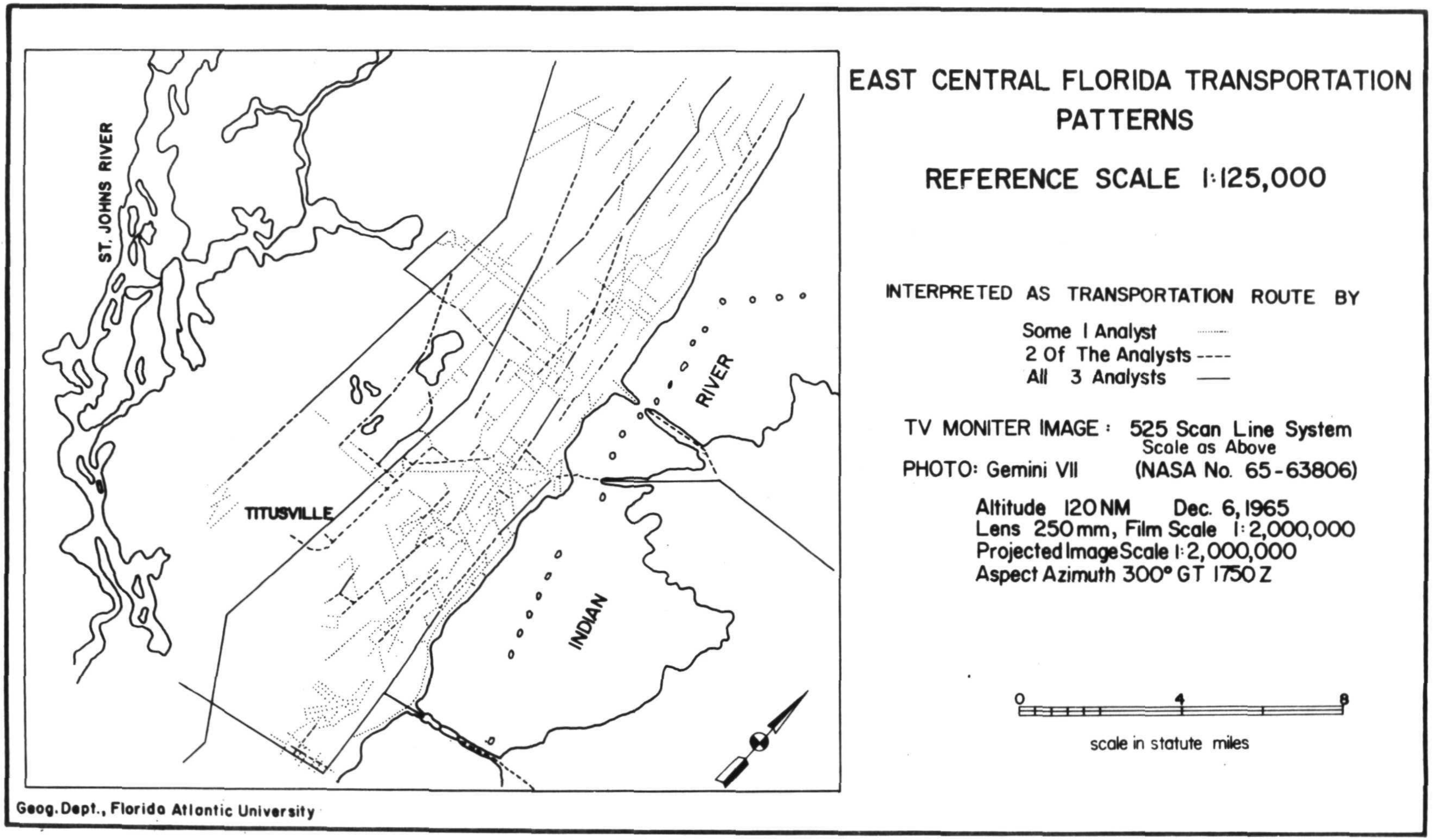

ST. JOHNS
RIVER
TITUSVILLE
INDIAN
RIVER
EAST CENTRAL FLORIDA TRANSPORT PATTERNS
REFERENCE SCALE 1:250,000
INTERPRETED AS TRANSPORTATION ROUTE BY:
Some 1 Analyst
2 Of The Analysts
All 3 Analysts
TV MONITOR IMAGE
525 Scan Line System
Scale as Above
PHOTO= GEMINI VII (NASA No. 65-63806)
Altitude 120 NM Dec 6, 1965
Lens 250mm Film Scale 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT 1750Z
0
4
8
12
16
scale in statute miles
Geog. Dept., Florida Atlantic Univ.

Figure 35.



EAST CENTRAL FLORIDA TRANSPORTATION PATTERNS
REFERENCE SCALE 1:125,000
INTERPRETED AS TRANSPORTATION ROUTE BY
Some 1 Analyst
2 Of The Analysts
All 3 Analysts
TV MONITER IMAGE: 525 Scan Line System
Scale as Above
PHOTO: Gemini VII (NASA No. 65-63806)
Altitude 120 NM Dec. 6, 1965
Lens 250 mm, Film Scale 1:2,000,000
Projected Image Scale 1:2,000,000
Aspect Azimuth 300° GT 1750 Z
0
4
8
scale in statute miles
ST. JOHNS RIVER
TITUSVILLE
INDIAN
RIVER
Geog. Dept., Florida Atlantic University

Figure 36.

The 945 scan line rate image of the Titusville area of East Central Florida is displayed in Figure 37 as it appeared on the monitor at the 1:125,000 scale which bounds the region under study. When the transportation route net information that was compiled from it is observed in Figure 38, it is evident that it compares closely to that secured also at the small 1:1,000,000 scale from the less intense 525 line image. Apparently the scan line change is not significant enough to overcome the scale factor which still displays only the major pattern aspects. However, major features are seen, and one interpreter speculated that this degree of generalization might be very useful for imaging a larger region, like south Florida. It was observed that it seemed that a greater area was adversely affected by cloud tones now, although the same slide was projected. It may be that the increase in scan lines tends to exaggerate bright tonal responses, and reduce interpretability of haze-attenuated images.

The transportation patterns from the 945 scan line rate mapped in Figure 39 closely resemble those mapped for the 525 line image at the same 1:500,000 rate. One interpreter commented that, "The transportation pattern showed through the cloud blur that rendered the 1:1,000,000 photo so difficult to interpret. Road alignments rather than precise road locations are probably what is interpreted at this scale." When Figure 40 is compared with Figure 35, it is notable that the former interpretation from the 945 line image does display a significant increase over the detailing of routes in the lower scan image. It is also notable that although both are at the 1:250,000 monitor scale, the 945 seems to bring out more agreement among the interpreters. At the 1:125,000 scale images from both scan line rates are similar, with Figure 41 from this more intense system resembling its previous 525 counterparts high degree of network pattern. It seems to display superiority in the more distant western portion of the image, however and one interpreter classifies the 945 system as"somewhat superior." He also says, "At this scale, and scanline density, I have doubts as to the correctness of road location. For new construction the tone is a continuous straight line without irregularities in width. However in downtown Titusville what must be highly reflective surfaces like parking lots or large expanses of coated roafing disrupt the linear pattern of roads. I believe that the road is in such instances the darker line trace between brighter blobs."

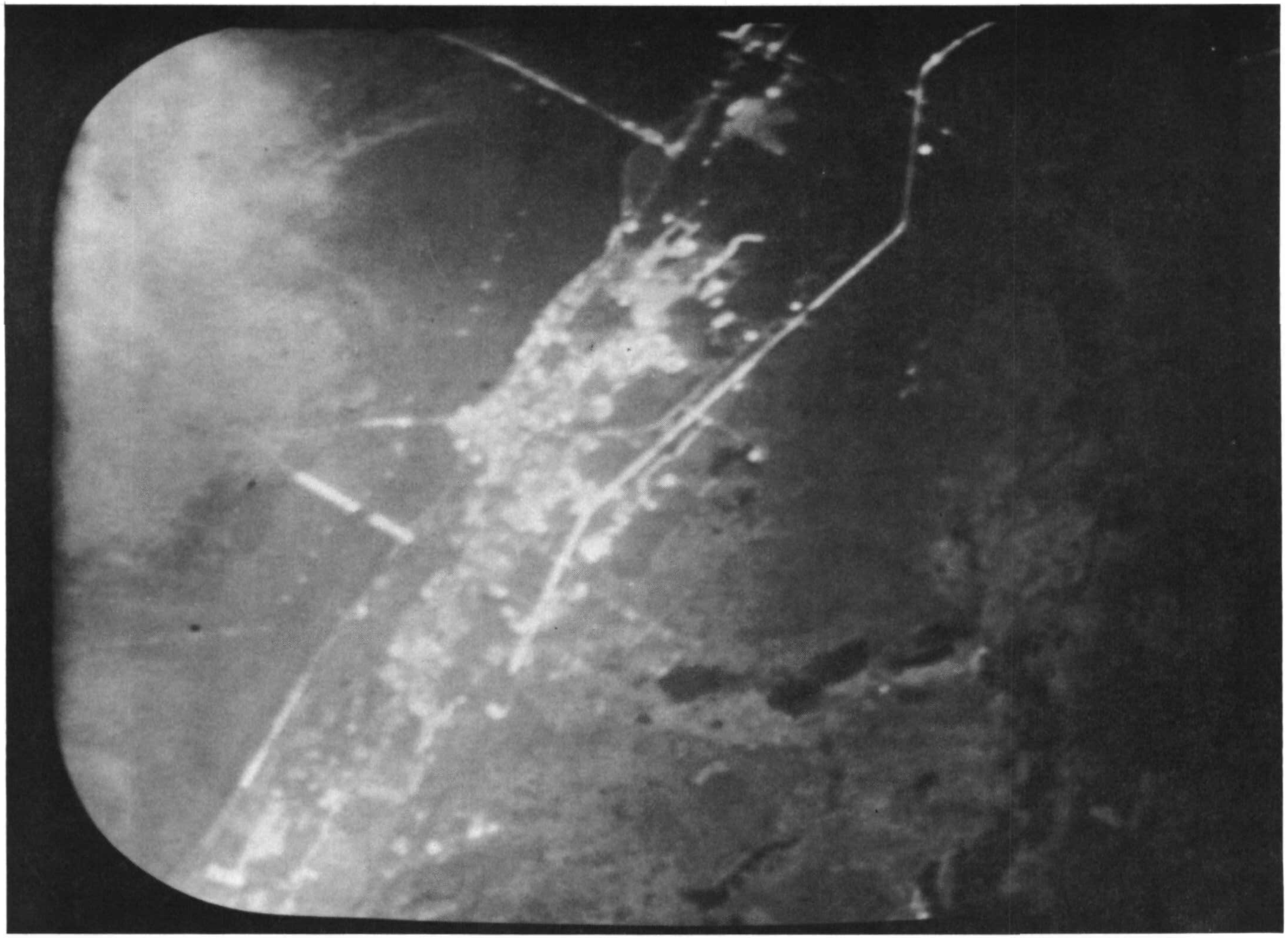
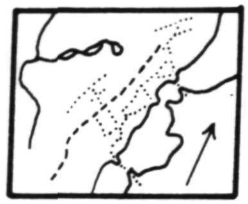


Figure 37. A 945 scan line rate simulated television image of the Titusville area of East Coast Florida as displayed on a 14 inch monitor at a scale of 1:125,000.



EAST CENTRAL FLORIDA TRANSPORTATION PATTERNS

REFERENCE SCALE 1:1,000,000

INTERPRETED AS TRANSPORTATION ROUTE BY:

··········	Some 1 Analyst
- - - -	2 Of The Analysts
———	All 3 Analysts

TV MONITOR IMAGE

945 Scan Line System

Scale as Above

PHOTO = GEMINI VII (NASA No. 65-63806)

Altitude 120NM Dec 6, 1965

Lens 250mm Film Scale =1:2,000,000

Projected Image Scale 1:250,000

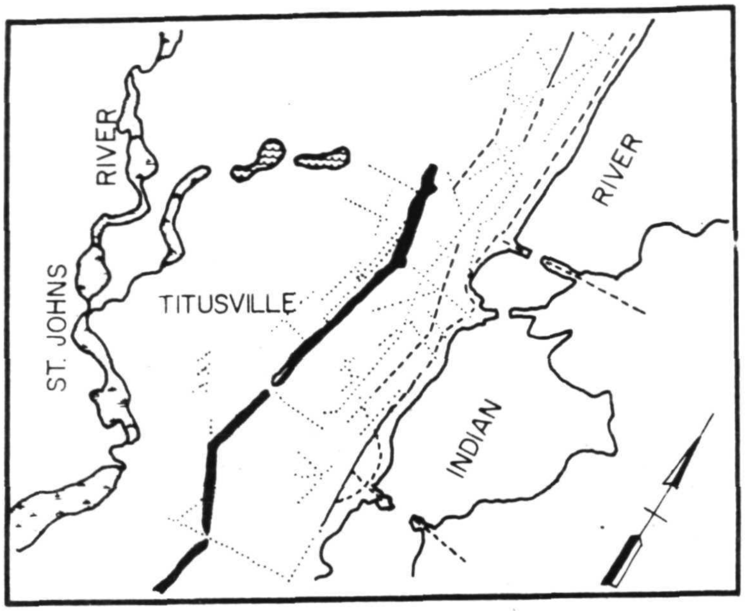
Aspect Azimuth 300° GT 1750Z

0 15 30

scale in statue miles

Geog Dept, Florida Atlantic Univ

Figure 38.



EAST CENTRAL FLORIDA TRANSPORTATION PATTERNS

REFERENCE SCALE 1:500,000

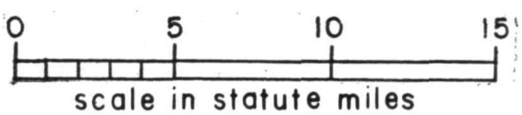
INTERPRETED AS TRANSPORTATION ROUTE BY

········ Some 1 Analyst
---- 2 Of The Analysts
All 3 Analysts:
——— Existing Route
Major Construction

TV MONITOR IMAGE

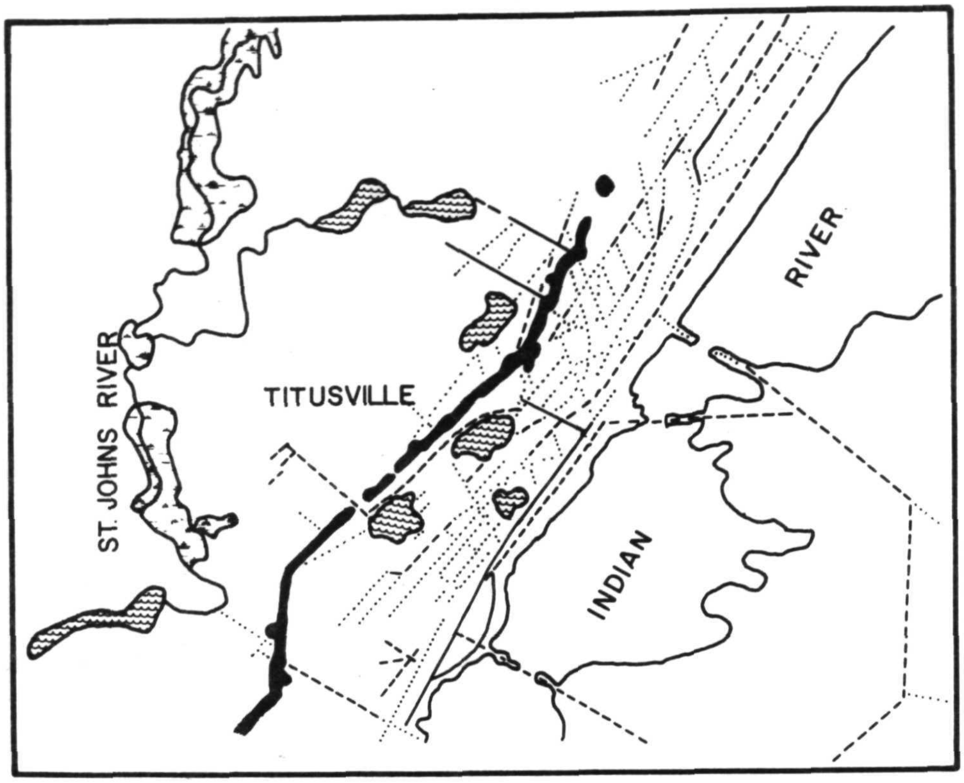
945 Scan Line System
Scale as Above

PHOTO = GEMINI VII (NASA No. 65-63806)
Altitude 120NM Dec 6, 1965
Lens 250mm Film Scale = 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT 1750Z



Geog. Dept., Florida Atlantic University

Figure 39.



EAST CENTRAL FLORIDA TRANSPORT PATTERNS
REFERENCE SCALE 1:250,000

INTERPRETED AS TRANSPORTATION ROUTE BY:
- Some 1 Analyst
- 2 Of The Analysts
- All 3 Analysts
- Existing Route
- Major Construction

TV MONITOR IMAGE
945 Scan Line System
Scale as Above

PHOTO = GEMINI VII (NASA No.65-63806)
Altitude 120 NM Dec 6, 1965
Lens 250mm Film Scale 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT 1750Z

0 4 8 12 16
scale in statute miles

Geog. Dept., Florida Atlantic Univ.

Figure 40.

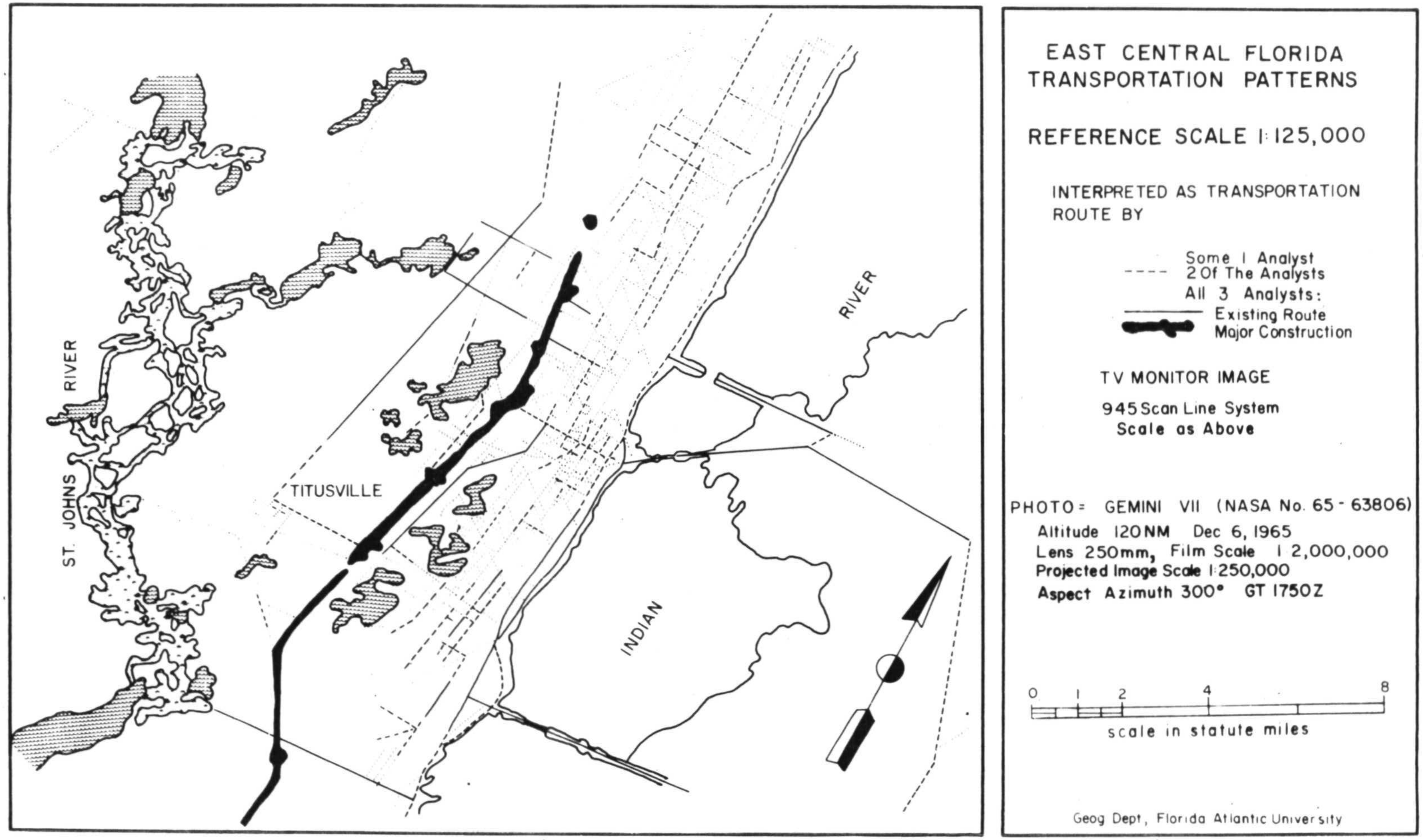

EAST CENTRAL FLORIDA
TRANSPORTATION PATTERNS
REFERENCE SCALE 1:125,000
INTERPRETED AS TRANSPORTATION ROUTE BY
Some 1 Analyst
2 Of The Analysts
All 3 Analysts:
Existing Route
Major Construction
TV MONITOR IMAGE
945 Scan Line System
Scale as Above
PHOTO = GEMINI VII (NASA No. 65 - 63806)
Altitude 120NM Dec 6, 1965
Lens 250mm, Film Scale 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT 1750Z
0 1 2 4 8
scale in statute miles
Geog Dept, Florida Atlantic University
ST. JOHNS RIVER
TITUSVILLE
INDIAN
RIVER

Figure 41.

Land use interpretation of the same four scale alternates for the simulated orbital television images of the Titusville area were also completed by the three interpreters for each of the two scan line rates being studied. This report will include only the maps which resulted from the superior 945 line scan, but the discussion will include some comparative evaluation of the 525 line use evaluations made by the investigators. The 525 maps were compiled first for all scales before the analysts mapped the discernable categories from the 945 line imagery.

The smallest 1:1,000,000 scale imagery is generalizing the test area with less than 50 scan lines for the 525 rate and with less than 85 for the 945 rate, hence it can be expected that land use identification will suffer because of a lack of resolution and a lack of gray tone discrimination. Only land, large water surfaces, and well developed or cleared surface lands versus undeveloped land may be reliably interpreted. Recently cleared transport routes involving extensive land usage will also be seen, and perhaps confused with urban lineaments. Figure 42 presents a good example of the patterns perceived. Although this may be a useful generalization for a large area it is not a very informative categorization or as discriminating as one might desire at the 1:1,000,000 scale.

At the 1:500,000 scale illustrated in Figure 42, interpreters report that even with the less intense 525 line imagery, urban fringes can be approximated quite well. Wetland and open bodies of water can be outlined, and rural land use, except pasture, is just beginning to "show up." There are few patterns of tonal difference discernable in the non-urban areas but there are probably few cropland occurrances in this area and it is "speculated that larger cropland units could be discernable at this scale in either scan rate. However, interpreters felt confident in locating the St. John River lowland area where cypress and other swamp vegetation fringe the watercourses and marsh grass extends toward dryer soils.

The interpreters expressed a belief that the most "optimum scale for interpretation of the TV scan line imagery lay within the range from 1;250,000 to something greater than 1:500,000. They speculate that this is a function of the pattern discrimination associated with the distance between scan lines - which helps to determine the boundary contrasts between gray tones. Figure 44 presents the 1:250,000 land use map which demonstrates once again the sharp rise in interpreted data at this level. This scale also permitted a more confident outlining and internal deliniation of urban area. A lack of defineable rectangular field patterns continued to discourage "rural agricultrual" classification except in the northwest corner, although a plowed field over 2 acres in size should be readily seen.

EAST CENTRAL FLORIDA LAND USE PATTERNS
REFERENCE SCALE 1:1,000,000

TV MONITOR IMAGE
945 Scan Line System
Scale as Above

URBAN GENERAL NOT INTERPRETABLE

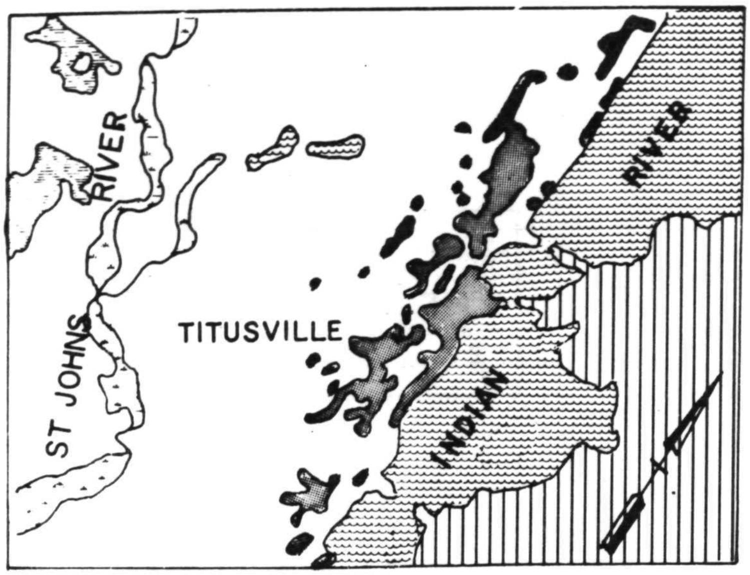
WATER

PHOTO = GEMINI VII (NASA No. 65 - 63806)
Altitude 120 NM Dec 6, 1965
Lens 250mm, Film Scale 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT 1750Z

0 5 10 15 30
scale in statue miles

Geog. Dept., Florida Atlantic Univ.

Figure 42.



EAST CENTRAL FLORIDA LAND USE PATTERNS
REFERENCE SCALE 1:500,000

TV MONITOR IMAGE
945 Scan Line System
Scale as Above

- URBAN COMMERCIAL–INDUSTRIAL
- URBAN GENERAL
- MINERAL (borrow pits, open pits and spoil banks)
- RURAL AGRICULTURAL
- MIXED – RURAL NON FARM AND AGRICULTURAL
- UNCLASSIFIED
- RURAL WOODLAND
- FLATWOODS
- GRASSLANDS
- WETLANDS – PRAIRIE
- WATER
- NOT INTERPRETABLE

PHOTO= GEMINI VII (NASA No. 65-63806)
Altitude 120NM Dec. 6, 1965
Lens 250mm, Film Scale 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT 1750Z

0 5 10 15
scale in statute miles

Geog. Dept., Florida Atlantic University

Figure 43.

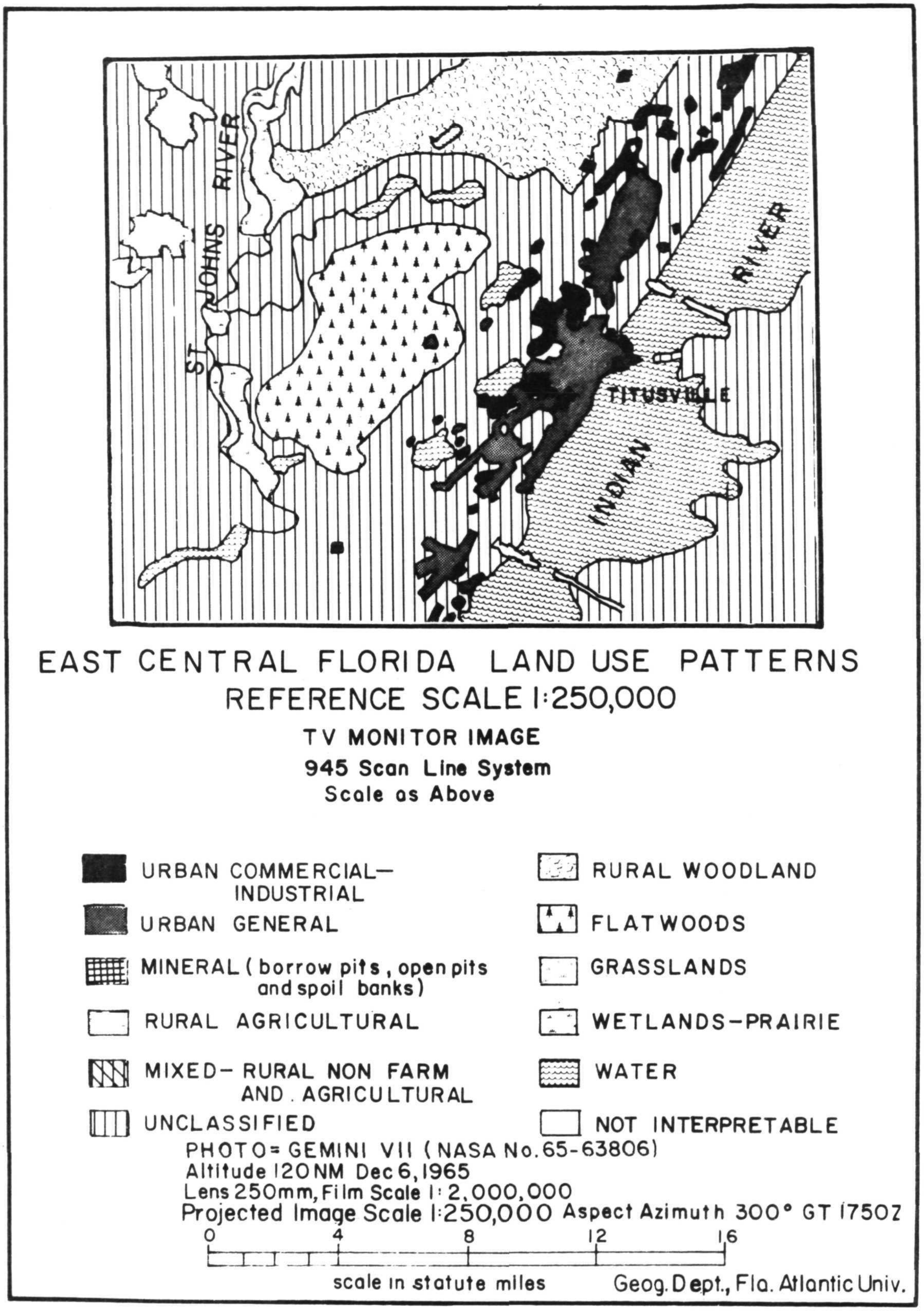

ST JOHNS RIVER
TITUSVILLE
INDIAN RIVER
EAST CENTRAL FLORIDA LAND USE PATTERNS
REFERENCE SCALE 1:250,000
TV MONITOR IMAGE
945 Scan Line System
Scale as Above
URBAN COMMERCIAL— INDUSTRIAL
URBAN GENERAL
MINERAL (borrow pits, open pits and spoil banks)
RURAL AGRICULTURAL
MIXED— RURAL NON FARM AND AGRICULTURAL
UNCLASSIFIED
RURAL WOODLAND
FLATWOODS
GRASSLANDS
WETLANDS—PRAIRIE
WATER
NOT INTERPRETABLE
PHOTO= GEMINI VII (NASA No.65-63806)
Altitude 120 NM Dec 6, 1965
Lens 250mm, Film Scale 1:2,000,000
Projected Image Scale 1:250,000 Aspect Azimuth 300° GT 17507
0
4
8
12
16
scale in statute miles
Geog. Dept., Fla. Atlantic Univ.

Figure 44.

At the 1:125,000 scale of TV scan line imagery, an "ultimate" in data extraction for land use category mapping is being approached for both the 525 and the 945 line systems. Although Figure 45 includes some portions still "unclassified," not all our interpreters agreed with that cautious approach. Detailed patterning and bounding of categories are now mapped, and internal differentiation of principal urban areas is possible. All categories in the map legend are now interpreted in some portion of this area.

This map has been compared with similarly scaled land use category maps generated by the laborious ground surveys, photo interpretation and compiling methods usually followed by planning agencies. The patterns in this map compare well with those produced in such a time consuming fashion. And this map could be produced in a few days or less if orbital television imagery was available.

CONCLUSIONS

Many interpretive insights are noted in the preceding pages of this study of stimulated orbital TV imagery, but it seems useful to concisely summarize here some of the conclusions of the Principal Investigator:

1. It is feasible to thematically map transportation and land use category patterns from orbital television imagery with less than a thousand scan lines in a system operating under two hundred miles above the earth, even with only a black and white image.

2. Monitor image scales between 1:250,000 and 1:125,000 are desirable, for general category or transport route analyses. Larger scales up to 1:50,000 seem quite feasible, with optical modifications, as a means of further refining the categorization but they will obviously yield less synoptic images with less coverage per image, on the 14 inch monitor display.

3. Aerial platforms with black and white television systems are capable of securing valuable imagery for surveying and mapping land use or other surface patterns.

4. Although higher scan line rates are helpful, they are not essential at lower orbital altitudes and consequent savings in transmission bandwidth and data processing or storage requirements are possible.

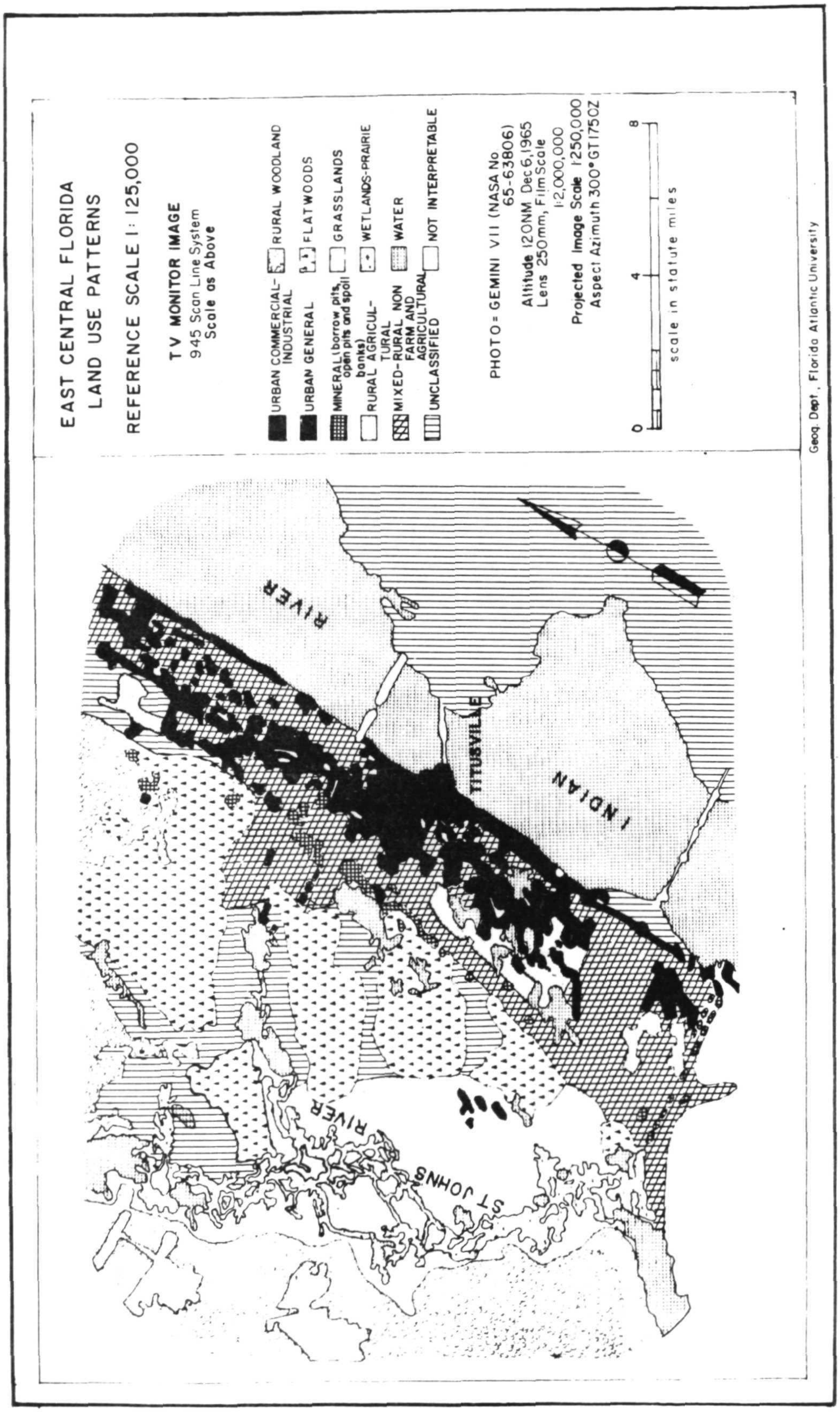

EAST CENTRAL FLORIDA
LAND USE PATTERNS
REFERENCE SCALE 1: 125,000
TV MONITOR IMAGE
945 Scan Line System
Scale as Above
URBAN COMMERCIAL-INDUSTRIAL
URBAN GENERAL
MINERAL (borrow pits, open pits and spoil banks)
RURAL AGRICULTURAL
MIXED-RURAL NON FARM AND AGRICULTURAL
UNCLASSIFIED
RURAL WOODLAND
FLATWOODS
GRASSLANDS
WETLANDS-PRAIRIE
WATER
NOT INTERPRETABLE
PHOTO = GEMINI VII (NASA No 65-63806)
Altitude 120NM Dec 6, 1965
Lens 250mm, Film Scale 1:2,000,000
Projected Image Scale 1:250,000
Aspect Azimuth 300° GT1750Z
0
4
8
scale in statute miles
Geog. Dept., Florida Atlantic University
RIVER
TITUSVILLE
INDIAN
ST JOHNS
RIVER

Figure 45.

5. As higher scan line rates and narrower scan lines are integrated into a sensor system it may use higher orbits and acquire comparable imagery for a wider path of coverage.

6. It is feasible to economically simulate orbital television imagery of earth surface in a laboratory for training or experimental purposes.

7. Larger monitor faces which increase the scale of imagery display but do not contain additional scan line data are not an advantage for interpretation, since pattern perception and recognition with scan line imagery requires the interpreter to integrate the patterns separated by the blank spacing between scan line paths.