GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

no action
[illegible]

Date: December 7, 1976

Project Title: Landsat Digital Analysis to Determine Land Cover in Central Georgia

Project No: A-1909

Project Director: Mr. N. L. Faust

Sponsor: Heart of Georgia Planning & Development Commission; Eastman, Ga. 31023

Agreement Period: From 11/1/76 Until 2/1/77 (Contract Expiration)

Type Agreement: Standard Industrial Contract dated 11/1/76.

Amount: $4,500

Reports Required: Monthly Progress Letters; Final Summary Report.

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Mr. John L. Leonard
Director of Planning
Heart of Georgia Planning & Development Commission
P. O. Box 667
Eastman, Georgia 31023

Phone: (912) 374-4771

Defense Priority Rating: None.

Assigned to: Electromagnetic Laboratory (School/Laboratory)

COPIES TO:

Project Director	Library, Technical Reports Section
Division Chief (EES)	Office of Computing Services
School/Laboratory Director	Director, Physical Plant
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Accounting Office	Project File (OCA)
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Security Coordinator (OCA) ✓	Other
Reports Coordinator (OCA)	

CA–3 (3/76)

no action
OCA
Cobb

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: March 1, 1978

Project Title: Landsat Digital Analysis to Determine Land Cover in Central Georgia

Project No: A-1909

Project Director: Mr. N. L. Faust

Sponsor: Heart of Georgia Planning & Development Commission; Eastman, Ga. 31023

Effective Termination Date: 4/30/77 (Final Report subm. 2/17/78)

Clearance of Accounting Charges: Final Invoice subm. 6/2/77.

Grant/Contract Closeout Actions Remaining:

NONE.

_ Final Invoice and Closing Documents
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
_ Other ______________

Assigned to: Electromagnetics Laboratory (School/Laboratory)

COPIES TO:

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Library, Technical Reports Section
Office of Computing Services
Director, Physical Plant
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other ______________

CA–4 (3/76)

Monthly Progress Reports Numbers 1 & 2
For the Period November 1, 1977 through December 31, 1977

LANDSAT Data Processing for Heart of Georgia Area Planning and Development Commission

by

N. L. Faust

Contract No. A-1909

20 April 1977

Prepared for

Heart of Georgia Area Planning
and Development Commission
Eastman, Georgia

by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

I. INTRODUCTION

This project is designed to computer process digital data from the LANDSAT satellite and to provide landcover maps of all counties in the Heart of Georgia Area Planning and Development Commission area.

II. TECHNICAL PROGRESS

During this period training field selection for the area around Eastman, Georgia was accomplished and statistics were generated for the signatures. Ground Control Points (GCP's) were located in the imagery and on maps. This data allowed the conversion of the UTM coordinates for the vertices of Dodge County to LANDSAT pixel coordinates.

III. PROBLEMS

No significant problems were encountered during this period.

IV. BUDGET

	BUDGET	EXPENDED	FREE
Technical Effort	$3,016	$2,703	313
Materials & Supplies	484	200	284
Computer	1,000	--	$1,000
	$4,500	$2,903	$1,597

Monthly Progress Reports Numbers 3 & 4
For the Period January 1, 1977 through February 28, 1977

LANDSAT Data Processing for Heart of Georgia Area Planning and Development Commission

by

N. L. Faust

Contract No. A-1909

20 April 1977

Prepared for

Heart of Georgia Area Planning
and Development Commission
Eastman, Georgia

by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

I. INTRODUCTION

This project is designed to computer process digital data from the LANDSAT Satellite and to provide landcover maps of all counties in the Heart of Georgia Area Planning and Development Commission area.

II. TECHNICAL PROGRESS

During this period several additional computer programs were developed to process Heart of Georgia APDC data. Example data for Dodge County was produced.

III. PROBLEMS

Because of rectification software and hardware problems, the schedule for completion of all the counties has slipped.

IV. BUDGET

	BUDGET	EXPENDED	FREE
Technical Effort	$3,016	$4,552	$(1,536)
Materials & Supplies	484	259	225
Computer	1,000	--	1,000
	$4,500	$4,811	$ 311

Monthly Progress Report Number 5
For the Period March 1, 1977 through March 31, 1977

LANDSAT Data Processing for Heart of Georgia Area Planning and Development Commission

by

N. L. Faust

Contract No. A-1909

20 April 1977

Prepared for

Heart of Georgia Area Planning
and Development Commission
Eastman, Georgia

by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

I. INTRODUCTION

This project is designed to computer process digital data from the LANDSAT Satellite and to provide landcover maps of all counties in the Heart of Georgia Area Planning and Development Commission area.

II. TECHNICAL PROGRESS SUMMARY

During this period EES developed a new technique for agregating statistics for landcover. Data will be classified for a rectangular area encompassing all desired counties and subsequently the county pixel coordinates will be used to agregate statistics for each county. This data will in turn be rectified to a UTM coordinate system and printed at a scale of 1:4000.

III. PROBLEMS

No new problems were encountered during this period.

IV. WORK PLANNED FOR NEXT PERIOD

During the next period, LANDSAT digital data will be processed for all counties lying within the LANDSAT scene. All county coordinates will be input to agregate statistics by county.

V. BUDGET

	BUDGET	EXPENDED	FREE
Technical Effort	$3,016	$5,238	$(2,222)
Materials & Supplies	484	260	224
Computer	1,000	--	1,000
	$4,500	$5,498	$ (998)

Monthly Progress Report No. 6

For the Period April 1, 1977 through April 30, 1977

LANDSAT Data Processing for Heart of Georgia Area Planning and Development Commission

by

N. L. Faust

Contract No. A-1909

Prepared for

Heart of Georgia Area Planning
and Development Commission
Eastman, Georgia

by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

I. INTRODUCTION

This project is designed to computer process digital data from the LANDSAT satellite and to provide landcover maps of all counties in the Heart of Georgia Area Planning and Development Commission area.

II. TECHNICAL PROGRESS SUMMARY

During this period EES has had to modify existing software for the production of landcover statistics by county from classified LANDSAT data. Once this is checked out, the statistics and maps for all Heart of Georgia counties will be available.

III. PROBLEMS

EES has experienced several problems during this study which called for the development of new software for the aggregation of LANDSAT classified data by specific boundaries. These developments were necessary to provide a general capability for data aggregation which will be available for future projects.

IV. WORK PLANNED FOR NEXT PERIOD

During the next period, EES plans to finish all software modifications to the ERDAS system and to provide statistics for all Heart of Georgia counties.

V. BUDGET

	BUDGET	EXPENDED	FREE
Technical Effort	$3,016	$4,291	$(1,275)
Materials and Supplies	484	259	225
Computer	1,000	0	1,000
TOTAL	$4,500	$4,550	(50)

Monthly Progress Report No. 7

For the Period May 1, 1977 through May 31, 1977

LANDSAT Data Processing for
Heart of Georgia Area Planning and Development Commission

by

N. L. Faust

Contract No. A-1909

Prepared for

Heart of Georgia Area Planning
and Development Commission
Eastman, Georgia

by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

I. TECHNICAL PROGRESS SUMMARY

During this period statistics for seven of the nine Heart of Georgia counties were aggregated and sent to John Leonard. The data for the other two counties will follow soon. Work is proceeding on putting the county classified data in a format acceptable for production of a color film negative.

II. PROBLEMS

Two counties - Laurens and Treutlen - are not entirely included in the LANDSAT scene that we have obtained. It is expected that these two counties will be processed however as a part of the statewide LANDSAT effort.

III. WORK PLANNED FOR NEXT PERIOD

During June the two remaining counties - Wilcox and Telfair will be processed and the statistics sent to Heart of Georgia. Work will proceed on the creation of color negatives for each county.

IV. BUDGET

	BUDGET	EXPENDED	FREE
Technical Effort	$3,016	$4,240	(1,224)
M & S	484	260	224
Computer	1,000	0	1,000
TOTAL	$4,500	$4,500	0

Monthly Progress Report No. 8

For the Period June 1, 1977 through June 30, 1977

LANDSAT Data Processing for Heart of Georgia Area Planning and Development Commission

by

N. L. Faust

Contract No. A-1909

Prepared for

Heart of Georgia Area Planning
and Development Commission
Eastman, Georgia

by

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

I. TECHNICAL PROGRESS SUMMARY

During this period classification statistics were compiled for all Heart of Georgia Area Counties and were forwarded to John Leonard. Some new computer software had to be developed to allow all nine counties to be put on one magnetic tape so that a color product could be made.

II. PROBLEMS

There were no new problems this period.

III. WORK PLANNED FOR NEXT PERIOD

During the next period, work will initiate on the final report for this project, and the digital tape containing the H.O.G. nine counties will be sent to Dicomed, Inc. for processing.

IV. BUDGET

	BUDGET	EXPENDED	FREE
Technical Effort	$3,016	$4,240	(1,244)
M & S	484	260	244
Computer	1,000	0	1,000
TOTAL	$4,500	$4,500	0

FINAL REPORT

LANDSAT DATA PROCESSING FOR HEART OF GEORGIA AREA PLANNING AND DEVELOPMENT COMMISSION

by

N. L. Faust

Contract No. A-1909

Prepared for

Heart of Georgia Area Planning
and Development Commission
Eastman, Georgia

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

10 February, 1978

I. INTRODUCTION

The National Aeronautics and Space Administration (NASA) has endeavored for the last ten years to apply space collected data to real world problems. After landing a man on the moon, NASA began to focus its sophisticated instruments on the earth itself; sending images of the earth's surface to be used in enhancement of man's knowledge of his own planet. The application of these images and data to earth oriented problems became known as the field of Earth Resources Analysis. Initially, the group that gained the most benefits from space data were geologists. The images taken from space combined a large field of view with an almost orthogonal perspective of portions of the earth's surface. Geological trends here-to-fore unmapped, were discovered because of the ability to see large portions of the surface in one picture. Aerial photography covered only a fraction of this area in one image and often large scale trends were missed. In addition to the geologists, geographers, environmentalists, hydrographers, and agricultural experts began to evaluate the role of space photography and sensor data in their disciplines.

In 1972, the Earth Resources Technology Satellite (ERTS-I) was launched as NASA's first dedicated satellite for earth resources. This satellite was inserted into a 570 nautical mile circular orbit, whose path tracked approximately north-south. Actually the orbit is at a ten degree inclination to a north-south plane through the center of the earth. Because of the non-symmetrical shape of the earth and the earth's rotation, the satellite orbit tracks over a different portion of the earth on each pass. For example, if the satellite passes over Atlanta in one orbit, on the next orbit it will pass over the central United States because the earth has rotated on its axis that distance east to west in the time taken for that orbit (approximately 90 minutes). The satellite orbit was calculated such that the satellite would pass over Atlanta exactly eighteen days later at the same time of day to eliminate problems with comparing imagery from one date to the next because of shadows. This type of orbit is called a sun-synchronous orbit. ERTS was designed to pass over Atlanta at approximately 10:05 a.m. every eighteen days. In January, 1975 ERTS-II was launched into another near polar orbit, but one that was at right angles to the ERTS-I orbit. The period and inclination of the orbits were identical, and the orbits were placed such that data was taken over Atlanta at 10:05 a.m. every nine days instead of eighteen. Likewise, every point on the earth was imaged by an ERTS sensor every nine days. Since the satellites primarily provided information on land masses and since NASA had a satellite under development for measuring sea parameters called Seasat, the name ERTS for the Earth Resources Satellites was changed to Landsat. Landsat I and Landsat II are still in operation, sending immense amounts of data every day to earth receiving stations about earth resources.

The Landsat satellites have two primary sensors on board. Since data is telemetered to earth a camera as such could not be used because there was no way to retrieve the film and send up new supplies. A sensor called the Return Beam Vidicon (RBV) performs a similar function by imaging a picture of a segment of the earth's surface on the photosensitive screen on the satellite. This screen is then scanned by a television type raster scan and the image data are converted to digital data which may be transmitted to earth. A filter type system is designed such that images from two portions of the visible electromagnetic spectrum and one image from the near infrared portion of the spectrum are taken separately. If these images are superimposed to form a color image once they are received on the earth, the combination closely resembles an image taken with a camera using aerial color-infrared film. This type film has been used extensively by foresters, agriculturists and others to detect differences in the health of vegetation. The image that is transmitted to earth from Landsat covers an area 115 miles by 115 miles or 13,225 square miles.

The second sensor on board Landsat is the Multispectral Scanner (MSS). The MSS performs the same function as the RBV but actually records a continuous strip of the earth's surface in four regions of the electromagnetic spectrum instead of three. The instrument consists of a rotating mirror, a prism, and a bank of detectors which digitally record the light from a small portion of the earth (approximately 1.1 acres) at any instant. As Landsat heads north to south over the United States the mirror scans west to east providing an image of a narrow strip of the earth's surface. The spacecraft motion is such that the next scan is adjacent to the last, forming a continuous strip 115 miles wide. For compatibility with the RBV system, these data are also normally divided into scenes of 115 miles by 115 miles.

Because of instrument failure in the RBV system in both Landsats I and II, the MSS images have become the most widely used of all Landsat products.

The area covered by Landsat data (115 miles by 115 miles) provided geologists the same perspective offered by earlier manned photographic missions. As the data became available world wide, geologists from mineral and oil exploration companies became the most extensive users of Landsat data. However, because of the increased coverage and the quality of the data, other disciplines became more and more involved in deciding on the usefulness of Landsat data for their applications. It quickly became obvious that the MSS data which were obtained through a digital process on board Landsat were well adapted to computer analysis for enhancement and pattern recognition. Any film imagery that was made from the digital data would undergo a degradation in quality relative to the original data. By processing Landsat data with computers, many new applications of the data were discovered and confidence in the data for earlier applications was increased. It was found that by locating a known area with one type of land cover (e.g. - forest) both in the Landsat data and on the ground a set of statistics could be generated which would allow the computer to recognize a similar area elsewhere in the image. This computer analysis of Landsat data has been found to be highly accurate in determining land cover types in rural areas[1].

The Georgia Tech Engineering Experiment Station (EES) has developed an Earth Resources Digital Analysis System (ERDAS) (Appendix I) and computer software for the analysis of Landsat data and the application of these data to local, state, and regional problems.

II. PROJECT DESCRIPTION

In November 1976 the Heart of Georgia Area Planning and Development Commission (HOGAPDC) contracted with Georgia Tech EES to produce land cover maps and generate statistical summaries for its member counties. HOGAPDC and EES selected Landsat digital data which combined cloud free image quality with coverage of most of the nine county region. HOGAPDC was responsible for provision of ground truth data in the form of aerial photographs and assistance in the location of training fields on the Georgia Tech ERDAS system. It was agreed that EES would initially supply land cover statistics for each of the HOGAPDC counties and later supply either grey scale maps or color images of the counties. Because of the potential value of color products for reports and displays, HOGAPDC and EES agreed that efforts should be concentrated on provision of color images if possible. At the time of contract initiation, EES had not yet developed the necessary software for conversion of the data to a format compatable with a color digital film writer. Also, EES had not yet established contractual relations with a commercial image producing establishment, although several were being investigated for price and image quality.

Mr. John Leonard acted as the representative of HOGAPDC and brought aerial photographs of the Eastman, Georgia area to be used as ground truth information in addition to his personal knowledge of the area. Unfortunately, the aerial photographs of the area were over fifteen years old. There were significant land cover changes in the Eastman area in that time span, as shown by the 1975 Landsat data used, and this situation led to some difficulty in locating training samples. Nevertheless, Mr. Leonard's knowledge of the area supplemented the photographs, and we were able to determine training fields for general land cover categories.

The Landsat data selected for the area were for December 28, 1975. It was felt that winter data over the area would allow better discrimination of a low density urban category and pine and hardwood tree types.

Boundaries for the HOGAPDC counties were not initially available in digital form so EES gathered 1:250,000 scale maps and 1:24000 scale maps, where available, to use as a basis for deliniation of the boundaries. A problem was encountered in that very little of this area had been mapped at a 1:24000 scale. On a 1:250,000 scale it was difficult to obtain accurate coordinates for a polygon representing the county boundaries. An alternate source of digital boundaries was provided by data from the Federal Department of Transportation.

III. RESULTS

EES used the statistical signatures defined for each land cover class on the ERDAS system to categorize each Landsat pixel (an area of 1.1 acres on the ground) as to land cover type for the entire frame of Landsat data. The Landsat data were then geo-referenced to a latitude-longitude coordinate system so that polygons of categorized data for each county could be defined. A summary of the land cover categories for each county is given in Table I. Two counties, Laurens and Treutlen were not totally included in the selected Landsat scene so the summary indicates only that portion of the county included in the scene. A color film writer negative and transparency of those counties which are totally included in the scene accompany this report.

For the general categories defined by the ERDAS signatures the results seem to be reasonable given the ground truth situation. Low density and high density urban categories occasionally showed up in bare fields because of the high reflectance in the visible region for both categories. Orchards could not be differentiated because the trees were leafless during the Landsat overpass. Thus grassy areas underneath the trees tended to control the orchard signature. Consequently, this category was confused with a pasture/open land signature. Wetlands, water, and pine forest categories seemed to be very accurate in a qualitative sense. No definite accuracy figures are available because of the out-of-date ground truth information.

EES had some difficulty during this project because of the necessity of developing the computer software for geographic referencing of the data and the software for compatibility with a film writer. This software development took significantly longer than expected and thus, there were delays in the production of the final products. Since all of the software has now been developed, it is estimated that EES could categorize Landsat data for an area and extract polygons representing counties which are wholly or partially contained in a scene for approximately $1.25 per square mile, assuming that the county boundaries are provided by the user in a digital format ("i.e." - coordinate pairs). Because the time involved for training sample selection, polygon extraction, and map production is essentially the same if only a small portion of the scene is to be categorized or if the whole scene is to be categorized, an area of 4,000 square miles should be the minimum area for analysis. A period of three to four months should be allowed for data analysis once the Landsat data are received.

IV. CONCLUSION

Even though there were some difficulties encountered in this project, these problems have been solved. The results of this project show the capacity of Landsat data for discriminating land cover types over large areas at a minimal cost.

REFERENCES

1. Spann, G. W., and Faust, N. L., "Landsat Information for State Planning", EES Final Technical Report, Project A-1621, June 1977.

TABLE I - LAND COVER STATISTICS FOR HOGAPDC COUNTIES

LAURENS COUNTY

Forest	104.7 sq. mi.
Water	4.4 sq. mi.
Pasture-Field	179.5 sq. mi.
Marsh (fresh)	146.2 sq. mi.
Urban	36.7 sq. mi.

BLECKLEY COUNTY

Forest	43.7 sq. mi.
Water	1.9 sq. mi.
Pasture-Field	104.3 sq. mi.
Marsh	57.4 sq. mi.
Urban	12.5 sq. mi.

WHEELER COUNTY

Forest	165.9 sq. mi.
Water	3.5 sq. mi.
Pasture-Field	118.0 sq. mi.
Marsh	25.8 sq. mi.
Urban	9.7 sq. mi.

MONTGOMERY COUNTY

Forest	108.2 sq. mi.
Water	1.4 sq. mi.
Pasture-Field	83.7 sq. mi.
Marsh	42.8 sq. mi.
Urban	8.6 sq. mi.

DODGE COUNTY

Forest	198.3 sq. mi.
Water	5.3 sq. mi.
Pasture-Field	216.1 sq. mi.
Marsh	69.1 sq. mi.
Urban	18.3 sq. mi.

TELFAIR COUNTY

Forest	220.2 sq. mi.
Water	4.9 sq. mi.
Pasture-Field	148.1 sq. mi.
Marsh	64.2 sq. mi.
Urban	11.5 sq. mi.

PULASKI COUNTY

Forest	47.4 sq. mi.
Water	1.0 sq. mi.
Pasture-Field	142.5 sq. mi.
Marsh	63.4 sq. mi.
Urban	21.6 sq. mi.

TREUTLEN COUNTY

Forest	39.5 sq. mi.
Water	.6 sq. mi.
Pasture-Field	95.8 sq. mi.
Marsh	35.6 sq. mi.
Urban	16.7 sq. mi.

WILCOX COUNTY

Forest	156.0 sq. mi.
Water	3.8 sq. mi.
Pasture-Field	176.9 sq. mi.
Marsh	25.8 sq. mi.
Urban	24.9 sq. mi.

APPENDIX A

THE ERDAS SYSTEM

The Georgia Tech Earth Resources Data Analysis System (ERDAS) was designed and constructed by EES to allow true interactive digital processing of all types of remote sensing data (Figure A-1). ERDAS consists of a set of 4 modules: 1) minicomputer subsystem, 2) input medium, 3) hardcopy output medium, and 4) display subsystem.

The minicomputer subsystem consists of a NOVA-2/10 minicomputer with 64000 bytes of core memory and a dual Diablo disk system with 5.0 megabytes of storage for programs or data.

The input medium for the ERDAS system is a set of two nine track dual density (phase encoded/NRZI selectable) magnetic tape drives and controller -- both drives with a capacity for 10 (ten) 1/2 inch reels of tape.

The hardcopy output medium is a twenty inch electrostatic dot matrix printer/plotter. Scaled maps of Earth Resources data can be made using this medium. A CROMALIN$^{(R)}$ photographic process may then be used to generate a color coded output hardcopy product. Color products may also be obtained through a service offered by a commercial producer of film writers.

The display subsystem consists of a high quality video monitor that is interfaced to the minicomputer for complete user interaction in the choice of training samples for earth resources classification.

Elements of the subsystem are:

1. Color monitor
2. Trackball cursor
3. Self contained refresh memory
   a. one image 512 x 512 elements by 8 bits or
   b. three image 256 x 256 elements by 8 bits

ERDAS is a completely software oriented system. Training statistics can be calculated instantaneously for cursor located fields. A histogram may then be displayed to check homogeniety of training fields. Classification may be performed on stored data sets or data sets read in from the system's magnetic tape drives. This system is inherently interactive, and ratioing of MSS bands, level slicing, classification, and change detection software will provide display data to be fed to the color monitor.

The EES ERDAS System may be used in either of two general modes. In Mode 1 an image may be displayed on the display screen with a resolution of 512 by 512 elements with data values ranging from 0-black to 255-white. These data values may be color coded via a psuedo color memory to produce a false color display of the image. The user may select sixty-four display colors from a possible variety of 4096 colors (4 bits for each color gun). The colors are arranged in the pseudo color memory such that data values 0-3 are assigned the first color values, 4-7 are assigned the next, etc. A pseudo color scale that is often used varies from dark blue to green, yellow, orange, and red with different shades and combinations of these colors filling out the chart. This method is often used is displaying an image in as nearly a natural color state as possible (Figure A-2).

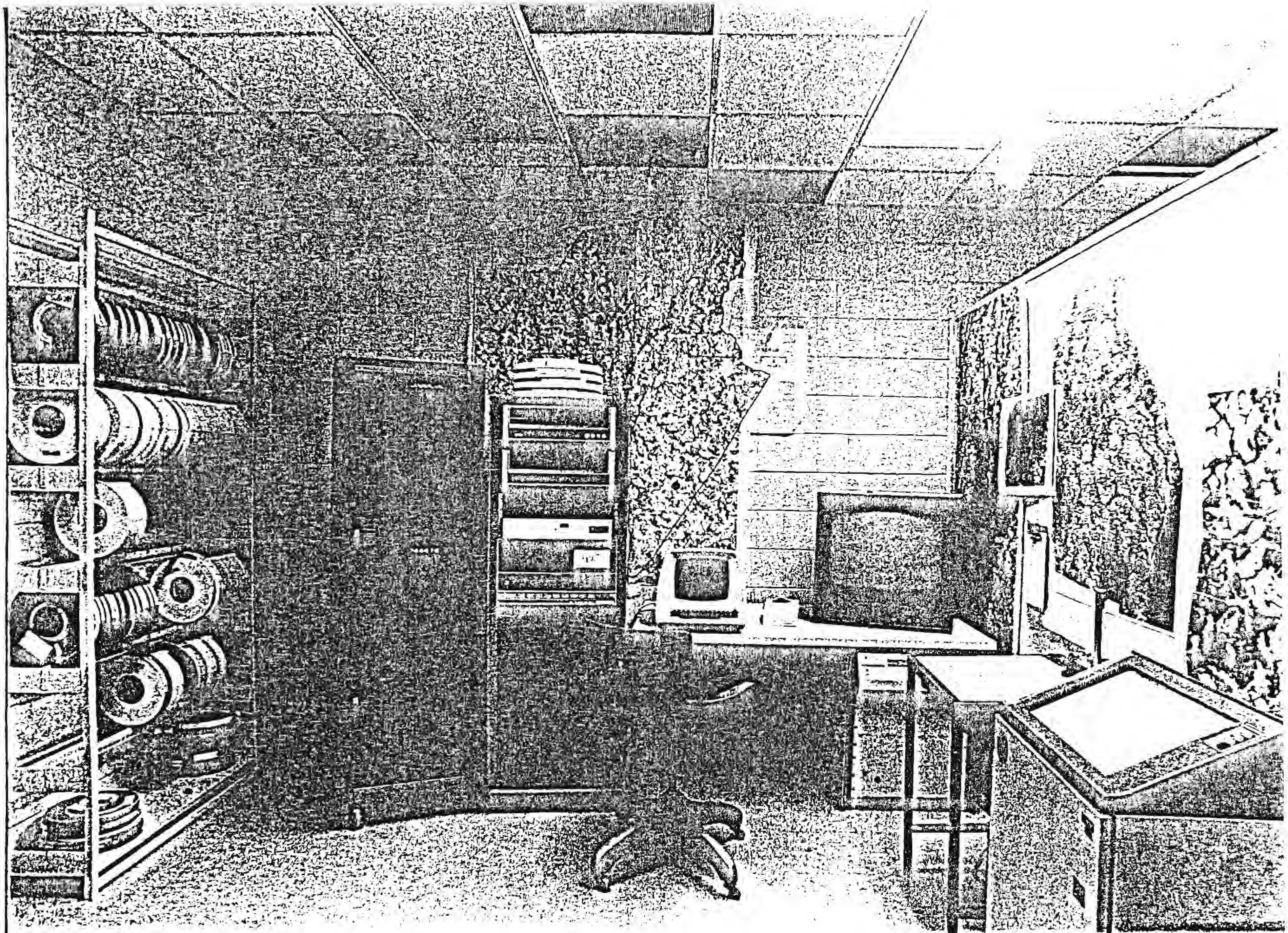
In addition to the pseudo color capability of the ERDAS System, it also has the capability of passing the original data values through a function memory before the data are displayed. As with the pseudo color memory, this function may be selected by the user. For example, if a linear function memory with a slope of one is to be used, a value "o" would be coded as a zero, a 10 as a 10, and so on. If, however, a linear function is selected with a slope of 2, a value "o" would be coded as a "0" but a 10 would be coded as a 20, and so on. After the value of 127 is coded to a 254, all subsequent values would be coded as 255. The function memory may be envisioned by a two dimensional grid with the bottom axis as the original data value and the vertical axis as the coded data value. The two examples given above are shown in Figure A-3. A logrithmic example is also given in Figure A-4. This capability allows the dynamic density stretching or compression of any image by linear or nonlinear functions. In all cases the data in the image memory remains the same as the original image. The function only operates on the image that is displayed on the television screen.

The second mode of the ERDAS System has a resolution of only 256 by 256 elements on the television screen but three Landsat or other images may be displayed at the same time. As before, each image contains data values between 0 and 255, but in this case each image may be assigned specifically to one color gun of the television. (Figure A-5). For Landsat data, normally three of the four channels of Landsat data are assigned to individual color guns. If channel one and channel two (visable bands) of Landsat data are applied to the blue and green guns, and channel 4 (near infrared) is applied to the red gun, a simulated near infrared image is displayed on the screen. This type of picture incorporates three channels of Landsat data at one time and results in a very similar color scheme to that of color infrared aerial photography. This technique has been most effective in the location of training fields for Landsat classification (Figure A-6) and as an aid in interpretation of the raw Landsat image.

All of the function memory and pseudo color memory operations discussed above may be performed in this mode also for each of the three images. For example, three different functions may be applied to the three images and the result shown as an enhanced color infrared display.

The remote sensing data at EES are processed by one or more picture processing computer programs. Basic analysis modules available are:

1. Supervised Classification (Maximum Likelihood)
2. Linear Supervised Classification
3. Sequential Unsupervised Classification (Clustering)
4. Non-Sequential Clustering (ISODATA)
5. Histogram Generation
6. Level Slicing
7. Registration and Rectification
8. Factor Analysis
9. Grey Scale Display
10. FFT (Fast Fourier Transform)
11. Change Detection
12. Polygon Training Field
13. Polygon Classification
14. Edge Enhancement
15. Ratioing



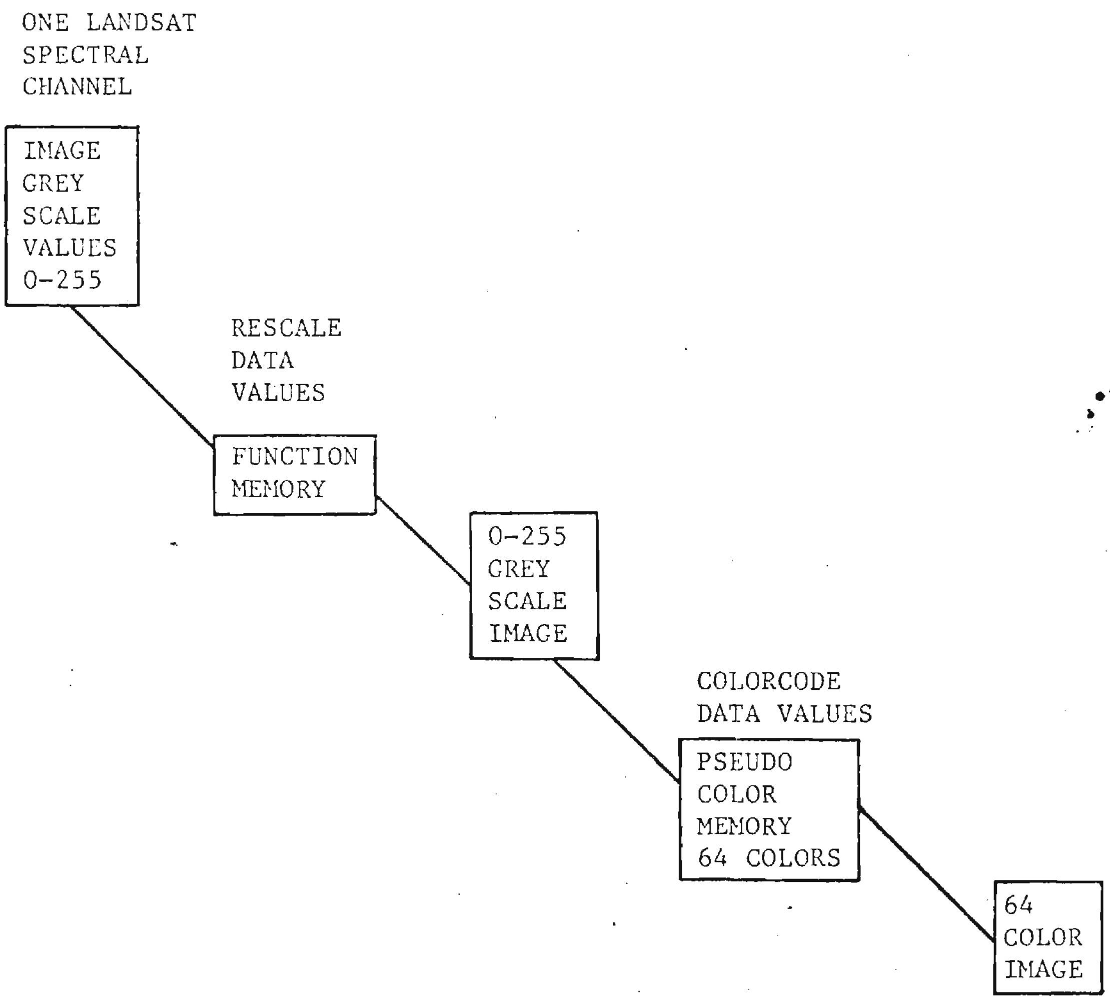


FIGURE 2. Color Video Display - Mode 1

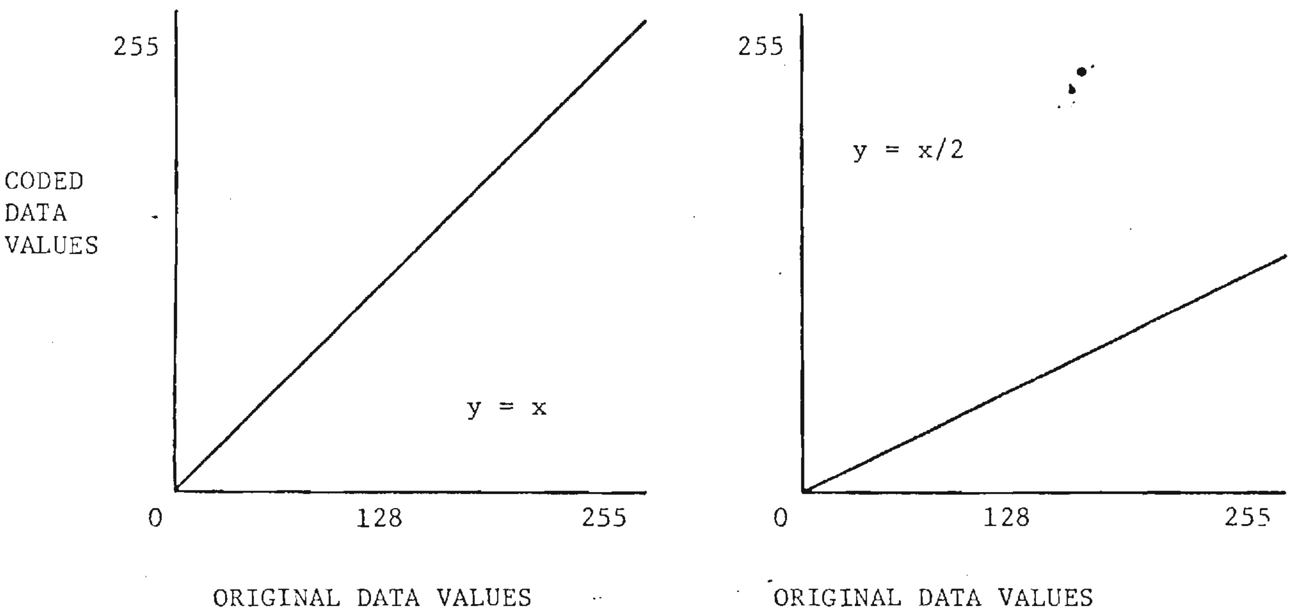


FIGURE 3. Linear Function Memory Example

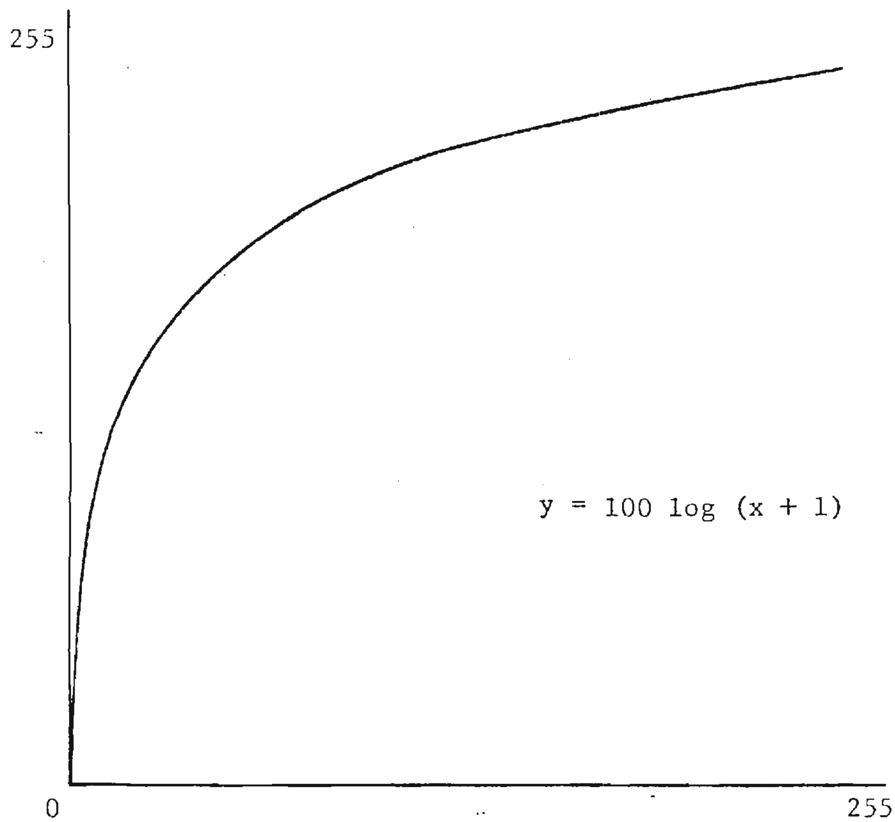


FIGURE 4. Logrithmic Function Memory

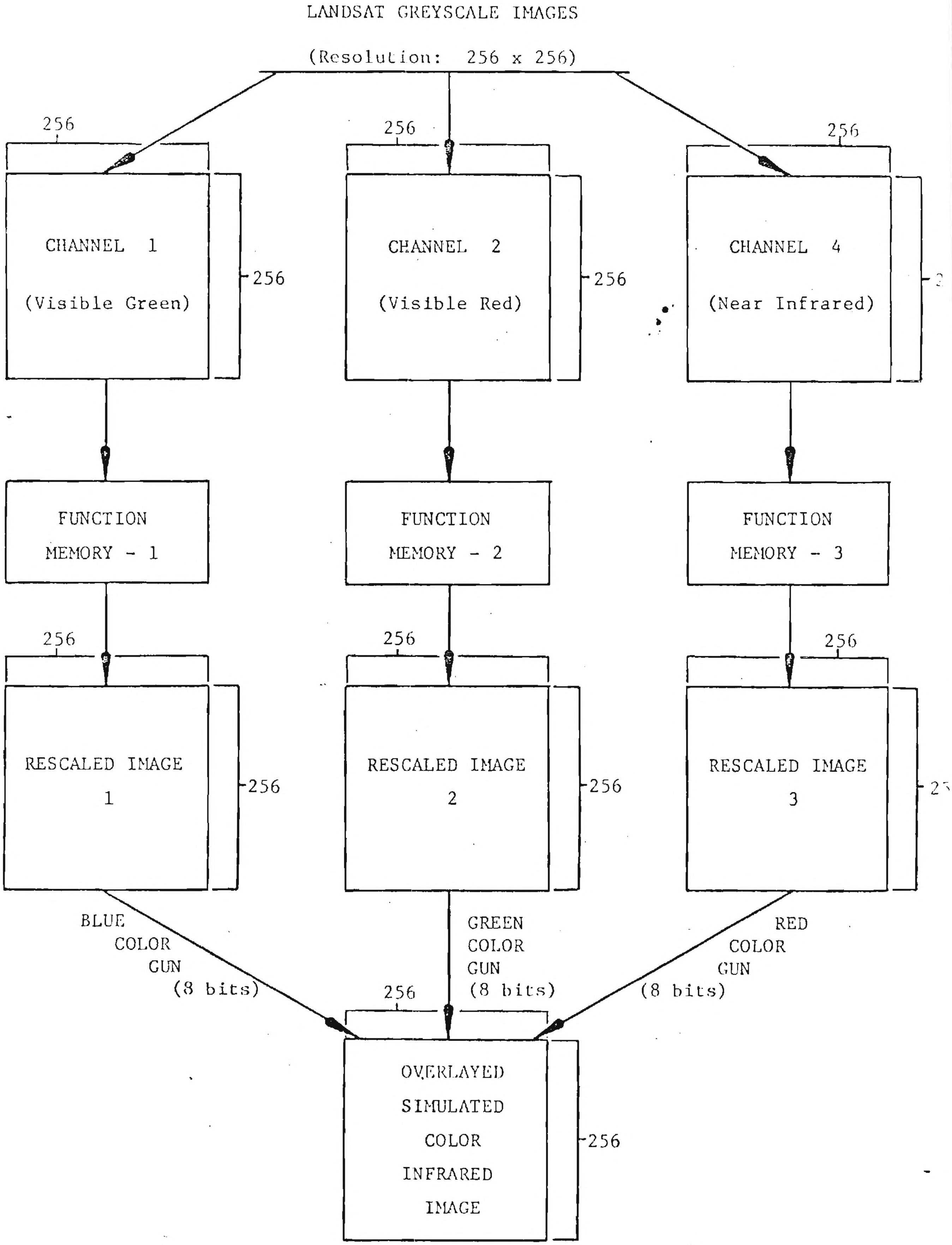


Figure 5: Block diagram of Mode 2 of the Color Video Display.