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**FINAL PROJECT REPORT
FOR THE
GROUND RECORDING AND PLAYBACK SYSTEM
(GSFC SPIN SCAN CLOUD COVER FACILITY)**

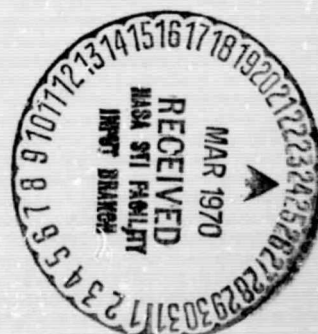
(JULY 1968-DECEMBER 1969)

CONTRACT No. NAS 5-11597

Prepared by

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**For
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND**

FINAL PROJECT REPORT
FOR THE
GROUND RECORDING AND PLAYBACK SYSTEM
(JULY 1968 - DECEMBER 1969)

CONTRACT NO. NAS 5-11597

GODDARD SPACE FLIGHT CENTER

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SECTION I

INTRODUCTION

1.1 PURPOSE AND SUMMARY

The purpose of this report is to summarize the work performed under NASA contract NAS 5-11597. These contract tasks were in conjunction with the Goddard Space Flight Center playback facility for generating photographic images on film from ATS spin scan camera data.

To implement this facility two subsystems were required - a set of data handling units and a color film recorder. This contract did not include the implementation or modification of a film recorder to meet the system needs. However, the data handling units were designed to interface with a film recorder electrically equivalent to the color film recorder now part of the ATS MSSCC equipment now at Rosman. In addition, a mode exists whereby a black and white film recorder may be used in lieu of the color recorder. In this mode any single color of a recorded ATS SSCC tape may be played back to form a black and white film record.

The data input to this facility consists of digital tapes recorded at the Rosman and Mojave data acquisition sites, and analog data transmitted via a GFE ground data link from the Rosman site. This equipment is capable of manipulating the data prior to film exposure to meet specific experimenter needs; this manipulation consists of both spatial and intensity (color) changes.

In addition, a study to specify the selection and addition of a small computer to the proposed facility was performed.

1.2 PROJECT BACKGROUND

The Applications Technology Satellites, ATS-1 and ATS-3 were launched into synchronous orbit in December 1966 and November 1967, respectively. In addition to several other experiments these spacecraft were used to test spin scan cameras (black and white aboard ATS-1 and color aboard ATS-3). These cameras, which are really scanning radiometers, use the spacecraft spin to scan one line of Earth data every 0.6 seconds. Mechanical tilting of the radiometer by a small angle in elevation once per revolution spaces these scan lines vertically. The camera and related data is transmitted directly to ATS data acquisition station at Rosman, North Carolina. At this station the video data is converted into digital form under control of a timing system which is synchronized with the spinning of the spacecraft. These digital signals are used to produce a photographic image and a digital tape recording. Each record on this tape contains the video data from one scan line (in each color). The digital samples are each 8 bits in intensity and are spaced about 0.0025 degrees apart (measured at the spacecraft) so that 8192 samples recorded on each line subtend an angle of 20 degrees. The line to line spacing is about 0.0075 degrees. These digital tapes can be played back at the data acquisition site to produce original quality photographic images or can be played back at most computer facilities for analysis purposes.

The need for a digital data processing and display facility at the NASA Goddard Space Flight Center was established early in 1968. The data acquisition sites primary function of recording data was occupying such a substantial amount of the available equipment operational time that playback of previously recorded data could not be accomplished at the desired rate. Also, since a digital tape recording of a full color ATS-3 picture requires

three standard size computer tapes, storage of previously recorded data was rapidly becoming a problem at the acquisition site.

The playback facility has the normal playback capabilities of the acquisition sites plus means for directly producing controllable enhanced photographic images in black and white and color and means for producing higher resolution black and white and color film images than possible at the acquisition sites. Another benefit of this facility was its accessibility near Washington, D.C. as compared to the Smoky Mountains. The coordination of playback to produce the film film processing, and evaluation of the picture requires less effort and a greatly reduced "turn-around" time.

SECTION 2

GROUND RECORDING AND PLAYBACK SYSTEM

2.1 SYSTEM DESCRIPTION

The Ground Recording and Playback System and its relationship to the Government Furnished Equipment is illustrated in figure 2.1.

The Rosman Microwave Interface unit accepts data from the MSSCC equipment for transmission via the microwave link to the data timing unit. The data timing unit selects either the analog signal from the microwave link or the digital signal from the digital playback unit. The digital playback unit contains two tape transports and sufficient magnetic core to implement its basic functions of direct playback as well as that of linear expansion, pseudo color, contrast control and data manipulation.

The data input to this system is from magnetic tape or a direct microwave link from the Rosman ATS site. The specific data input is limited to:

1). Analog

Direct analog data via the microwave link from the Rosman ATS site. The data input to the microwave link may be:

- a. analog recorder playback
- b. digital recorder playback
- c. real time buffered output

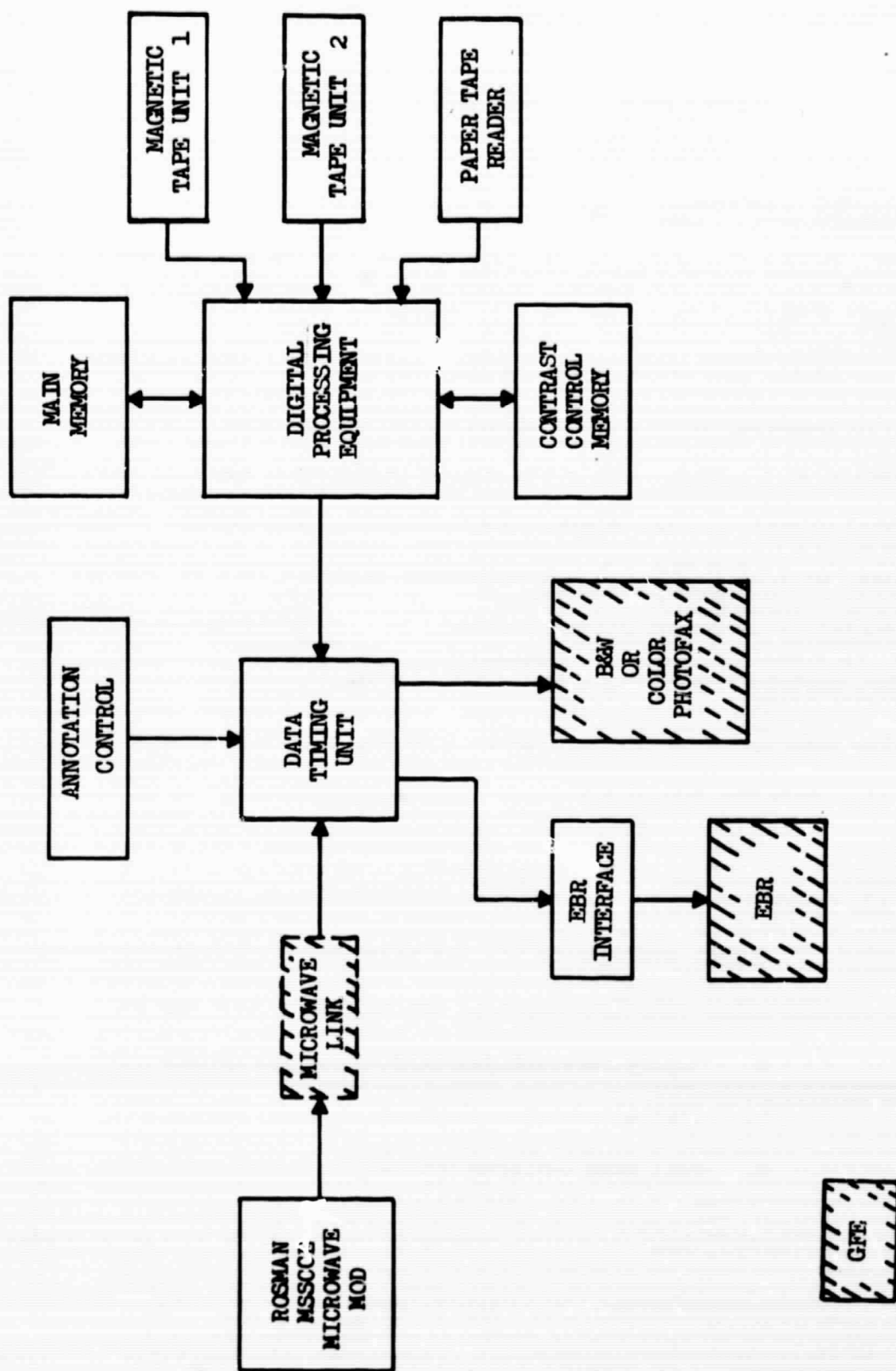


Figure 2.1. Ground Recording and Playback System Block Diagram

2). Digital

- a. Tapes generated by the digital recorder on all modes by the Rosman MSSCC unit.
- b. Tapes generated by the digital recorder by the Mojave SSCC unit.
- c. Tapes generated in any manner (for example, an off-line computer) having a proper format.

Data manipulation takes place at the digital playback system.

Data manipulation capabilities include:

1. Linear expansion of selected areas of data frame by 1X, 2X, 4X or 8X.
2. Single color playback of any selected color from a tri-color tape.
3. Pseudo-color and contrast control for single color inputs-whether from Mojave or Rosman ATS-1 data, or ATS-3 single color recorded data.
4. Contrast control for tri-color data.
5. Pseudo-red pictures from ATS-3 digital tapes.
6. Linear expansion, contrast control and pseudo-red modes may be simultaneously activated.

2.2 SUBSYSTEM DESCRIPTION

2.2.1 MAGNETIC TAPE UNITS

The GRPS utilizes two Ampex TM-12211 magnetic tape units for playback of recorded digital data. The tape units are 7-track (6 bits plus parity) IBM compatible machines capable of handling 1 or 1.5 mil computer tapes. The units operate at 120 IPS with 800 BPI packing density. Special +6 volt

interface circuits are provided for direct connection with the DTL integrated circuits used in the Digital Processing Equipment.

The tape units provide two basic system functions; playback of Rosman and Mojave Earth tapes and loading of pseudo red matrix data.

2.2.2 PAPER TAPE READER

The contrast control memory constants are loaded from paper tape using a Chalco 5000 Series Phototape Reader. The reader is a 6 level (4 bits data, 1 bit blank, and 1 bit start/stop) punch tape reader used to transfer data at approximately 30 characters per second.

2.2.3 MAIN CORE MEMORY

The main core memory is used for buffering data between the magnetic tape units and the film recorders. The unit is a Honeywell-3C ICM 40 Magnetic Core Memory System. The memory system has a 1 usec full-cycle and contains 8,192 twenty-four bit words with data partitioning to divide the memory into three 8 bit X 8,192 sections.

In color operation, three color records are read, from the magnetic tape into the three memory partitions and then read-out sequentially to the film recorders. In Black and White operation, the tape record is read into the first partition and then read-out to the film recorder.

2.2.4 CONTRAST CORE MEMORY

Contrast control and pseudo color functions are accomplished by the use of the contrast control core memory. The unit is a Datacraft Magnetic Core Memory Model DC-31. The core memory consists of 1,024 words of 8 bits per word. In operation, the 1,024 words are divided into 4 groups of 256 words each. Each 256-word bank contains 256 new amplitude values per color or black and white as referenced to 256 linear values. To derive these new values

the main core output is used, in conjunction with the color identity lines, to address the memory. The normal strobe line is converted to the memory "Read Command" line, and the memory is therefore addressed and commanded to read. Near the completion of the memory full-cycle time, the memory outputs a memory word with an output strobe pulse. The memory output word is then directed to the interface drivers, and the strobe pulse is transformed into the data strobe.

2.2.5 ROSMAN MSSCCE MICROWAVE MODIFICATION

The Rosman microwave interface unit accepts analog data from MSSCC equipment for transmission to the Goddard Facility. It accepts D/A digital playback, FRI800L analog playback or real time D/A data. This unit can receive analog playback data without interrupting normal data acquisition of the MSSCC equipment or digital playback at Rosman. The data input to the microwave link is controlled by a switch on the Video Processor front panel for selecting the desired mode of operation.

Two control signals, line start and line step, are also transmitted for proper synchronization of the analog video. Pulse width modulation is used to facilitate pulse identification at GSFC. The line-start pulse width is 100 microseconds, and the line step pulse width is 200 microseconds. Both are converted to +1 volt pulses to properly interface with the microwave transmitter.

2.2.6 DIGITAL PROCESSING EQUIPMENT

The Digital Processing Equipment provides digital tape playback, contrast control, pseudo-color, and pseudo-red capabilities. Figure 2.2 is a simplified block diagram of the DPE.

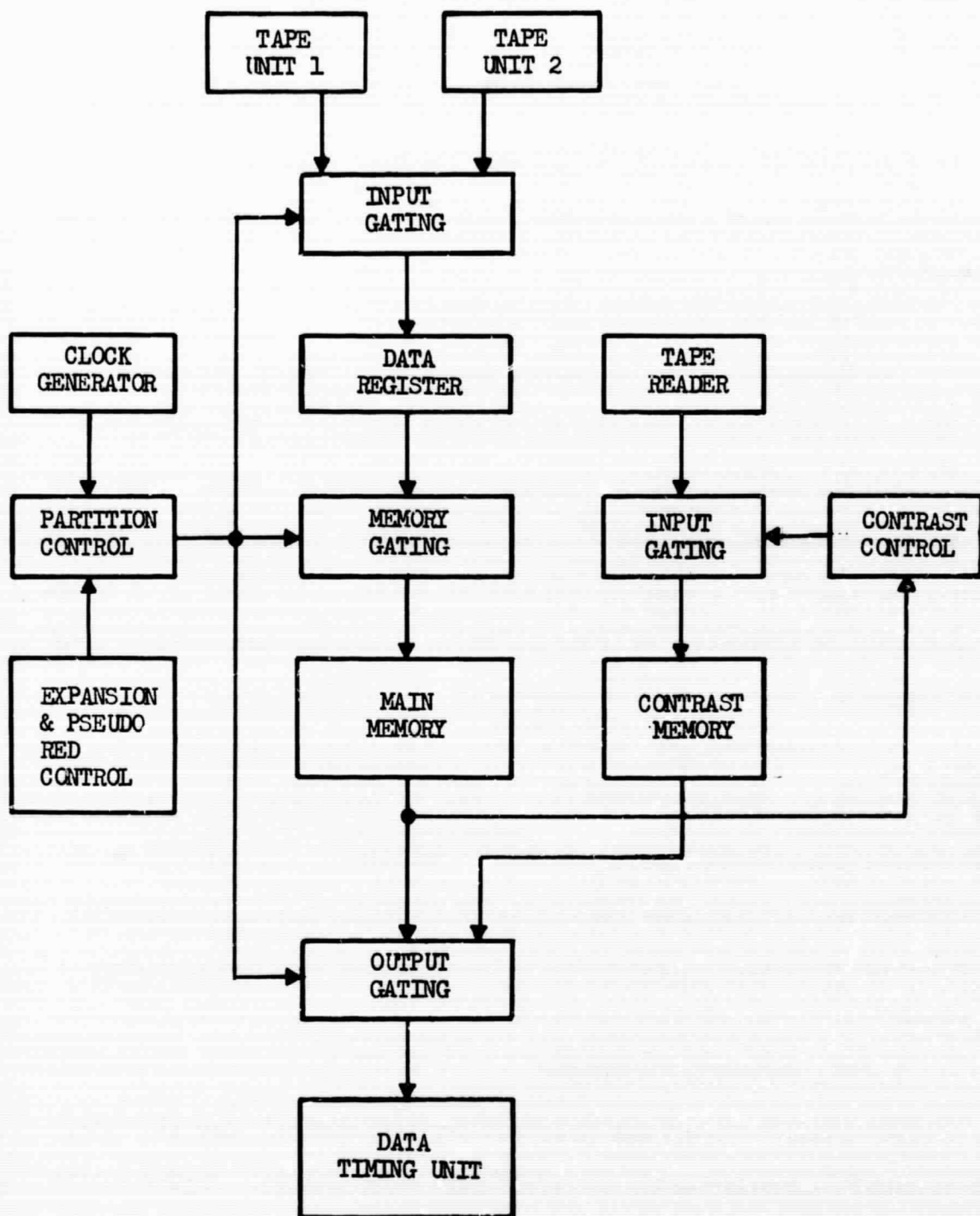


Figure 2.2. Digital Processing Equipment Simplified Block Diagram

The digital tape playback data function is capable of accepting digital tape data from two tape transport units. The tape data inputs consist of the Mojave ATS-1 black and white, Rosman ATS-1 black and white or Rosman ATS-3 color tape data. The digital tape playback function of the digital processing circuits processes the data from the tapes and buffers it to the data timing unit.

The digital tape playback function provides the following five data manipulation capabilities: (1) linear expansion of selected areas of data frame by 2X, 4X or 8X; (2) pseudo-color and contrast control for single color inputs; (3) contrast control for tri-color data; (4) pseudo red picture from ATS-3 digital tapes; and (5) simultaneous operation of linear expansion, contrast control and pseudo-red modes.

The DPE control panel contains all necessary switches for setting the playback mode, degree of expansion, and zone of expansion. Display lights are provided for the data register and essential monitoring functions.

The Rosman Tri-Color tapes are recorded with sequential green, red, and blue data on a line by line basis. In playback the data for one line (three sequential tape records) is read into the three partitions of the main core. This is accomplished by using 4-six bit tape words to form a 24 bit word in the data register and then loading 3-eight bit words into a partition of the main core. The process continues until all data for the green, red, and blue records have been loaded into the three core partitions. The data from the three partitions is then buffered sequentially at a 90 kHz rate to the Data Timing Unit. The process repeats until all lines recorded on the magnetic tape have been read.

In Rosman black and white or single color playback only the first

partition of core is used to buffer data.

The Mojave black and white playback is similar to the Rosman black and white playback. However, the data format on tape is different. For this mode of operation 3-six bit tape words are used to form an 18 bit word in the data register and then 2-eight bit words are loaded into the core partition.

Linear expansion is accomplished by specifying a vertical line count and horizontal A/D sample position on the DPE control panel. The tape unit is advanced until the selected line count is located. The main core is then loaded with the data for the selected line. However, instead of starting the buffering of data to the DTU with the first sample in core the read-out is started at the selected A/D sample. Each A/D sample and each line will be repeated the selected number of times (2,4, or 8).

The contrast control function consists of two parts. The major part involves a small core memory look-up table whereby the digital signal to the film recorders can be made any arbitrary function of the encoded video signals. This function may be individually set for each color, and black and white. The function of this part is to introduce desired non-linearity into the film density curve to compensate for film characteristics and to emphasize certain features, e.g., land masses. Special effects can be produced; these include:

- 1) Multi-colored contour maps.
- 2) Black-white pictures with selected color transition zones at given intensity values.
- 3) Intensity inversion, that is, replacement of high intensity values with low, and vice versa.

A second part of this contrast control permits generation of pseudo-color prints.

Implementation of these functions involves the use of a core memory look-up table capability. Normal IX, 2X, 4X and 8X expansion modes may be operated in conjunction with these new modes.

The eight bit outputs from the main core are used with the partition controls to address the contrast core. The contrast core output is then buffered to the DTU.

During pseudo-color all three sections of the main core are loaded in parallel with the data from the single color tape. Data is unloaded from the core in the conventional color contrast mode, thus providing a pseudo-color picture. The color generated for each intensity value is stored in the contrast core memory.

The pseudo-red part of the digital processing equipment has the function of replacing the (defective) red channel video with a pseudo-red video derived from the green and blue video. The theory of operation of this technique is discussed in the "ATS-1 SSCC Data Reduction and Analysis Final Report" May 15, 1968.

The red partition of the main memory unit is loaded from a magnetic tape containing the proper matrix constants for the 4096 locations.

The operating sequence for Pseudo-Red output is relatively simple once the constants have been loaded in the Red partition of the main memory. The Green partition of memory is read-out first in normal operation. Following the completion of Green data the Green and Blue partitions are read-out together into a 12 bit register.

This 12-bit address corresponds to the 6 most significant bits of green (IG) and the 6 most significant bits of blue (IB). The address is used to select one of the 4096 8-bit words in the red section of memory.

The Red partition then outputs a constant for that address. The Green/Blue partitions are sequenced through their 4096 locations in this cycle to complete the output of "RED" data. Finally, the Blue partition is sequenced through to completion and, in this manner, the generation of a multicolor line is included.

2.2.7 DATA TIMING UNIT

The Data Timing Unit interfaces and coordinates the other elements of the system. It accepts either analog data from the microwave link or digital data from the Digital Processing Equipment. Interface circuitry is provided to operate an EIS black and white Photofacsimile Recorder or a color Photofacsimile Recorder electrically equivalent to the unit at Rosman. Figure 2.3 is a simplified block diagram of the DTU.

The microwave interface receives pulsewidth modulated line start and line step pulses on a single cable from the GFE microwave link. The pulses are threshold detected, pulsewidth discriminated for noise rejection, and pulsewidth demodulated to separate the pulses. The line step pulse is used to synchronize the color video control circuitry. The line start pulse is used to initiate the photofax data handling and start the PEP counter which generates picture element pulses to advance the photofax horizontal deflection system.

The DPE interface receives the 8-bit digital data, line starts, data strobes, and filter advance pulses. These inputs are used to supply photofax outputs in the digital playback mode.

The BCD line counter is used to indicate on a front panel NIXIE display the number of video lines that have been processed.

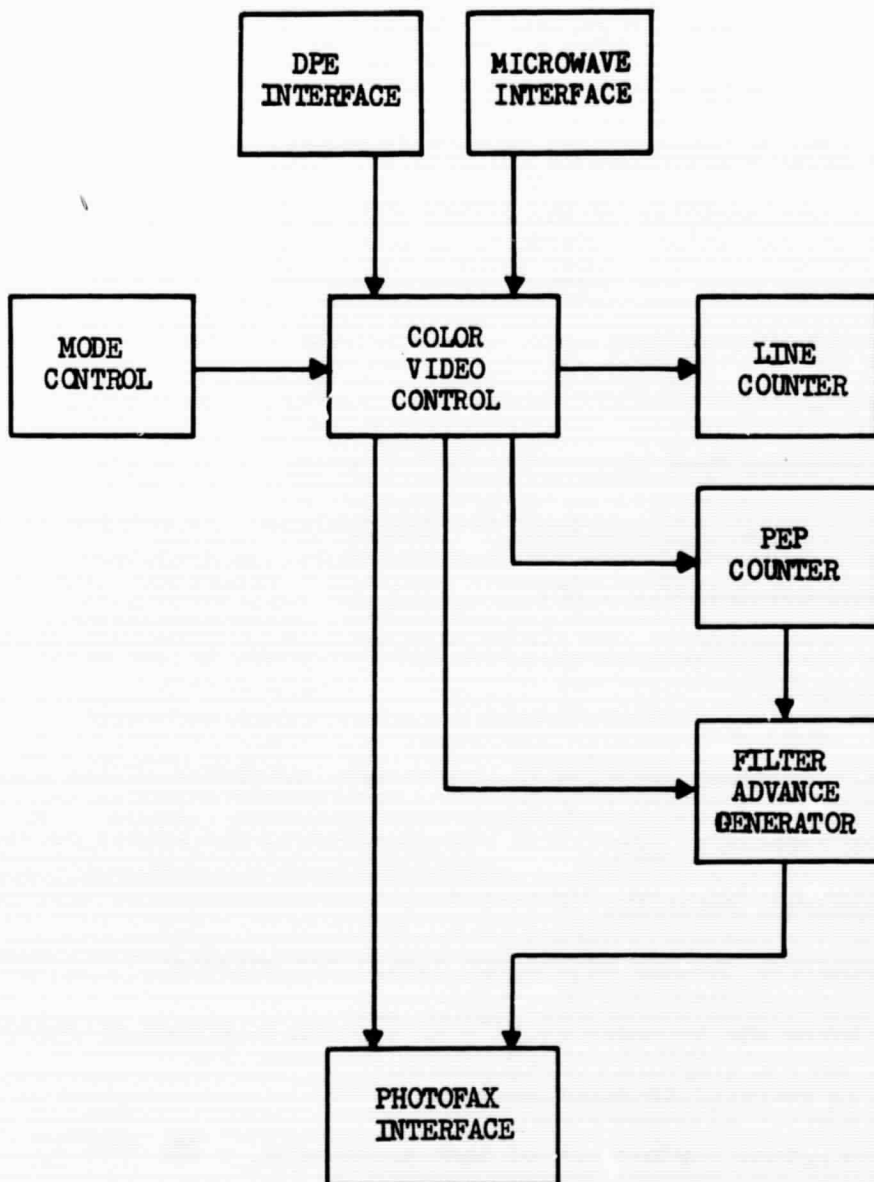


Figure 2.3. Data Timing Unit Simplified Block Diagram

The color video control generates video enable to synchronize and control the processing of the green, red, blue or black and white video signals in the photofax.

The filter advance generator performs two functions. The first function is to generate a pulse train to advance the color filter wheel in the photofax after a color record has been processed. The second function is to synchronize the position of the filter wheel, based on a resolver output from the photofax, with the video enables generated by the color video control.

2.3 SYSTEM TEST SUMMARY

2.3.1 IN-PLANT TESTS

2.3.1.1 Acceptance Test Plan

The program for equipment testing included the writing of an Acceptance Test Plan and Evaluation Report. This was a formal document written by Westinghouse and submitted to NASA for approval prior to the start of acceptance testing.

This document provided the basis for acceptance of the GSFC SSCC Data Handling Facility. The format was designed to facilitate documentation of test procedures, recording of test data, and evaluation of test results. The test procedures contain sufficient detail for engineering personnel to perform the tests and document results by filling in blanks or attaching photofacsimile recorder or scope pictures.

The actual performance of test procedures, collection of test data, and documentation of results were witnessed by the NASA Technical Officer or his authorized representative.

2.3.1.2 Data Timing Unit Test Unit

The GRPS is capable of processing analog data received from the MSSCC equipment at Rosman via the microwave link. Since a microwave terminal does not exist at Westinghouse for receiving transmissions from Rosman, in-plant testing was limited to processing simulated inputs.

The DTU Test Unit was constructed for unit testing of the Data Timing Unit. For Acceptance Testing only the facilities for simulating the uwave link were used.

The DTU Test Unit simulates the uwave link by counting down a 45 kHz input clock to produce 88 usec line start pulses and 176 usec line step pulses. The line start pulses are spaced 180 msec with the line step pulse occurring 45 msec before each third line start. The line start/stop pulses are "OR" ed to simulate the single line received from the uwave link. The uwave link video signal is simulated by a resistor dropping network and front panel switch for selecting 1, 0.5, 0.25, or 0 volt video levels.

2.3.1.3 Test Tapes

A series of eight magnetic and one paper tape were used for acceptance testing. These tapes were generated as part of the acceptance test program and were designed to exercise the GRPS in all modes with all data formats. The eight magnetic tapes contain test patterns written in the Rosman and Mojave formats. The paper tape contains four look-up tables of 256 words each for use in the contrast memory.

A complete description of each test tape is contained in the Acceptance Test and Evaluation Report.

2.3.1.4 Acceptance Test Summary

Table 2.1 summarizes all acceptance tests that were performed. In this table similar tests have been grouped to facilitate review of acceptance tests versus operational modes and it is not intended to specify the order in which the tests were performed. The order of performing the acceptance tests was selected to minimize changing of cables, loading of magnetic and paper tapes, and equipment mode switching.

TABLE 2.1. ACCEPTANCE TESTS

A. MICROWAVE LINK INTERFACE TESTS

Mode	Data Source For Tests At Westinghouse	Data Source For Tests At Goddard	Test Result	Evaluation
1. Buffered Real Time B&W	DTU Test Unit	a) DTU Test Unit	FAX Picture 5 Gray Levels; 400 Lines per Level	Visual Examination
		b) Rosman "B" Cali- brate Test Pattern	FAX Picture Bar Pattern with 10 Gray Levels	Visual Examination
2. Buffered Digi- tal Play B&W	-----	Rosman Digital Play of Tape Recorded in A-lb	Same as A-lb	Visual Examination
3. FRL800L Play B&W	-----	Rosman FRL800L Play of Tape Recorded in A-lb	Same as A-lb	Visual Examination
4. Repeat of A-1, A-2, A-3 with Tri-color Format and Sin- gle Color Se- lection	DTU Test Unit	a) DTU Test Unit	FAX Picture 5 Gray Levels; Changed in 500 Line Increments; Color Select changed in 800 Line Increments	Visual Examination

TABLE 2.1.1. ACCEPTANCE TEST (Cont'd)

Mode	Data Source For Tests at Westinghouse	Data Source For Tests At Goddard	Test Results	Evaluation
		b) Rosman "C" Calibrate Test	FAX Picture Bar Pattern with 10 Gray Levels; Color Select changed in 800 Line Increments	Visual Examination

NUMBER OF PHOTOGRAPHIC RECORDS REQUIRED FOR A1-A4.

AT WESTINGHOUSE	2	PHOTOFAX PICTURES
AT GODDARD	8	PHOTOFAX PICTURES

TABLE 2.1. ACCEPTANCE TEST (Cont'd)

B. FILM RECORDER INTERFACE TESTS

Mode	Data Source	Westinghouse & Goddard	Signal	Evaluation
1. B&W Film Recorder; B&W Mode; uwave Data Input	a) DTU		Frame Start	Visual Observation of B&W FAX Starting when FRAME START push button on DTU is depressed.
			Frame End	Visual Observation of B&W FAX resetting when MASTER CLEAR push button on DTU is depressed.
	b) DTU Test Unit		Analog Video	Measurement of Input Voltage vs. Output Voltage for 5 Video Levels available on DTU Test Unit.
				Measurement of Noise Level for 0 Volt Input with DTU operating in uwave Mode.
2. B&W Film Recorder; B&W Mode; Digital Data Input	Tape VII		Line Start	Scope Measurement of Signal Characteristics.
Rosman Format			Digital Video & Digital Data Strobe	Scope Picture of Timing Relationship between Bit 1 and Data Strobe during first 1,220 lines.

TABLE 2.1. ACCEPTANCE TESTS (Continued)

Mode	Data Source Westinghouse & Goddard	Signal	Evaluation
3. Color Film Recorder Color Mode; unwave Data Input	DTU Test Unit		Scope Observation of BITS 2-8 and Data Strobe during first 1,220 lines.
			Repeat for 2nd 1,220 lines; picture and observation.
		a) 500 Hz Clock	Scope Observation of Signal Characteristics
		b) Line Start	Scope Observation of 3/Line
		c) Gray Scale Control (Simultaneous with B-3b)	Scope Observation of Occurrence of 3/Line
		d) Data Strobes	Scope Observation of occurrence of 3 Groups/Line (A-Trace)
		e) Color Select Green (Simultaneous with B-3d)	Scope Observation of Bracketing of 1st Data Strobe Group (B-trace)
		f) Color Select Red (A-Trace Depicting B-3d)	Scope Observation of Bracketing of 3rd Data Strobe Group (B-Trace)
		g) Color Select Blue (A Trace Depicting B-3d)	Scope Observation of Bracketing of 3rd Data Strobe Group (B-Trace)

TABLE 2.1. ACCEPTANCE TESTS (Cont'd)

Mode	Data Source Westinghouse & Goddard	Signal	Evaluation
4. Color Film Recorder; B&W Mode; unwave Data Input	DTU Test Unit	h) Color Select	Scope Observation that only Selected Color Enable Occurs Green/Red/or Blue
		i) Filter Advance	Scope Picture Illustrating Advance/Retard/Normal
		a) Color Select	Scope Observation that B&W Enable is at 0 V. and G,R,B Enables at +6 V.
		b) Filter Advance	Scope Observation that no Filter Advance Pulses Occur.
5. Color Film Recorder; Color Mode; Digital Play Tri-Color Format	Tape III (1st Reel)	Repeat of B-3a to B-3h	Scope Observation and comparison with B-3a to B-3h Test Results.
6. Color Film Recorder; B&W Mode; Digital Play Rosman Format	Tape VII.	Repeat of B-4a and B-4b.	Scope Observation and Comparison with B-4a and B-4b Test Results

NUMBER OF PHOTOGRAPHIC RECORDS REQUIRED FOR B1 - B6.

AT WESTINGHOUSE	4	OSCILLOSCOPE PICTURES
AT GODDARD	4	OSCILLOSCOPE PICTURES

TABLE 2.1. ACCEPTANCE TESTS (Cont'd)

C.	DIGITAL PLAY B&W TESTS	Data Source Westinghouse & Goddard	Test Result	Evaluation
	Mode			
1.	Digital Play B&W Rosman Format	Tape I.	FAX Picture Resolution and Gray Scale	Visual Examination
2.	Digital Play B&W Mojave Format	Tape II.	FAX Picture Resolution and Gray Scale	Visual Examination
3.	Digital Play B&W Rosman Format 4X and 8X Expansion	Tape I.	FAX Pictures (3) Over- lapping Fine Detail and Gray Scale	Visual Examination
4.	Digital Play B&W Mojave Format 4X and 8X Expansion	Tape II.	FAX Pictures (2) Over- lapping Fine Detail and Gray Scale	Visual Examination
5.	Digital Play B&W Rosman Format with Contrast Control	Tape IV and Tape A	FAX Pictures (2) 16 x 16 pattern; 1st picture without contrast control 2nd picture with contrast control	Visual Comparison of the pictures.
6.	Digital Play B&W Mojave Format with Contrast Control	Tape V and Tape A	FAX Pictures (2) 16 x 16 pattern; 1st picture with- out contrast control; 2nd picture with contrast con- trol	Visual comparison of the pictures.

TABLE 2.1. ACCEPTANCE TEST (Cont'd)

Mode	Data Source Westinghouse & Goddard	Test Result	Evaluation
7. Digital Play B&W Mojave Format	Earth Tape	FAX Picture	Visual Comparison with Mojave FAX Picture

NUMBER OF PHOTOGRAPHIC RECORDS REQUIRED FOR C1-C7.

AT WESTINGHOUSE	11	PHOTOFAX PICTURES
AT GODDARD	11	PHOTOFAX PICTURES
AT MOJAVE	1	PHOTOFAX PICTURES

TABLE 2.1. ACCEPTANCE TEST (Cont'd)

D. DIGITAL PLAY COLOR TESTS			
Mode	Date Source	Test Results	Evaluation
	Westinghouse & Goddard		
1. Digital Play Pseudo Color; Rosman Format	Tape IV and Tape A	FAX Picture; Color Select Changed in 800 Line Increments.	Visual Examination and com- parison with FAX Picture generated in C-1.
2. Digital Play Pseudo Color; Mojave Format	Tape V and Tape A	FAX Picture; Color Select Changed in 600 Line Increments.	Visual Examination and com- parison with FAX Picture generated in C-2.
3. Digital Play Tri-Color Format	Tape III (3 reels)	FAX Picture; Resolu- tion and Gray Scale; Color Select changed in 800 Line Increments.	Visual Examination
4. Digital Play Tri-Color For- mat 4X and 8X Expansion	Tape III	FAX Pictures (2) Over- lapping Fine Detail and Gray Scale; Color Select Changed on 800 Line Increments	Visual Examination
5. Digital Play Tri-Color For- mat; Contrast Control	Tape VI (2 reels) and Tape A	FAX Pictures (2); 16 x 16 with Color Bars; 1st Picture without Contrast Control; Color Select changed in 500 line in- crements.	Visual Comparison of the Pictures

TABLE 2.1. ACCEPTANCE TESTS (Cont'd)

Mode	Data Source Westinghouse and Goddard	Test Results	Evaluation
6. Digital Play Tri-Color For- mat; Pseudo Red; Color Select Red	Tape VIII	FAX Pictures (2); Red Color Select; 1st Pic- ture without Pseudo Red; 2nd Picture with Pseudo Red	Visual Examination and Comparison of the Pictures
7. Digital Play Tri-Color For- mat; X4 Expan- sion; Pseudo Red; and Con- trast Control.	Tape VIII, and Tape A	FAX Picture; Color Se- lect changed in 800 Line Increments.	Visual Examination
8. Digital Play Tri-Color For- mat	Earth Tapes	FAX Pictures (3); 1 each Color Select	Visual Comparison with Rosman FAX Pictures

NUMBER OF PHOTOGRAPHING RECORDS REQUIRED FOR D1 - D8

AT WESTINGHOUSE	13	PHOTOFAX PICTURES
AT GODDARD	13	PHOTOFAX PICTURES
AT ROSMAN	3	PHOTOFAX PICTURES

2.3.1.5 Acceptance Test Results

The series of acceptance tests conducted demonstrated the capability of the GRPS to perform all contractually required functions. The following photographs are examples of test results selected from the Acceptance Test and Evaluation Report.

Figure 2.4 shows the test result of the black and white Rosman format compatibility test, and contains an 8 level gray scale, a center MTF pattern, and an edge MTF pattern. This test demonstrates the ability of the GRPS to process and display data recorded on magnetic tape in the Rosman single color format.

Figure 2.5 demonstrates the ability of the GRPS to expand picture data recorded on magnetic tape in the Mojave format.

Figure 2.6 demonstrates the compatibility of the GRPS with tapes generated at the Rosman site.

2.3.2 GSFC TESTS

Acceptance testing at Goddard was conducted in two phases. Phase one was an exact duplication of all tests performed during in-plant testing at Westinghouse. This demonstrated that no degradation in performance occurred in shipping. Phase two was a series of tests involving transmission of data from Rosman to Goddard via the GFE microwave link. The microwave link testing involved transmission of both real time and recorded data to checkout the microwave source switching network that was installed in the MSSCC equipment at Rosman.

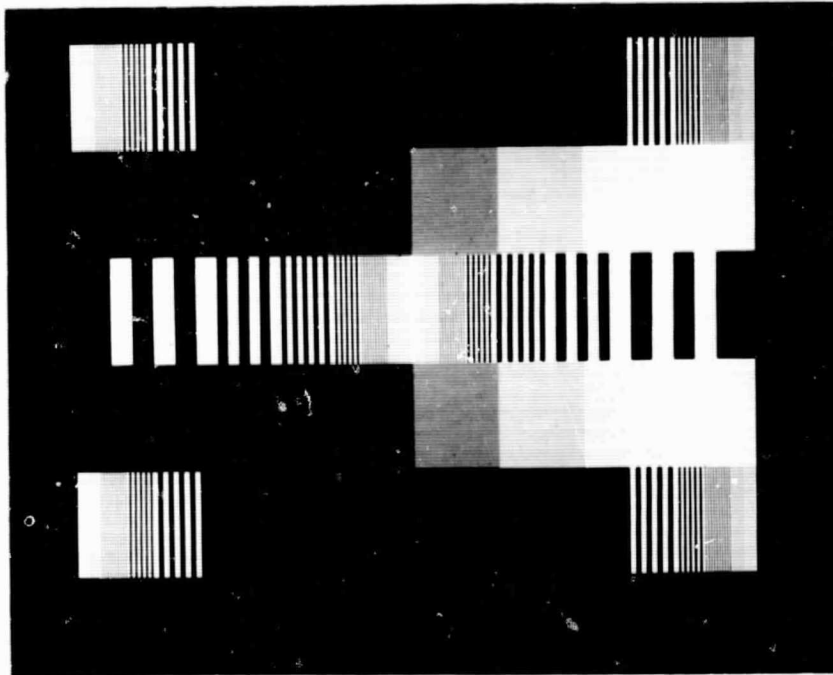


Figure 2.4. Rosman Black and White MTF

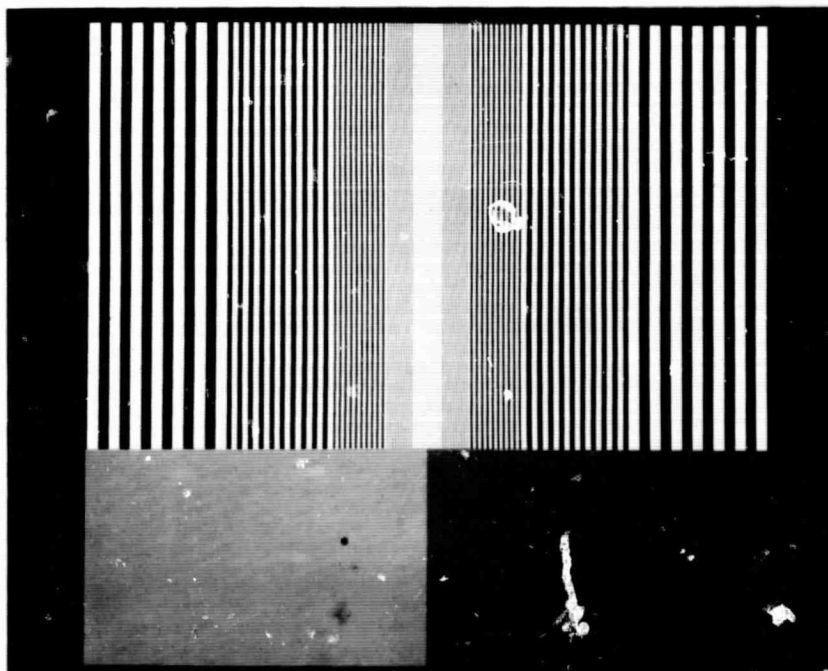


Figure 2.5. Mojave 8X Expansion

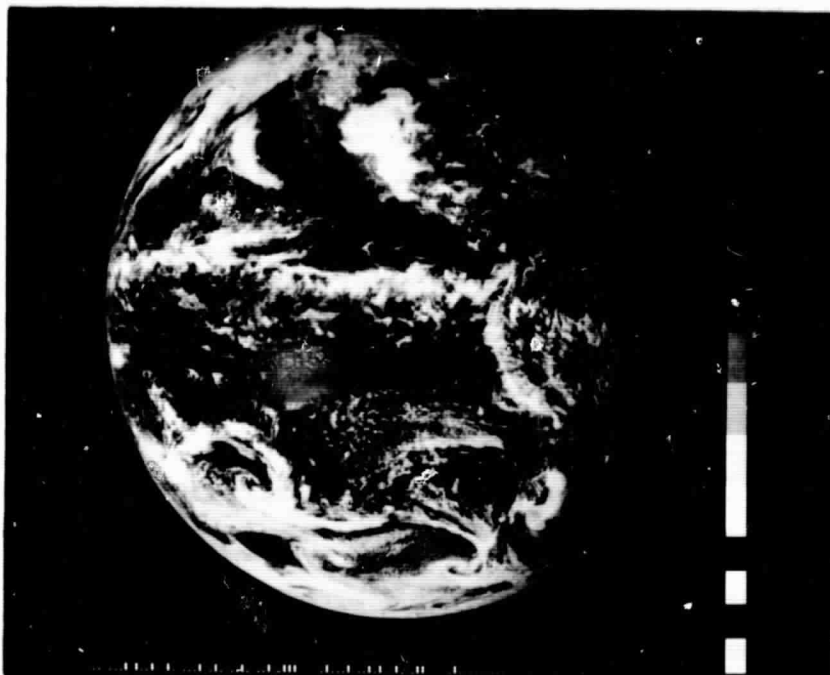


Figure 2.6. ATS-3 Earth Data-Red Channel

SECTION 3

MODIFICATIONS

Three modifications to the basic GRPS were made after system acceptance tests were completed. The first modification involved the addition of circuitry to provide timing and video signals to interface with a CBS Electron Beam Recorder. The second modification involved the addition of circuitry and controls for annotating Time (year, day, hours, and minutes) and Data Source on the Photofax and EBR negatives. The third modification increased the selectivity of the starting point for expanded playback pictures.

3.1 EBR INTERFACE

A modification to the Ground Recording and Playback System (GRPS) was made to provide video and line start timing inputs to the CBS Electron Beam Recorder (EBR) at the Goddard Facility. Since the EBR is a Black and White recorder the capability to select single color data from either the microwave link or digital tape playback was provided. All modes such as 4X and 8X expansion, contrast control, pseudo-color and pseudo-red are operational while providing signals to the EBR. In addition, 2X expansion capability was added to the system operational modes.

In the microwave mode, the analog video and the line starts are derived from those generated by the Rosman equipment and have the same characteristics as those supplied to the Photofax.

In the digital playback mode, a digital to analog (D/A) converter was added to furnish the analog video. The D/A output contains twice the number of samples of the digital video per line as the digital output to the FAX.

The digital video is sampled every 11 microseconds for the D/A output to the EBR.

The EBR can be operated at the same time as the FAX to record the same picture data. However the EBR can only generate pictures from the green component of tri-color data while the FAX is producing a color picture.

The EBR interface modification was installed by Field Engineering and Support. An Acceptance Test Plan and Evaluation Report similar to the GRPS ATP was written and two magnetic test tapes were generated. The performance of the tests was witnessed by the NASA Technical Officer.

3.2 ANNOTATION CODE

This modification provides a means for annotating Time (year, day, hours, and minutes) and Data Source on the photofax and EBR negatives for all data processed which does not already contain this information.

The modification consisted of adding an annotate control panel and a single bay logic rack. The annotate control panel contains 10 BCD thumb-wheel switches (2 digits-year, 3 digits-day, 2 digits-hours, 2 digits-minutes, 1 digit-data source); an ON/OFF toggle switch; and an ANNOTATE START push-button switch.

When the ON/OFF switch is ON the photofax and EBR are limited to 2400 lines of data as determined by the DTU line counter. Then, when the ANNOTATE START is depressed the information set on the thumbwheel switches is recorded on the next 40 lines. The appearance of the annotation code is essentially identical to the ROSMAN ATS annotation code. The annotation generator is capable of generating white in either the color or black and white.

Annotation of analog data can be accomplished by the operator changing the equipment switch settings to digital before depressing the ANNOTATE START.

The installation and checkout of the Annotation modification was made by Field Engineering and Support. Results of the tests were documented in an FE&S Field Trip Report submitted to the NASA Technical Officer.

3.3 EXPANSION LOCATION VERNIER

A modification to the Recording and Playback System was made to increase the capability to select the starting point for an expanded playback picture.

The vertical starting point could previously be selected in increments of 100 lines. The modification provided the capability to select the vertical starting point in increments of 1 line. This was accomplished by adding two switches to the "vertical line count" switch plate on the digital processing equipment (DPE) control and display panel and making the required changes to the DPE circuits.

The horizontal starting point could previously be selected in increments of 512 A/D samples. The modification provided the capability to select the starting point in increments of 64 A/D samples. An eight position rotary switch was added to the DPE control and display panel to provide this capability. To implement the change, the "pseudo color" switch was moved to a different location on the panel. A new rotary switch was mounted on a plate positioned in the area where the pseudo color switch was removed. The DPE circuitry was changed as required to accept the inputs from the new switch.

The installation and checkout of the Expansion Location Vernier modification was made by Field Engineering and Support. Results of the tests were documented in an FE&S Field Trip Report submitted to the NASA Technical Officer.

SECTION 4

COMPUTER REQUIREMENT DEFINITION STUDY

4.1 PURPOSE OF STUDY

The objective was to investigate, and report on, additional functions which a computer can perform as part of the GSFC Data Handling Facility (DHF). As presently designed the DHF has the capability of accepting all types of digital data tapes recorded at the Mojave and Rosman SSCC ground stations, and generating black and white or color film records. In addition to such direct playback, certain manipulation of the data can be performed. Included are 4 X and 8X linear magnification of the data prior to photographic recording, production of pseudo-color images from monochrome digital data, transformation of intensity values to change picture contrast of for special effects, and introduction of pseudo-red data to replace the spacecraft defective red data.

The function of a computer would be: (a) to permit more sophisticated display of the data, (b) for printout of computed data analysis results and (c) to write a processed data tape.

The study was conducted by first specifying the types of computer programs to be run, and then selecting those programs requiring the maximum speed or storage. On the basis of these selected programs, seven computers were considered and, for each, the computation time and storage requirements were determined. For the most suitable computers, estimates were made of the extent and cost of additional interface hardware required. Finally, these elements were combined to generate conclusions and recommendations.

4.2 CONCLUSIONS

The study considered all low cost 16 and 24-bit computers known to Westinghouse. The seven computers discussed thus represented minimum units as available today. A comparison of the least expensive 16 and 24 bit computers is shown in table 4.1. The SCC-660 appears to be the best overall choice when considering capability and delivery. The Sigma II is about 13 percent cheaper, but has a computation time of 50 percent greater and delivery time of 7 months longer.

The SCC-660 is a general purpose, high-speed, binary computer with a single address structure allowing indexing and indirect addressing. Salient features such as hardware multiply and divide, fully parallel internal processing, memory protection, and automatic subroutine linkage provide a high system performance capability. The entire magnetic core memory of the SCC-660 is directly addressable and consists of one to a eight independently addressable memory modules. Each memory module has a 1.75 usec memory cycle and contains an address register, a data register and 4096 twenty-four bit words of core storage. Although, for the present system, only four modules are proposed, the flexibility of 4 K modules yields expansion capabilities at minimum cost. Scientific Control Corporation provides a Symbolic Assembler (SFL), a FORTRAN compiler, a Conversation Algebraic Language, a Batch Operating System (BOS), program debugging system, hardware diagnostic programs, utility routines and mathematical routines for the SCC-660.

Programming costs to produce an executive program as well as perform the gridding and attitude computations will require about one man-year of effort at a direct cost of about \$24,000. Other costs such as for documentation, installation and checkout of the hardware and software are not included in the cost figures cited.

TABLE 4.1. FINAL COMPUTER COMPARISON

	Computation Time (Minutes)		Costs (\$10 ³)		DELIVERY (Months)
	GRID	ATTITUDE	COMPUTER	INTERFACE	
SIGMA II	10	30	75	20	10
SCC-660	7	20	85	24	3
				TOTAL	
				95	
				109	

4.3 REMOTE COMPUTER UTILIZATION

The purchase and installation of a computer as part of the GSFC Data Handling facility would cost about \$100,000 (See Table 4.1). This cost can be eliminated or substantially reduced by the use of an existing computer at GSFC. Three such computers have been identified and their location is specified in Table 4.2.

TABLE 4.2 COMPUTER LOCATION

<u>Computer</u>	<u>GSFC Building Number</u>
SDS-930	11
SDS-9300	22
IBM 360/75	21

Two methods of using these computers have been considered: direct hardware interface and magnetic tape interface. The direct hardware approach would involve placing special interface units at both the computer and DHF equipment and providing the necessary cables between these units. Such an arrangement would be similar to having a computer located at the DHF and could provide similar benefits. However we must recognize that these other computers normally operate in a batch mode where one program after another is executed with little or no wasted time between runs. To coordinate one of these computers with the DHF to, for example, grid a picture would involve interrupting this data flow for perhaps one hour. Of this hour period, the first and last fifteen minutes would be used for initial and final set-up and coordination. The central half-hour would involve about 6 minutes of computation and 24 minutes of data transfer to the DHF. Other than this inefficiency we must consider the scheduling problem associated with the use of computers assigned to other projects, the cost of the interface, and

interruption of normal computer operating during interface installation.

Alternately, the use of the magnetic tape interface avoids these objections. With this approach the input data tape would be directly mounted on a computer tape deck and used to generate either a second processed tape or (in the case of such tasks as attitude determination) a standard paper printout. The computer time to execute the gridding program with this approach would be directly mounted on a computer tape deck and used to generate either a second processed tape or (in the case of such tasks as attitude determination) a standard paper printout. The computer time to execute the gridding program with this approach would be about 16 minutes of which ten minutes would be for reading and writing tape.

All three computers shown in table 4.2 can readily handle the tasks discussed in this report at speeds comparable to the fastest computer. The present use of these computers varies from 40 hours per week for the SDS 9300 to essentially full time use of the IBM 360-75.

4.4 RECOMMENDATIONS

It is recommended that the magnetic tape interface approach described in section 4.3 be employed initially to handle all DHF tasks for which a computer is required. At such time as the workload can no longer be effectively handled in this manner implementation of the conclusions cited in section 6 should be considered.

SECTION 5
INSTALLATION AND SUPPORT

5.1 INSTALLATION AND CHECKOUT

The GRPS equipment was shipped from the Westinghouse Defense and Space Center on 10 February 1969 following successful completion of in-plant acceptance tests and completion of required NASA modifications to building six (6) at GSFC. Installation and checkout were completed by 17 February when GSFC final acceptance tests were started.

5.2 FOLLOW-ON SUPPORT

Follow-on support commenced on 10 April 1969 and was completed on 10 October 1969. The function provided one engineer at the GRPS and additional support, as required, from the Westinghouse Defense and Space Center. Assistance was provided to NASA in the maintenance and operation of the GRPS as well as the application of the equipment in various task requirements.

SECTION 6

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