ATS-6 MILLIMETER WAVELENGTH PROPAGATION EXPERIMENT

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16. Abstract

The real time digital data acquisition system used to acquire ATS-6 propagation data at the OSU Fixed, Transportable, and Unmanned Terminals is described. This system performs all digital conversion, formating, merging, and recording. All data from the remote sites are transferred to the Fixed Terminal for recording on a common digital tape.

The current status and summary of operations are also reviewed.

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INTRODUCTION

The primary objective of the ATS-6 Millimeter Wavelength Propagation experiment is the determination of reliability improvement resulting from the use of path diversity on millimeter wavelength earth-satellite communication links. This objective is being accomplished by measuring the path attenuation observed on 20 and 30 GHz ATS-6 downlinks at two spatially separated ground terminals.

Previous reports have described the complete experiment [1], the Transportable Terminal [2], and the Fixed Terminal [3] in detail. This report describes the digital data system which is used to digitize, format, merge, and record all data acquired. The current status of the experiment and summary of operations are also reviewed.

DIGITAL DATA SYSTEM

All data acquired in this experiment are digitized and recorded on a common digital tape in real time. The data acquired at the remote terminals are digitized at the point of acquisition and transmitted to the Fixed Terminal via telephone lines. These data together with data from the High Resolution Radar/Radiometer System are merged and recorded on a single digital magnetic tape. In addition to these data, various status switches indicating operating modes and conditions are also monitored and recorded. The operator at the Fixed Terminal maintains control of the entire data system at all times.

DATA SYSTEM STRUCTURE

The data acquisition system consists of an HP-2115-A minicomputer and control hardware, a digital magnetic tape deck, and two remote process controllers which are directed by the HP-2115-A via commercial telephone lines (Fig. 1). One remote controller located at the Transportable Terminal (Fig. 2a), acquires, buffers, and transfers data blocks at the request of the central computer. The data, sampled once a second, consist of status checks and the receiver and radiometer outputs from the Transportable Terminal. The remote controller, located at the Unmanned Terminal (Fig. 2b) samples one radiometer, interrogates a status register, samples test voltages, or performs a control function at the request of the central computer and returns the desired word of information once a second. The central computer must request each word of data or status separately and the remote controller returns the desired word after a 400 msec. delay. The central computer, in addition to controlling the remote processors, examines the status and samples the receivers and radiometers of the Fixed Terminal at rates of 10 or 200 samples per second, and records all data on magnetic tape.

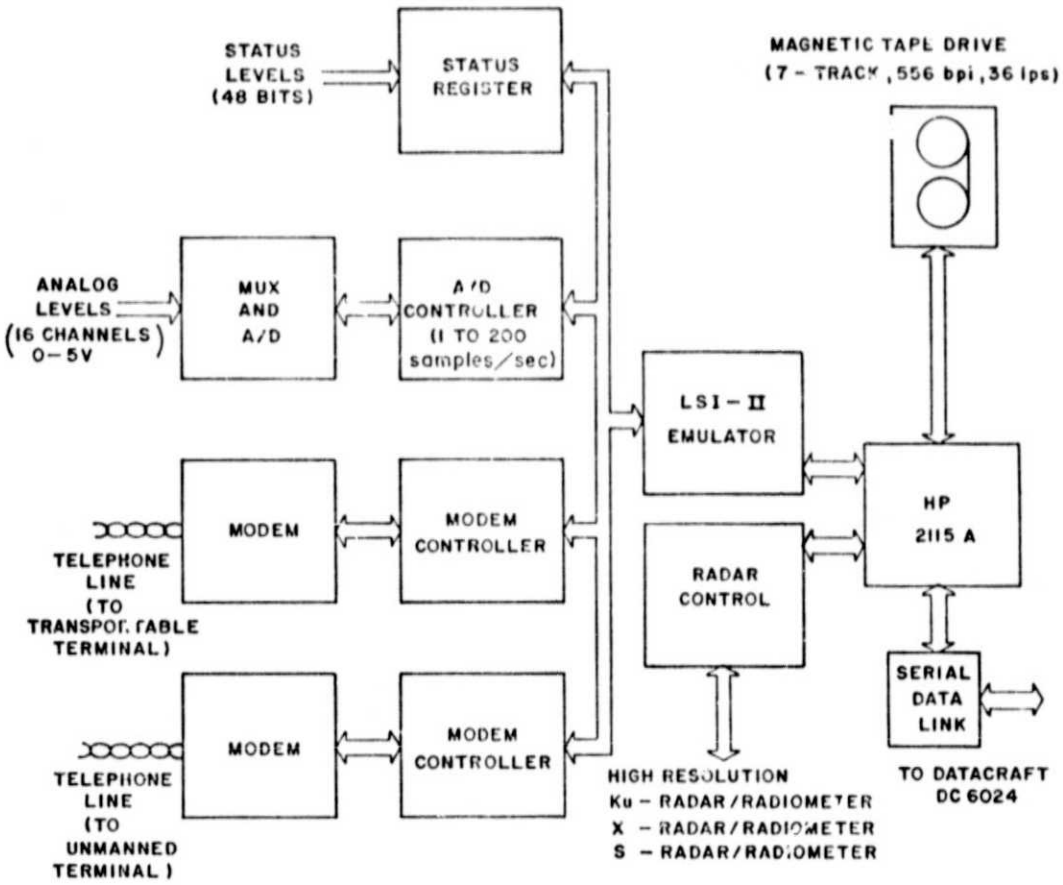


Fig. 1. Fixed Terminal Data Acquisition System.

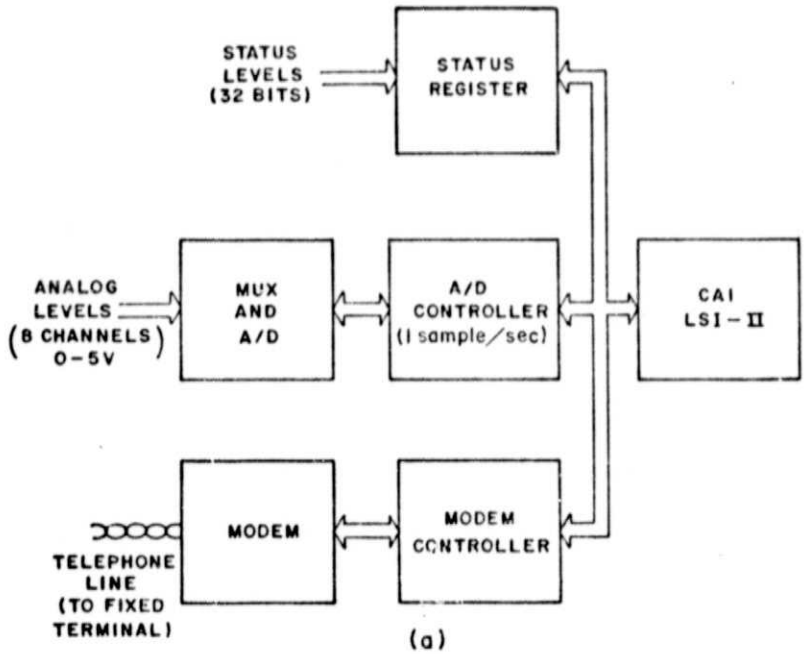


Fig. 2a. Transportable Terminal Data Acquisition System.

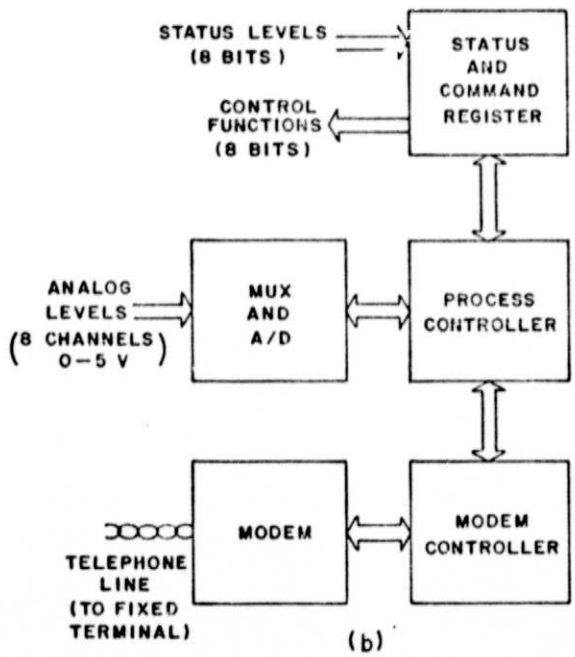


Fig. 2b. Unmanned Terminal Date Acquisition System.

The data acquisition system at each terminal consists of three types of control units, each tied to a computer or controller by a bus structure. The control units are addressed by and return data through the I/O and control bus. At the Transportable Terminal a Computer Automation Inc. LSI-II minicomputer serves as the controller; and at the Unmanned Terminal an inhouse designed and fabricated process controller serves this purpose. At the Fixed Terminal the control units are tied from a bus structure through a unit that emulates the LSI-II control and I/O functions to a duplex register in the HP-2115-A computer. This emulator allows the HP-2115-A to simulate an extended I/O instruction set, providing flexibility for adding or modifying units on the simulated bus and enabling control units of the same design to be used with either the LSI-II or HP-2115-A.

A/D conversion, status acquisition, and data transmission and reception are performed by the three control units. The analog signals are multiplexed and then converted. All A/D conversions provide seven significant bits plus sign. Provisions were made for sixteen sampled analog channels at the Fixed Terminal and eight at the Transportable Terminal. An A/D controller operates the A/D converter and multiplexer and provides an interrupt signal to the I/O bus.

Status levels are held in three sixteen-bit words (Table 2). The first status word for the Fixed and Transportable Terminals consists of the positions of a switch register upon which the operator indicates which units in the receiving system are functioning and are to be recorded and/or which function he wishes to perform with the operation program. Note that provision has been made to control the High Resolution Radar/Radiometer System at the Fixed Terminal through its digital control unit [4]. The program which controls this operation records the integrated video signal on a range bin-by-range bin basis from each radar every six-tenths of a second, depending upon the position of bits 6, 7, and 8. The second status word monitors conditions within the receivers and radiometers. The third status word at the Fixed Terminal accesses a modulo 1000 counter, which provides a time reference for the control program. The counter is synchronized to the seconds count of a DATATRON 3000 time code generator which is read through the radar control interface.

Data are transferred from the remote controllers to the Fixed Terminal data system via commercial voice-grade telephone lines. A pair of Vadic VA-1600 modems are used for data communication with the Transportable Terminal and two Bell System type 103 modems are used with the Unmanned Terminal. Modem controllers at each terminal provide the correct parallel-to-serial conversions, control, and interrupt logic.

DATA RECORDING

Several different record types are used to record the information from the various data sources. The record format (Table 1a) consists of a sixteen word header, followed by either sampled data or auxiliary data and then sampled data. Referring to Table 1b, the header contains the number of words in the record, the record type (Table 4)

Record Type	Data Source
3	K_u-Band radar/radiometer
4	X-Band radar/radiometer
5	S-Band radar/radiometer
8	Transportable terminal
9	Fixed terminal-high rate
10	Fixed terminal-low rate
11	Unmanned radiometer

the three status words previously described, and the millisecond count of the record. Note that a change of status terminates a record independently of the number of data samples in the record. Hence, status information is maintained for the duration of a record and any change forces a new record to be written. The real-time-clock words, from the DATATRON 3000, are listed in Table 3. The fast queue interval (1/200 second) or slow queue interval (1/10 second) indicates the time between samples in the sampled data portion of the record, and word eleven indicates the number of samples in a record.

The data block following the header generally consists of sampled data from the 8-bit A/D converters whose outputs are Mofified Two's Complements with ± 5 volt ranges. However, for radar records or Transportable Terminal records, auxilliary data, consisting of a fixed number of data or additional descriptive words, preceeds the sampled data. The data block may have a variable length, with the number of words per record indicated in word 0 of the tape header. For sampled data, the sample time may be obtained from the header clock words and the queue interval. In addition, for the high rate data, a millisecond count preceding and following each sample is recorded with each A/D sample. These two times provide a measure of interval uncertainty for the sample if an interrupt from another device shifts the sample time. This information permits time skew to be determined during data reduction.

Data tapes at the Fixed Terminal are written according to the formats of Table 5. These tapes are subsequently transmitted to the Datacraft DC 6024 via a serial data link and are then recorded as fixed-length records. When read by a FORTRAN program, each DATACRAFT word (24 bits) contains an HP word (16 bits) right justified.

OPERATIONS

Both the Fixed and Transportable Terminals remain operational. The total operating times of the four receivers at these two terminals as of February 15, 1975, were:

	20 GHz	30 GHz
Transportable Terminal	3,386 min.	4,364 min.
Fixed Terminal	2,187 min.	2,724 min.

Total Time: 12,661 min.

CURRENT STATUS

The Transportable Terminal was moved to its remote site on March 13, 1975 and became operational at that location on March 15, 1975. This site is located 12.5 Km from the Fixed Terminal in approximately the northeast direction. The Unmanned Terminal was moved to its remote site on April 4, 1975 and became operational at that location on April 8, 1975. The Unmanned Terminal is located 13.4 Km from the Fixed Terminal in approximately the west direction. The separation distance between the Transportable and Unmanned Terminals is 13.4 Km. Data acquisition is continuing at these terminal locations.

Table 1a

Tape Record Formats

Table 1b
Tape Record Header Format

Word Number	
0	No. of words in record
1	Record type
2	Status word 1
3	Status word 2
4	Status word 3
5	Millisecond count
6	Clock word 1
7	Clock word 2
8	Clock word 3
9	Fast queue interval
10	Slow queue interval
11	No. of samples in record
12	Spare
13	Spare
14	Spare
15	Spare

Table 2
Status Words

Bit No.	Word 1 Fixed Terminal		Word 2 Fixed & Transportable Terminal		Word 3 Fixed Terminal		Word 1 Transportable Terminal
0	20 GHZ Receiver		0 dB		1		Unassigned
1	20 GHz Radiometer	Slow Sample rate	10 dB	20 GHz	2		"
2	30 GHz Receiver	(10 per sec.)	20 dB	receiver gain	4		"
3	30 GHz Radiometer		30 dB		8		"
4	20 GHz Receiver	Fast Sample rate	Antenna		16	Modulo	"
5	30 GHz Receiver	(200 per sec)	Hi Ref.	20 GHz	32	Counter	"
6	K_u-band Radar/Radiometer		Lo Ref.	Radiometer	64		"
7	X-band Radar/Radiometer		Calibrate		.28		"
8	S-band Radar/Radiometer		0 dB		256		20 GHz Receiver
9	Record Transportable Terminal		10 dB	30 GHz	512		20 GHz Radiometer
10	Record & Calibrate unmanned radiometer		20 dB	Receiver Gain	Unassigned		30 GHz Receiver
11	Record unmanned radiometer		30 dB		"		30 GHz Radiometer
12	Unassigned		Antenna		"		Unassigned
13	Unassigned		30 GHz Radiometer	30 GHz Radiometer	"		"
14	Idle		Lo Ref		20 GHz rcvr phase lock		20 GHz rec. phase lock
15	Stop		Calibrate		30 GHz rcvr phase lock		30 GHz rec. phase lock

Table 3
Real-Time-Clock Words

Bit No.	Clock Word 1	Clock Word 2	Clock Word 3
0	1 } Seconds, units	1 } Minutes, tens	1 } Days, units
1	2	2	2
2	4	4	4
3	8	1 } Hours, units	8
4	1 } Seconds, tens	2	1 } Days, tens
5	2	4	2
6	4	8	4
7	1 } Minutes, units	1 } Hours, tens	8
8	2	2	1 } Days, hundreds
9	4	Unassigned	2
10	8	"	Unassigned
11	Unassigned	"	"
12	"	"	"
13	"	"	"
14	"	"	"
15	"	"	"

Table 4

Record Type Formats

- Types 3 (K_u-Radar), 4 (X-Radar), 5 (S-Radar)

Word No.	Record Contents																
0 : 15	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Auxilliary Data
16						Elevation angle											
17						S-band radiometer 8-bit bipolar 0-5 volts												
18						S-band power "											
19						X-band radiometer "											
20						X-band power "											
21						K_u-band radiometer "											
22						K_u-band power "											
23						Clock word 1											
24						Clock word 2 see Table 3												
25						Clock word 3											
26						Azimuth word 1											
27						Azimuth word 2											
28 . 127	-Video Data Samples -32 integrations on an 8-bit, 10-5 volt A/D converter, each sample representing a 2 sec. range bin. Bit eleven indicates overflow																Data

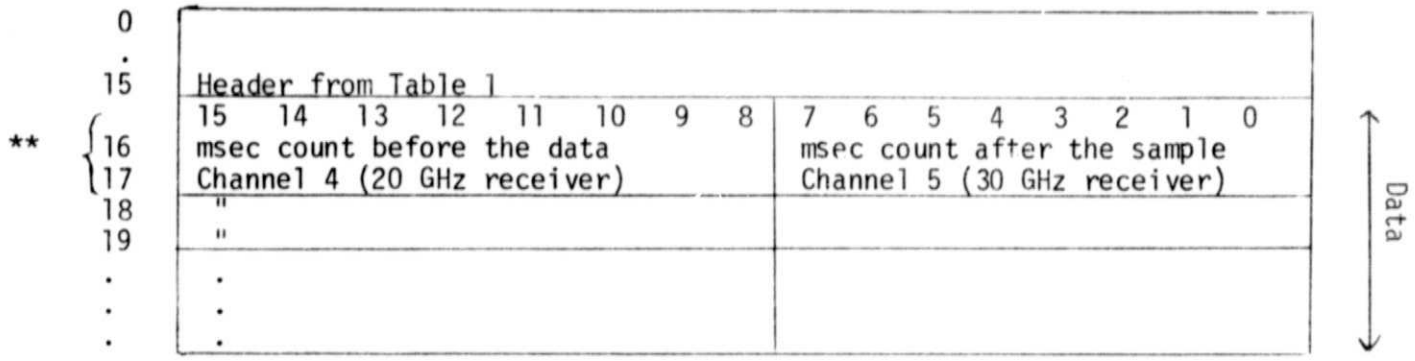
- Type 8 (Transportable Terminal)

0 : 15	Header from Table 1		Aux. Data
16	Status word 1 from Table 2		
17	Status word 2 from Table 2		
18	Unassigned		
19	Transaction no., modulo 256		Data
20	Channel 0 (20 GHz receiver)	Channel 1 (20 GHz radiometer)	
21	Channel 2 (30 GHz receiver)	Channel 3 (30 GHz radiometer)	
* 22	Channel 4 (Wind speed)	Channel 5 (Wind direction)	
23	Channel 6 (Rain guage)	Channel 7	
. . . .			

*Repeats a maximum of 20 times in one record; 8-bits bipolar 0-5 volts.

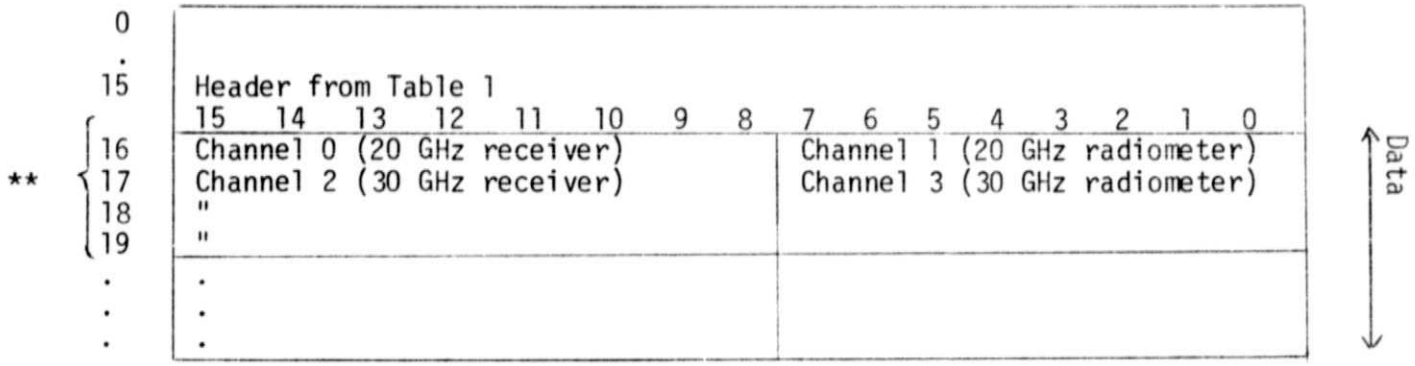
Table 4
Continued

- Type 9 (Fixed terminal-high rate)



**Repeats a maximum of 100 times in one record; 8 bits bipolar 0-5 volts

- Type 10 (Fixed Terminal-low rate)



***Repeats a maximum of 50 times in one record; 8 bits bipolar 0-5 volts.

- Type 11 (Unmanned radiometer)

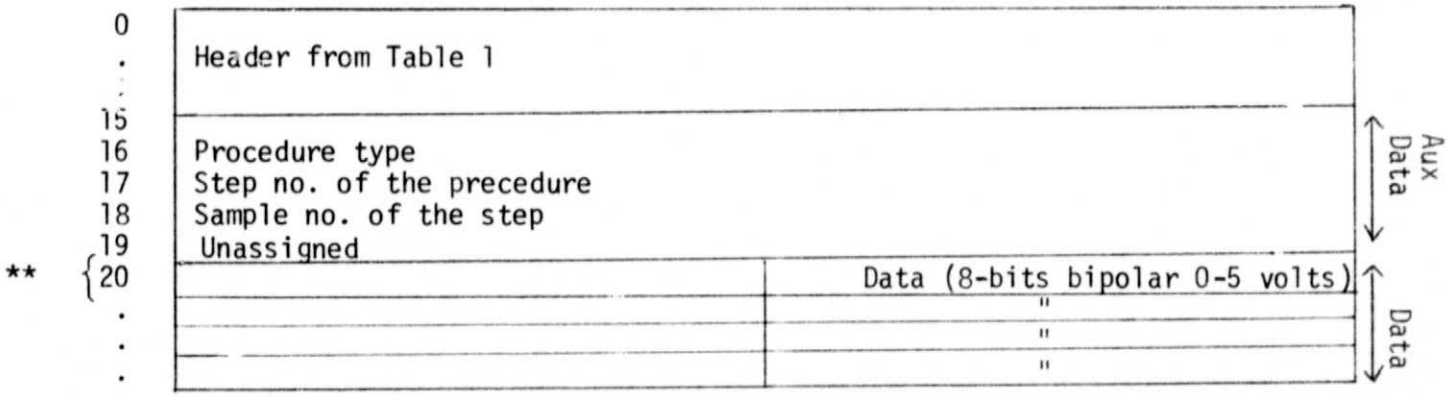


Table 5
Data Transmission Format

HP-2115-A Data Word

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Data
Program (PACI)

HP-2115-A Tape Word

6	5	4	3	2	1	0	
P	15	14	13	12	11	10	Track No. Character 1
P	9	8	7	6	5	4	Character 2 P-Parity
P	3	2	1	0	X	X	Character 3

Serial Link
Programs (DUMS & DUMRT)

DC6024 Word

24																								0
X	X	X	X	X	X	X	X	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Fortran Tape Write

DC 6024 Tape Word

8	7	6	5	4	3	2	1	0	
P	X	X	X	X	X	X	X	X	Track No. Character 1
P	15	14	13	12	11	10	9	8	Character 2
P	7	6	5	4	3	2	1	0	Character 3

Note: All DC6024 records have a fixed length of 255 words.
Files are preceded and terminated by a tape (file) mark.

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[2] D. B. Hodge and R. C. Taylor, "ATS-6 Millimeter Wavelength Propagation Experiment," Report 3863-2, September 1964, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract NAS5-21983 for National Aeronautics and Space Administration (NASA Goddard).

[3] D. B. Hodge and R. C. Taylor, "ATS-6 Millimeter Wavelength Propagation Experiment," Report 3863-3, March 1975, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract NAS5-21983 for National Aeronautics and Space Administration (NASA Goddard).

[4] D. B. Hodge and R. C. Taylor, "The Ohio State University ElectroScience Laboratory Radar/Radiometer Facilities for Precipitation Measurements," Report 2374-13, March 1973, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract NGR-008-080 for National Aeronautics and Space Administration (Office of Grants and Research Contracts).