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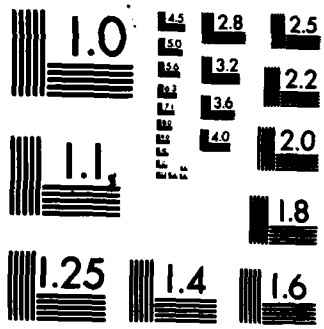

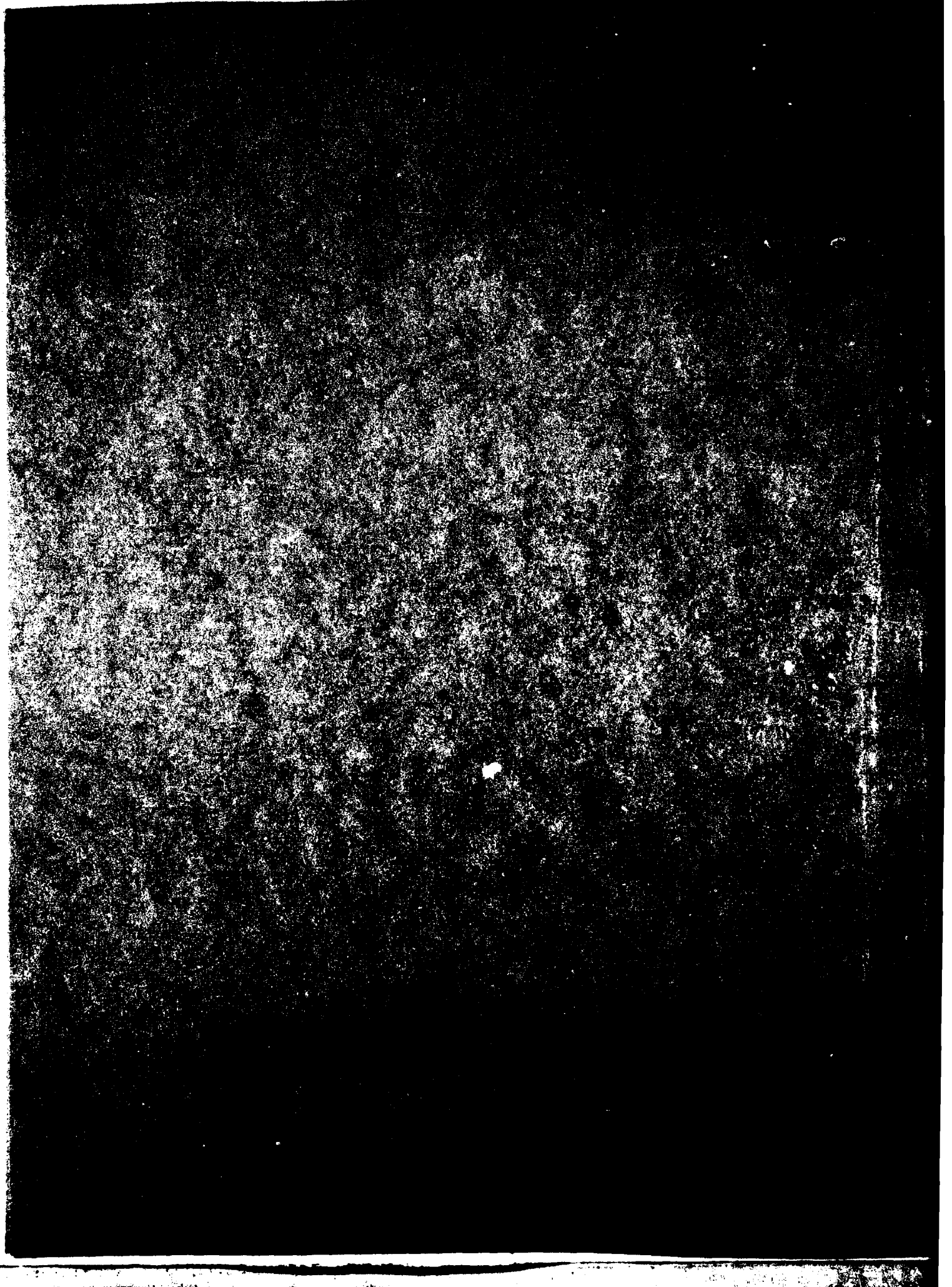

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-82-0311	2. GOVT ACCESSION NO. AD128987	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ENGINEERING AND INSTRUMENTATION SUPPORT OF THE AFGL RESEARCH ROCKET PROGRAM		5. TYPE OF REPORT & PERIOD COVERED FINAL REPORT 16 June 1979 - 30 Sept 1982
		6. PERFORMING ORG. REPORT NUMBER PSL #PE01004
7. AUTHOR(s) Arthur A. Gilcrease		8. CONTRACT OR GRANT NUMBER(s) F19628-79-C-0107
9. PERFORMING ORGANIZATION NAME AND ADDRESS Physical Science Laboratory Instrumentation Division - Box 3548 Las Cruces, New Mexico 88003-3548		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F 765904AV
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysical Laboratory Hanscom AFB, Massachusetts 01731 Monitor: Raymond E. Wilton/LCR		12. REPORT DATE 9 November 1982
		13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Sounding Rockets
Sounding Rocket Engineering and Instrumentation Support

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The work performed under this contract consisted of engineering and instrumentation operations in support of AFGL sounding rocket launches, and special research and developmental efforts in support of the AFGL Sounding Rocket Program.

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SUMMARY

This report summarizes the engineering and instrumentation effort provided in support of the AFGL Research Rocket Program. Research and developmental efforts included a study on the potential use of bubble memory systems for data collection and storage on sounding rockets, the development of an enhanced PCM telemetry station that can acquire in real-time up to 75K words per second for Aries type rocket payloads, and the development of a microprocessor based balloon azimuth controller for positioning the payload gondola of research balloons. A summary of the engineering and instrumentation effort provided in support of research rocket launches is also included.

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I. INTRODUCTION

This final report summarizes the work performed by the Missile Electronics Instrumentation (MEI) Section of the Physical Science Laboratory (PSL) under Contract No. F19628-79-C-0107 entitled "Engineering and Instrumentat'on Support of the AFGL Research Rocket Program." The contents and format of this report are presented as specified in Items 102 and 103 of the CDRL (DD Form 1423).

II. LIST OF CONTRIBUTING ENGINEERS

The following PSL engineers contributed to this effort:

Name	Function
A. Gilcrease	Chief, MEI Section
K. Lane	Principal Investigator (WSMR Technical Coordinator)
W. Harkey	Engineer, WSMR
V. Parkerson	Engineer, WSMR
J. Baker	Engineer, WSMR
R. Wagner	Engineer
H. Shaw	Engineer
J. Carr	Engineer

In addition to the above engineers, approximately 30 technicians supported this effort on a part time basis.

III. PUBLICATIONS

A scientific report entitled "Magnetic Bubble Memories for Data Collection in Sounding Rockets" dated 29 January 1982 was published as AFGL TR-82-0038. The contents of this report are summarized below.

IV. SUMMARY OF SUPPORT PROVIDED

The purpose of this effort was to conduct engineering and instrumentation operations to provide support for up to forty-five (45) rocket launch operations at White Sands Missile Range, New Mexico (WSMR). The types of support provided can be broadly categorized in two areas: (1) program support, and (2) launch support. The former support is more research or developmental oriented to enhance the long term or future capabilities of AFGL's Rocket Research Program; whereas the latter is oriented toward the day to day engineering and instrumentation support of rocket launch operations. Each category of support is summarized below.

A. Program Support

Several efforts were undertaken by the Physical Science Laboratory during the course of this contract to enhance the capabilities and successfulness of the sounding rocket program. These included a study of the potential use of magnetic bubble memories in sounding rocket payloads, design and fabrication of a PCM telemetry station with enhanced capabilities, and design and fabrication of a microprocessor controlled balloon azimuth controller.

1. Bubble Memory Study

Most of the vehicle status and scientific data gathered from sounding rockets is currently acquired either by on board tape recording or via radio telemetry link to a ground station for permanent recording on magnetic tape. And, with the advent of multiple and increasingly complex scientific payloads over the past several years, the quantity and acquisition rate of sounding rocket data has increased considerably. During this same period, the state of bubble memory technology has also advanced. Both these events provided the impetus for studying the feasibility of using bubble memory systems on board sounding rockets for data collection and storage. Therefore, this study was undertaken by PSL for AFGL.

The study began with a survey of bubble memory systems that were either available or would be available in the near future. This was followed by an investigation of relative advantages and disadvantages of bubble memories when compared with a typical digital magnetic tape recorder for on board data storage. It was determined that a single bubble memory system has less storage capacity than a typical digital tape recorder,but bubble memories are much more suitable for the physical environment imposed by sounding rockets. The major advantages of bubble memories for use in sounding rockets were found to be compactness, ruggedness, reliability and non-volatility. The major disadvantages of bubble systems are: (1) that storage capacity is currently limited to one megabit (per system); and (2) a considerable amount of support circuitry would be required for optimal use of bubble memories in sounding rocket applications. The study concluded that bubble memory systems were feasible for certain, somewhat limited applications on board sounding rockets. Examples of specific applications that are feasible, as well as a discussion of important considerations for the use of bubble memories in sounding rockets, are presented in AFGL TR-82-0038.

2. Enhanced PCM Telemetry Station

As the need to acquire high bit rate data in real-time became apparent, AFGL tasked PSL to provide for development of a portable PCM telemetry station with enhanced capabilities. The enhanced PCM telemetry station will acquire up to 75K words per second from Aries type rocket payloads. A PDP 11/34 computer and peripherals, an IRIG Time Code Generator/Translator, and a Bit Synchronizer were purchased for integration into the portable enhanced PCM station. A PCM decommutator and Direct Memory Access Interface were designed by PSL for integration into the system. A PCM Simulator was designed and fabricated by PSL for system checkout. Preliminary development of the system software was initiated. Thermodyne shipping containers were purchased for ease of transporting all station equipment.

A functional block/signal flow diagram of the basic system is shown in Figure 1. The operation of the system, briefly, is as follows. The PCM serial video data from the ground station receiver (or from an analog tape recorder) is fed to the Bit Sync and subsequently to the decommutator. The decommutator output is multiplexed with IRIG timing data in the DMA interface and fed to the UNIBUS where it can be processed or printed, recorded on disc, displayed or otherwise controlled as desired by the system operator at the console terminal.

Completion of the portable, enhanced PCM telemetry station will be performed under a separate contract.

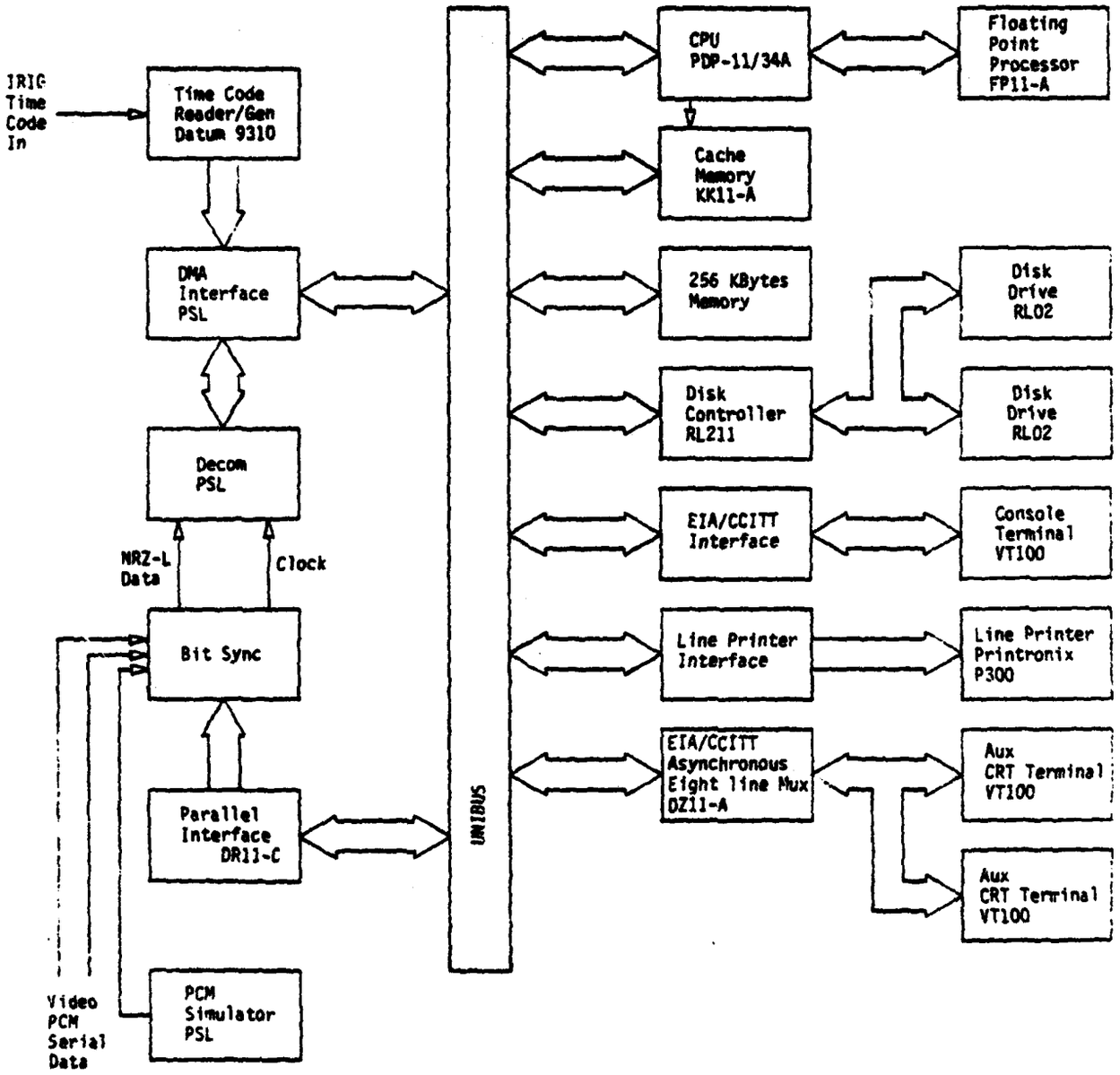

Figure 1. Block/Signal Flow Diagram,
AFGL PCM Portable Telemetry System

3. Ballon Azimuth Controller

During the course of this effort, PSL also undertook development of a Balloon Azimuth Controller (BAC). The BAC is a microprocessor based control system used to position the payload gondola on a research balloon. The BAC system was designed using the STD BUS structure incorporating a Z80 microprocessor, an AM9511A math processor, multichannel A/D card, dual channel D/A, serial I/O card, and a parallel I/O interface.

The BAC guides the gondola using a pair of magnetometers that sense the earth's magnetic field and provide sine and cosine reference signals for positioning the gondola. These reference signals are digitized using two A/D channels and are normalized and linearized using the AM9511 math processor in conjunction with the Z80 microprocessor. The D/A channels are used to control a servo amplifier which drives the rotor to position the gondola.

Interfacing with the ground station is done using the serial I/O for the command up-link with the parallel I/O providing telemetry data for the down-link. Examples of up-link commands include the choice of two different guiding routines, the ability to manually drive the gondola, the ability to modify parameters used in the calculations, update position coordinates, and the ability to examine various RAM locations relevant to control of the gondola. The down-link serves as a feedback path for data to the ground station in response to a request or to relay position data to confirm guiding accuracy.

The on board Z80 acts to control all processes and interfaces. The control program was written in Z80 assembly language and consists of 1275 assembled lines of code which reside in two 2716 EPROMS.

B. Launch Support

1. Launch Data

The following rocket launches were supported during the period covered by this report.

Launch Date	Launch No.	Vehicle Type	TM Systems(Qty)	Launch Station
08-02-79	A31.702	ASTROBEE "F"	PCM/FM FM/FM	WSMR
08-07-79	A18.805	BLACK BRANT	TV/FM PCM/FM FM/FM	WSMR
08-14-79	A08.705-2	NIKE TOMAHAWK	FM/FM	WSMR
08-14-79	A08.706-2	NIKE TOMAHAWK	PCM/FM FM/FM	WSMR
08-1 -79	A04.703	AEROBEE 170	FM/FM (2)	WSMR
05-21-80	A24.609-2	ARIES	PCM/FM (3) TV/FM FM/FM	WSMR
08-18-80	A24.6S1-1	ARIES	PCM/FM (3)	WSMR
09-18-80	A04.801	AEROBEE 170 (Recoverable)	FM/FM (2)	WSMR
02-03-81	A24.7S1-1	ARIES	PCM/FM (2)	WSMR
07-31-81	A24.6S1-2	ARIES	PCM/FM (3)	WSMR
01-23-82	A24.7S2-2	ARIES	PCM/FM (3)	WSMR
05-28-82	A24.609-3	ARIES	PCM/FM (3) TV/FM	WSMR
09-14-82	A24.7S2-3	ARIES	PCM/FM (3)	WSMR

2. Technical Support

The types of technical effort provided in support of the above launches include the following:

a. Support Planning - Support planning was initiated upon receipt of the Operational Requirements (OR) and the AFGL Technical Data (TECH DATA) package from AFGL. The information provided in the OR and

TECH DATA package was used to formulate plans for supporting each launch objective. Plans included the quantity and type of telemetry systems to be flown, the carrier frequencies and operating modes for each telemetry system, the number of data channels to be used and the channel capacity and usage allocations, data format, recovery system requirements, use of command for range safety, number and types of flight antennas to be used, number and types of telemetry records required, post launch data conditioning, and disposition instructions for completed recordings. Plans for each and every support requirement were worked out to the most minute detail in the Telemetry Ground Station (TGS) Formats. The TGS Formats were used to identify the types and quantities of equipment required, configuration of the equipment, the types and quantities of recorders and recording materials to be utilized, the number of ground stations required to support each mission, etc. If wiring or equipment was required to be installed in either the payload or launch vehicle, a plan was prepared by PSL for implementation of the wiring and/or equipment installation. Upon AFGL approval of the plans for each launch support, the plans were implemented through the PSL Technical Coordinator.

b. Technical Coordination - The Physical Science Laboratory provided a Technical Coordinator (TC) who received the OR and TECH DATA packages from AFGL and initiated the formulation of all plans required at WSMR for each launch support. The TC coordinated all engineering and instrumentation requirements for support of each launch operation, and served as a technical interface with, and representative for, the AFGL payload engineer. In this role, the PSL TC had a primary responsibility for insuring completion of all required range documentation. Technical coordination of all PSL activity was performed by the TC prior to, during, and following each launch operation.

c. Systems Integration - PSL provided systems integration, testing and checkout of all systems installed by PSL. These systems included telemetry packages, antennas, battery systems, radar

transponders, command receivers, RF cables and wiring harnesses, timing systems and pyrotechnic circuits for payload separation, despin and flight termination. Checkout and testing included both horizontal and vertical tests as well as ground station equipment and blockhouse control consoles.

d. Operation and Maintenance - PSL operated and maintained all GFE telemetry equipment and supporting equipment required for launch operations, such as IRIG timing equipment, recorders, S-Band tracking systems, TV systems, etc. Equipment operators thoroughly rehearsed operating procedures prior to each launch. Periodic preventative maintenance and on-the-spot repairs of equipment were performed as required.

V. EQUIPMENT ACQUIRED

Upon request from AFGL, PSL purchased two Honeywell Model 101 Wideband Tape Recorders. Purchases of other major equipment were those required for the enhanced PCM telemetry station as described above.

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