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ENGINEERING AND INSTRUMENTATION SUPPORT OF THE AFGL RESEARCH BALLOON PROGRAM

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The work performed under this contract consisted of engineering and instrumentation operations in support of AFGL Research Balloon launches and special research and developmental efforts in support of the AFGL RESEARCH BALLOON PROGRAM.

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SUMMARY

The activity during this report period was primarily concerned with the direct pre-flight and flight support of twenty-four (24) free balloon and seven (7) tether balloon missions at Holloman Air Force Base (AFB) and various remote locations. Extensive effort was also made in upgrading the Building 850 Control Center configuration for a more efficient operation while also generating up-to-date documentation.

The telemetry room computer equipment was reconfigured with major changes in both hardware and software systems. The telemetry van computer system was also upgraded to the same level of support as the telemetry room system.

A continuing effort was made to improve the quality of support given to Air Force Geophysics Laboratory (AFGL) and to the other agencies and users involved in the balloon operations as well as to enhance the utilization of the equipment and facilities at AFGL and Holloman AFB.

TABLE OF CONTENTS

		PAGE
	SUMMARY	iii
I.	INTRODUCTION	1
II.	LIST OF CONTRIBUTING ENGINEERS	1
III.	SUMMARY OF SUPPORT PROVIDED	1
	A. Program Support	1
	B. Free Balloon Flight Support	4
	C. Tether Balloon Flight Support	9
	D. Travel	10

I. INTRODUCTION

This final report summarizes the work performed by the Balloon and Sounding Rockets (FABS) Section of the Physical Science Laboratory (PSL) under Contract No. F19628-84-C-0039 entitled "Engineering and Instrumentation Support of the AFGL Research Balloon Program."

II. LIST OF CONTRIBUTING ENGINEERS

The following PSL engineers contributed to this effort:

Name	Function
Dwight Bawcom	Manager, FAB Branch
Ken Lane	Chief, FABS Section
Squire Seagraves	Group Supervisor, HAFB
Warren Harkey	Engineer, WSMR
Victor Parkerson	Engineer, WSMR
John Baker	Engineer, WSMR
Robert Wagner	Engineer
Harold Shaw	Engineer

In addition to the above engineers, three technicians supported this effort on a full-time basis, and approximately ten technicians supported the effort on a part-time basis.

III. SUMMARY OF SUPPORT PROVIDED

The purpose of this effort was to conduct engineering and instrumentation operations to provide for balloon launch support at Holloman Air Force Base, New Mexico and various remote locations. 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 Research Balloon Program; whereas, the latter is oriented toward the day-to-day engineering and instrumentation support of balloon 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

balloon program. These included Launch Arm refurbishment, MK-II and Smith Berger Winch Systems modification and refurbishment, High Frequency Communications System maintenance, Antenna design and fabrication for Polar ARCS, Software for CRESS and ABLE projects, and re-work of the Control Center.

1. Launch Arm Refurbishment

The Launch Arm condition was evaluated and recommendations were made for the refurbishment under Call #6 which was written in November 1984. AFGL approved the recommendations by PSL and TRN 07 was written in January 1985 to cover the refurbishment task. Various units were rebuilt by a subcontractor along with the repiping of the system. A new control panel was built and installed with all new electrical wiring. The trailer suspension system was rebuilt and all new hydraulic lines were installed with a new reservoir. The entire system was functionally tested and then given new paint. The system was delivered to Holloman AFB in June 1985.

2. The MK-II Winch

The MK-II Winch System was refurbished under TRN 03 which was signed in June 1984. New decking was installed by PSL and the winch was transported to Otis Engineering Company in Dallas, Texas for installation of new hydraulic lines and complete servicing of the system. Work was completed and the system was returned to Holloman AFB in August 1984.

3. Smith Berger Winch

The Smith Berger Winch system was remounted on an upgraded trailer and retrofitted with a new power plant, new hydraulic lines, and a redesigned drive train tension system under TRN 10 which was opened July 1985. The system was repainted and functionally tested before returning to Holloman AFB in April 1986.

4. High Frequency Communications System

The High Frequency Communications AM and SSB transmitters and associated control and switching systems were tested and all problems were resolved. Numerous small repairs were made to the facility and all schematics and diagrams were upgraded to reflect the current configuration. The upgrade task was performed under TRN 12 and Call #16.

5. Crew Trailer

Modifications were made to the Tether Control Center Van to enhance its usefulness in support of field operation, in particular, the SRHIT tether operation. An external patch panel was mounted in the wall of the van to feed RF signals to and from new antennas mounted on the roof.

6. Control Center

An intensified effort was begun to modify the communication consoles in the control center at Building 850. The effort was aimed at removing equipment no longer needed for the balloon real-time support and condensing the racks from eight to five.

7. ABLE II

PSL systems engineers coordinated with Lt. Estes of AFGL on his requirement for real-time data input to the AFGL MicroVax during the ABLE II flight. PSL recommended the purchase of two DMA data interface boards from Digital Equipment Corporation to provide the needed high speed data transfer from the PDP-11/34 computer to the MicroVax. The procurement for the boards was authorized and a purchase request was initiated. The two cards (a DR11-W and a DRV11-WA) provide interprocessor communication between the Unibus and Q-Bus. The system is designed to transfer data from the Holloman TM computer to the AFGL MicroVax employed to display the ABLE experiment data in real-time. A MicroVax computer was borrowed at PSL and a working system developed using the AFGL TM van and computer. The device handler software was modified in the 11/34 and the XA-Driver in the MicroVax. Test routines were written for both systems.

8. TM Upgrade

The TM Station computer was moved to the adjacent room to allow more space for operating personnel and equipment. The computer move also allowed some of the experimenter equipment to be located in the same room as the PDP-11/34 and in the adjoining room. Interface cables were run to the experimenter room, computer room, and the Control Center to facilitate experimenter support. Work was started on repair of the vacuum chamber system at Building 850. The altitude chamber was dismantled and cleaned. The vacuum chamber system was reassembled and testing was started in March 1986. All Microdyne telemetry receivers and components were removed from their rack or storage area and

transported to PSL at White Sands Missile Range in order to be checked out, aligned, or repaired as required by an experienced PSL technician. The AFGL portable TM station that was in use at the PSL main laboratory was taken to Holloman to demonstrate the software that PSL was developing for the Holloman and Hanscom TM stations. The Gould chart recorders in the telemetry room and telemetry van were repaired.

B. Free Balloon Flight Support

1. ABLE Payload Support

Modifications to the existing general purpose telemetry display program was completed. The program was verified at HAFB and used to support the chamber test during the first week of August 1984. The payload was launched on 23 August 1984.

2. GAMMA RAY Payload Support

Preliminary test of the PCM-2 balloon control systems, command units, rotators, transponders, and beacons was initiated on 19 July 1984. The microwave command system to J-10 site and telemetry links from J-10 were tested. After delays due to weather and repairs after a minor mishap, the payload was reflown on 4 August 1984. The flight was a success and the balloon was recovered 30 miles southeast of Phoenix, Arizona. In October 1984 software was modified and new digital tapes were sent to AFGL. In November 1984 a computer printout of the two magnetometer data channels was made and sent to JPL. Information about the computer data format and time format was sent to Patrick AFB, Florida.

3. DENVER, BIMMS, and SCRIBE Support

Joe Fumerola was the crew chief on DENVER #1 which was successfully released on 30 April 1985.

In May 1985 support was provided on DENVER #2 during the attempt and successful release. This support included two telemetry personnel, one recovery technician and one launch arm operator. Support was provided on the four attempts of the BIMMS mission. Support included telemetry station technician and standby for mission control support. The BIMMS flight was attempted on 20, 23, 24 and 25 May and was launched 5 June 1985. The balloon failed in flight. The TRN was extended through 30 June 1985 due to delays in the balloon schedule. On 12 June 1985 the BIMMS flight was successful. The SCRIBE balloon was released

on 21 June 1985. There was no useful experiment data obtained due to problems. The commands could not be received properly by the payload shortly after release. This task was closed out on 31 August 1985.

4. Gravity Program

The Gravity Program opened 2 August 1985. The purchase request for the tape decks was sent to procurement and other tasks of this TRN were initiated. On July 16 and 17, 1985, a meeting was held at PSL to review the requirements of the Gravity Measurement Project. The following persons attended: Dwight Bawcom, Roger Bramlett, Jerry Cooper, Wade Craddock, Ken Lane, Victor Parkerson, Squire Seagraves, Harold Shaw (PSL); Ralph Cowie, Carl Leyh and Catherine Rice (AFGL). Several action items were identified and the software tasks were reviewed. There were no changes identified in the software area. The problem of delay in obtaining the TRN for PSL support on the project was discussed.

The Kennedy digital tape drive stored at Holloman was brought back to PSL and repaired. Also, one RL-02 was brought back to PSL to be repaired and one RL-02 was brought back in order to start the programming task. An update of the data stream allocations was received from Ralph Cowie. The 35 MM camera was ordered and a sketch of the camera box wiring was sent to Catherine Rice, Hanscom AFB. Work was initiated on the FSK boards. The time available to complete these boards was becoming critical. Battery requirements were received from Ralph Cowie. In September/October 1985 one new digital tape deck and interface card came in. The tape deck was damaged slightly during shipment and the interface did not operate properly so the unit was returned to the manufacturer. The Kennedy digital tape deck and RL-02 disk drive were taken back to Holloman AFB and connected to the computers in the telemetry station and the telemetry van. The 35 MM camera order was delivered and a Cannon film loader was purchased for use with the camera. The camera box was delivered from the Machine Shop and the wiring of the boxes was completed.

The chamber test on the components of the payload which had not been previously environmentally tested was completed. Six dewars of liquid nitrogen were ordered and delivered to HAFB for use at the chamber test facility. Copper tubing insulation and material were also obtained for the chamber test. Tests were performed on the payload and the data was recorded on analog tape. The computer was overloaded with data from the RS-232 links because of the high number of interrupts.

An EMULEX Computer DHU Board with associated cabling, connection panel, etc., was received from the University of Texas Applied Research Lab. The board was borrowed to utilize on the Gravity Flight. The board was installed in the PDP-11/40 computer to input the RS-232 data stream from the Gravity payload downlink. While there was an improvement in the throughput of data to computer memory, it did not solve the basic problem caused by the generation of excessive interrupts from the RS-232 data stream.

The Gravity payload was successfully flown on 24 October 1985. Telemetry personnel, launch support and recovery personnel were provided for the operation. Real-time balloon control data and data links to the Z100 PC's used by AFGL and the University of Texas personnel were provided from the TM station computer.

Extensive computer programming was undertaken in an attempt to improve the throughput of the RS-232 data from the Gravity Payload to the memory of the TM Station PDP-11/40 computer. The programming effort was aimed at providing a real-time digital tape of each data stream type. Work was done on the camera boxes used on the Gravity payload. The boxes were fitted with screw mounted cover plates to secure the holes. New lithium batteries and additional miniature phono plugs were purchased to complete the camera wiring and provide backup supplies.

The flight mission was launched at Holloman AFB and recovered near Roswell, New Mexico. The software for the flight was modified slightly, and checked out by Roger Bramlett. Flight and recovery were successful and software operated flawlessly.

5. Astrofilm Tests

An Astrofilm balloon was successfully launched from HAFB Nenniger Site. The balloon control packages worked properly in all aspects, as did the TM and ground support equipment. However, the Astrofilm balloon burst at 50,600 feet and proceeded to an impact east of Timberon. The payload was recovered on 4 December 1985 and the balloon was recovered on 6 December 1985. Telemetry personnel, launch crew support, and recovery personnel were provided by PSL for the Astrofilm operation.

The Astrofilm E payload preflight checks were performed on 11 December 1986 and made ready for flight. The Astrofilm E flight 86-14 was launched successfully on 12 December at Holloman AFB. The balloon performed well and all flight

objectives were achieved. The payload was recovered in good condition north of Carlsbad, New Mexico.

The payload control packages for Astrofilm/Low Light Level were installed and cabling routed to the experimenter (Visidyne) and balloon points to provide commanded control functions. The payload was subjected to extensive testing in the high bay and the systems were verified to be flight ready.

The normal recovery aircraft was not available to support the Astrofilm/Low Light Level flight in January. The Detachment obtained aircraft support from the Army at White Sands Missile Range to provide air observation for the recovery team. PSL provided an observer to fly in the Army plane. Since the aircraft communications rack could not be used in the Army aircraft, the observer communicated with the control center via a hand-held VHF radio and the repeater. It was also necessary to build a portable backup control system for downrange use. A PSL technician traveled to Roswell and set up the backup control system to provide emergency commands if required.

The Astrofilm/Low Light Level balloon flight was launched on 14 January 1987 at approximately 0255 hours.

Assembly of the ASHCAN payload was completed. Payload was flown on the Astrofilm E balloon test flight. The flight was successful and the Sampler filter was shipped to Dr. Lifer for analysis.

The Astrofilm payload was rigged and prepared for flight. The flight, code named "Super-Pathfinder", was launched to provide a look at the probable flight path of the SCRIBE 99 experiment. The flight was successful and gave good training for the crew in launching and tracking a balloon from the Roswell area.

The ALFAN flight was supported with the telemetry station at Building 850 and with the telemetry van at Parker station on WSMR. The flight was successfully launched from Roswell and recovered west of Holloman AFB.

6. SCRIBE

The telemetry van, communication equipment, S-Band receiving dish and pedestal, and other support equipment were moved to Roswell, New Mexico to support the SCRIBE 99 flight.

The SCRIBE 99 payload was launched at Roswell. The launch was successful; however, the experimenter identified a problem and the flight was terminated shortly after obtaining float altitude.

The SCRIBE 99 payload was refurbished and successfully launched again from Roswell on 25 June 1987. The payload was tracked from the telemetry van at Roswell and good data was recorded.

The SCRIBE 99 prime data was recorded at Holloman in Building 850 telemetry station and in the TTAS mobil van provided by White Sands Missile Range. The balloon flight was terminated following completion of the experiment and recovered west of White Sands Missile Range in good condition. PSL supported the recovery by providing the observer in the recovery aircraft.

7. KESTREL

The Kestrel payload was shipped directly to Ramona, California from the Visidyne facility in Massachusetts where it was assembled and tested. The TM van, Control Center van, Crew van, storage van, and all other vehicles and launch equipment were transported to Ramona for project support. The facility was set up, the Oklahoma State University auto-track antenna was tested, and the flight batteries were filled and charged. The payload was tested, minor problems were resolved and the system was declared flight ready when it was learned that the schedule of the "target" had slipped approximately one month.

The payload and the entire launch facility was secured and all personnel returned to their home stations for one month. After returning to Ramona, the payload was once again made flight ready and launched on the day of the "target" flight. The launch was successful and all systems worked satisfactorily although the desired data was not obtained due to a delayed launch countdown.

PSL personnel at Yuma Proving Ground and one PSL person from Ramona set up a down range command station for KESTREL support.

8. GRAD

The Gamma Ray Advanced Detector (GRAD) was initially supported by sending the AFGL rotator system and complete documentation to the University of Florida Space Astronomy Laboratory (SAL) for modification to operate with solar sensors instead of a two-axis magnetometer. Later, a technician was sent to Florida to assist AFGL and SAL in the hardware integration of the gondola. A PSL PCM Bit

Synchronizer and Decommutator that had been designed and built for another project was modified for use by the GRAD program to handle the experiment data link. The Bit Sync/Decom unit was shipped to SAL to be used as an interface to the experimenter's VME system.

The GRAD gondola and all support equipment was sent to Holloman for payload integration, chamber testing, TM and Command link verification, and deployment to Antarctica. A borrowed Portable Computer Augmented Telemetry System was programed to support the Balloon Control telemetry link. The PCATS system was used in the C-130 r.f.i. tests as part of the airborne telemetry system to be used on the chase plane in Antarctica.

PSL was instrumental in the development of a phased array antenna system for the C-130 chase plane and provided technical assistance to the New Mexico Solar Energy Institute in the design, fabrication, and testing of the solar panel power and control system used on GRAD.

All GRAD flight components and ground support equipment were transported to McMundo Station, Antarctica by the Air Force and NSF. The system was integrated, tested, and launched on 8 January 1988 at Williams Field, Antarctica. This was the first large balloon (11MCF) flown from Antarctica.

C. Tether Balloon Support

1. Sure Hit (SRHIT)

The balloon launch technicians were required to support SRHIT and in November 1984 the SRHIT task was completed. In February 1985 this TRN was re-opened for additional SRHIT operations. In April 1985 support was again provided to support SRHIT and on 28 June 1985 SRHIT operation performed successfully.

Final preparations for the next SRHIT tether flight at WSMR were completed. The Tether Control Center Van and other support equipment were moved to WSMR and made ready. The balloon was tethered and launched 10 January 1986 with the mission completed that day. The tether cable was cut but the backup cutdown system operated properly and the balloon was recovered on WSMR. PSL personnel supported the flight in the control van as part of the launch crew and as part of the recovery team.

2. TAAP Launch Support, North Carolina Trip

Flight reservations and other arrangements were made to send Joe Fumerola and Jerry Cooper to Elizabeth City, North Carolina for TAAP (Tethered Aerostat Antenna Program) Launch Support beginning 7 January 1985. The operation with the TAAP at Elizabeth City, North Carolina from 7-15 January was a very successful and intensive operation. This task was completed in February 1985 and closed out on 8 September 1985.

3. 45K Tether

The 45K Tether ILC balloon was flown 12-14 August 1985. Assistance was provided by Joe Fumerola.

PSL was asked to support the JTIDS project at Elgin AFB in Florida. In preparation for this project, EV-13 smart valves were checked and one valve repaired. Gel cell batteries were charged to power the valves. The tether balloon was deployed with PSL support in Florida to provide a vehicle for antenna testing.

D. Travel

The Parachute Rigger technician was sent to Corpus Christi, Texas to support the BIMM Project.

A meeting at Hanscom AFB, attended by Ralph J. Cowie, AFGL/LCC; Catherine L. Rice AFGL/LCA; Andrew R. Lazarewicz; Brenda J. Schilinski; Carl Leyh (AFGL/LWG); James R. Clynch ARL/U of Texas; Daniel Dechichio Bedford Research; Roger Bramlett, Jerry Cooper, and Vic Parkerson (PSL/NMSU), was held to further discuss the Gravity Payload requirements and objectives. The format of the real time digital data tapes was determined, and the preliminary data formats of the two telemetry data streams were discussed. The general data characteristics were also determined.

Squire Seagraves traveled to Denver, Colorado to meet with SCRIBE 99 project personnel from AFGL and the SCRIBE 99 payload personnel at the University of Denver. In anticipation of the SCRIBE 99 flight the Northrop landing strip was surveyed as a possible launch site.

Joe Fumerola drove to California to support a tether flight at China Lake, returning to Holloman on 9 February 1986.

A trip was made to Yuma, Arizona in early December 1986 to retrieve the crane that had been left there for repair. The crane had developed engine problems on the return trip from California.

Packing and preparations for travel to Ramona, California to support the planned KESTREL Balloon flight were completed on 12 September 1986. Three PSL personnel traveled as drivers to Ramona, California.

Personnel returned to the Ramona, California area on 4 November 1986 to support the KESTREL flight. The telemetry van equipment operation was verified and communications equipment was deployed to support the flight.

Squire Seagraves traveled to Kwajalein Missile Range, Kwajalein Island as part of a site survey team from Air Force Geophysics Laboratory.

PSL personnel traveled to Washington, D.C. for National Science Foundation Antarctica Orientation.

PSL instrumentation technician traveled to University of Florida for GRAD payload integration. He assisted the AFGL engineer during the initial payload test.