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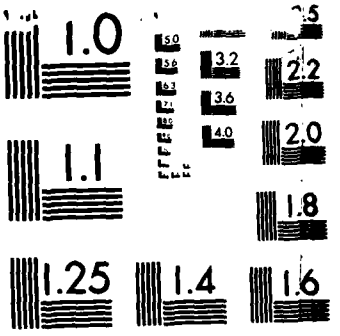

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FINAL TECHNICAL REPORT FOR SHARP
(STABILIZED HIGH ALTITUDE RESEARCH PLATFORM)

Physical Science Laboratory
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September 1985

Final Report
July 1983 - August 1985

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731

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The Stabilized High Altitude Research Platform, (SHARP) is a balloon-borne payload separable into two structures. The lower section, which is recoverable in mid-air, carries a gyroscopically-stabilized platform designed to stare at or scan an area on or above the earth's surface. Commands from the ground define the target or type of motion required.

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FOREWORD

This document, the Final Technical Report for the Stabilized High Altitude Research Platform (SHARP) program, is submitted to the U.S. Air Force Geophysics Laboratory (AFGL) under Contract No. F19628-81-C-0127 by the Physical Science Laboratory (PSL) of New Mexico State University (NMSU) in direct response to CDRL 104.

ABBREVIATIONS

AFGL	Air Force Geophysics Laboratory
BAMM	Balloon Altitude Mosaic Measurements
CDR	Critical Design Review
C	Celsius
CDRL	Contract Data Requirements List
HAFB	Holloman Air Force Base
ICD	Interface Control Document
IRIG	Inter-Range Instrumentation Group
NMSU	New Mexico State University
PCM	Pulse Coded Modulation
PDR	Preliminary Design Review
PSL	Physical Science Laboratory
RF	Radio Frequency
SD	Systems Development
SHARP	Stabilized High Altitude Research Platform

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INTRODUCTION

The Stabilized High Altitude Research Platform (SHARP) was developed for the U.S. Air Force Geophysics Laboratory (AFGL) by the Physical Science Laboratory (PSL) of New Mexico State University (NMSU) under Contract No. F19628-81-C-0127.

The SHARP is a three-axis, stabilized, pointing platform designed to fly on a high-altitude balloon and accommodate a variety of sensors. The platform compensates for horizontal velocity, vertical velocity, balloon rotation, balloon pendulation, and earth rotation to allow accurate observation of extended objects on the ground.

1.0 SCOPE

This report, the Final Technical Report for the Stabilized High Altitude Research Platform (SHARP) program, summarizes the program events and documentation associated with the program. A management overview is presented.

2.0 MANAGEMENT OVERVIEW

The SHARP platform was developed under the AFGL Contract No. F19628-81-C-0127. This platform was designed to accommodate instrumentation that required pointing accuracy for ground targets. The development of the platform was based on the original Interface Control Document (ICD), the subsequent Preliminary Design Review (PDR) and the following Critical Design Review (CDR).

Once the CDR was complete the final components were purchased and the structure was fabricated. The lower structure was taken to Hickman Field, Hawaii, and "air retrieval" qualified.

While the platform was being fabricated several of the concepts were being verified through test flights of the electronics packages on a "load bar" payload. The command system was qualified on such a flight from Holloman Air Force Base (HAFB). The navigation system and the telemetry encoder were also qualified on a similar flight from the same base. Once the electronics and air frame had been completely tested and flight qualified, the integration of the payload began in September 1983. All functions of the payload were completely tested and integrated by 31 October 1983.

Several intermediate tests occurred to ground qualify the payload before the 16 February test flight of the entire payload with an actual sensor aboard. Once this test flight was completed the payload was refurbished and made ready for the gulf coast developmental flight in June.

3.0 PROGRAM MILESTONES

Program milestones are depicted in Figure 1, beginning with the completion of the SHARP platform on 31 October 1983, and concluding with the system inventory on 27 March 1985. The platform was delivered to AFGL FOB PSL on 11 September 1985.

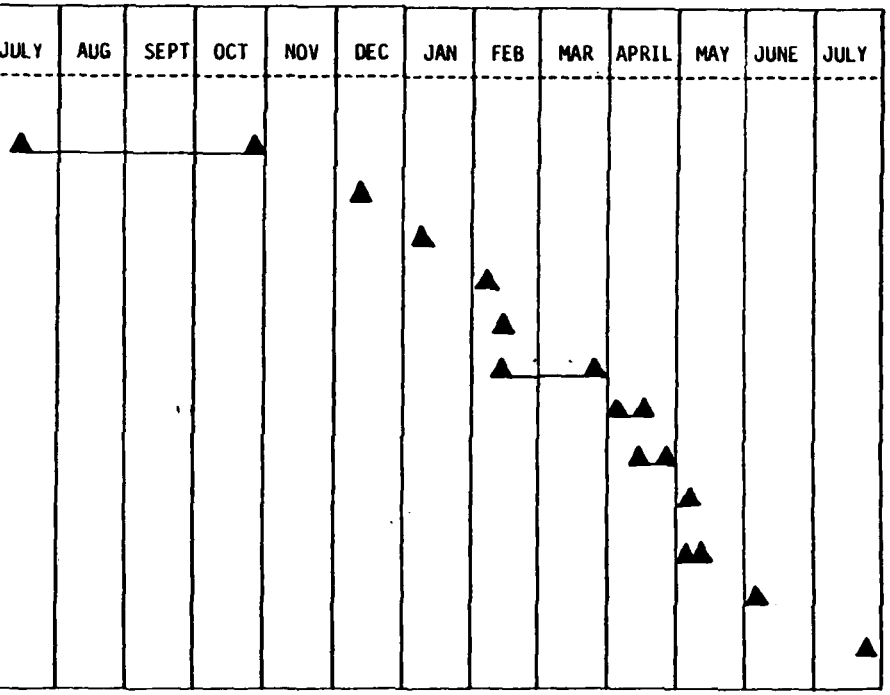
3.1 Platform Completed

All components of the platform structure were complete on 31 October 1983 except the drogue chute, sensor plate, locking forks, and ground handling equipment. This was the first major milestone in the development program. (See Figure 1, Program Milestones.)

3.2 Pointing Test #1

Pointing Test #1 was conducted at PSL West on 13 and 14 December 1983. This test checked the pointing capabilities of the platform using the radiometer data. The data was plotted in real-time in the BAMM van by the computer system. Plots were made of the various steps of the pointing test procedure used to run the test. This data was taken to AFGL for final analysis.

MILESTONE	STOP DATE
PLATFORM COMPLETE	Oct. 31
POINTING TEST #1	Dec. 13, 14
ENVIRONMENTAL TESTS 1 & 2	Jan. 12
POINTING TEST #2	Feb. 9
TEST FLIGHT	Feb. 16
PLATFORM REFURBISHMENT	Feb. 16-March 31
POINTING QUALIFICATION TESTS	April 1-15
SHIPMENT TO CORPUS CHRISTI	April 16-30
SENSOR INTEGRATION	May 4
LAUNCH READINESS TESTS	May 1-11
DEVELOPMENTAL FLIGHT	June 1
SYSTEM DELIVERY *	July 27



* System inventory was conducted by AFGL personnel 27 July 1984. (Refer to Section 3.12.) The SHARP Platform was delivered to AFGL FOB PSL 11 September 1985.

Figure 1. Program Milestones

3.3 Environmental Tests 1 and 2

Environmental tests of the SHARP platform were conducted on Thursday, 12 January 1984, after two days of setup and equipment shakedown. The tests occurred at the HAFB environmental chamber. The vans were moved to Building 850 at HAFB to support the chamber tests at Building 1261. The payload communicated with the van complex through RF links; a true remote control support function was established. All data processing and command control occurred from the vans.

This first test series was conducted using a PSL-generated procedure ("Environmental Chamber Test," SD-838-1074, Volume 2 - Procedures) and coordinated by a test conductor. Troposphere and at float (100,000 feet) temperatures and altitudes were simulated during the test. The gondola frame itself at one time reached a temperature of -70 degrees Celsius. All systems performed well under this environment, with each subsystem tested several times at the float altitude. No environmentally-induced anomalies were observed.

A second environmental test was conducted 31 January 1984. The main purpose of this test was to qualify the new FSK modification in the command system and the 5 volt regulators that replaced the high failure rate units. Both of these test goals were met and the command system for both the payload and balloon control performed perfectly.

3.4 Pointing Test #2

Pointing Test #2 occurred during the week prior to the test flight date of 16 February 1984 at HAFB in the high bay of the AFGL Building 850. The platform was suspended on the high bay crane, and scan and stare measurements were there taken.

3.5 Test Flight

After delays due to ground support equipment and surface winds, the SHARP was launched at 0715 on 16 February 1984. The platform ascended slowly and drifted to the east across the mountains from Holloman AFB. It reached the float altitude (100,000 ft.) at approximately 0840 and began drifting in a southwesterly direction.

During float, engineering data was collected on the performance of the platform, including the telemetry, navigation, power, command, pointing, and video subsystems. This data was collected for approximately two and three-fourths hours before a battery failure in the SHARP electronics power subsystem caused a failure in the payload. The payload was then brought down to recovery altitude where the upper and lower sections were separated. The lower structure was recovered by a C-130 aircraft; the upper structure returned to the ground on its parachute.

With the exception of the battery failure, all subsystems functioned well. The desired engineering data characterizing the platform's interaction with the balloon and the lift-train was obtained.

Data from the test flight yielded two significant factors:

- the tight coupling lift-train coupled the twisting moments of the balloon to the payload; and
- these moments were erratic and difficult to compensate for.

3.6 Platform Refurbishment

The SHARP platform was returned to PSL after the test flight on 16 February 1984 and the mechanical refurbishment began.

3.6.1 Upper Structure Refurbishment

The main damage to the upper structure was to the ballast hopper outlets where the long discharge tubes connect. This was expected because, if the structure lands properly, the first items to impact with the ground are the ballast discharge tubes. The damage done to the hoppers was minimal. The bearing that connects the upper structure to the lower structure was cleaned and tested.

3.6.2 Lower Structure Refurbishment

Some damage occurred to the ring section of the lower structure. Four cables had to be replaced; the elevation motor assembly and the transmission were damaged and had to be replaced; and the stow position indicators were bent and were replaced. This damage probably occurred because the sensor plate was not in the stow position for the air retrieval. It is speculated that the cabling was damaged when the payload was dragged into the recovery aircraft (C-130), but this cannot be determined for sure.

3.6.3 Electrical System

The electrical system on the lower structure had almost no damage; all the antennas were destroyed or lost, as expected, and some of the temperature sensors pulled loose.

3.6.4 Pointing System Elements

The gyros, other elements of the pointing system, and the command downlink functioned as before. An antenna connector on one DME was damaged when the cable was torn away. Most important is the fact that the gyros survived the air snatch without any damage.

3.7 Pointing Qualification Tests

Pointing qualification tests were completed during the period 1 through 15 April 1984 and results recorded by the AFGL testing team.

A modification to the upper structure was defined during the pointing qualification testing. This modification added two additional ballast hoppers to the structure to improve the moment of inertia and therefore allow better torquing ratios between the upper and lower structures. This also improved the isolation factors between the lift-train and the payload, but added about 500 pounds to the payload weight.

To augment pointing, the rotator device was added to the system. This device, active during the pointing tests, decoupled the payload from the lift-train by maintaining the payload position while the balloon rotated.

3.8 Shipment to Corpus Christi

The payload and mission support crew arrived at Corpus Christi, Texas, during the period 16-30 April 1984. The payload and most of the support equipment was shipped in a van and arrived on location 23 April. The upper and lower structures were re-mated and the subsystem checkout implemented. All of the ground support equipment was deployed and all systems survived the trip without damage.

3.9 Sensor Integration

The sensor integration period began the first week in May. All of the sensors were integrated and fully tested on the platform.

The interferometer integration was completed this period with good results. The command system and the RF transmitters were found to be compatible with the sensor. Data transmission to the BAMM Van was also tested, with good results.

3.10 Launch Readiness Tests

Launch readiness tests were conducted in Corpus Christi during the first two weeks in May. The "High Bay" test was completed on Friday, 11 May 1984, with the "All Systems" test being run the following Tuesday. An RFI sensor compatibility test was also conducted.

The first "All Systems" test indicated a need for revision of the flight test procedures. The integration of the radiometer and its special support requirements caused delays in accomplishing the required testing in preparation for a launch readiness state. Since a test of this magnitude had not been run before with the interferometer, it was not unexpected that some changes to the procedure would be necessary. This task was accomplished at the launch site and the test was re-run two days later with good results.

3.11 Developmental Flight

Weather conditions and balloon malfunctions delayed the launch until the morning of 1 June 1984. After a rough launch, at 0515, the platform ascended slowly and drifted to the east across the bay from the Naval Air Station at Corpus Christi, Texas. It reached the float altitude at approximately 0630 and began drifting very slowly in a westerly direction. During float, engineering data was collected on the performance of the platform, including the telemetry, navigation, power, command, pointing, and video subsystems.

The lower structure was recovered by a C-130 aircraft; the upper structure returned to the ground on its parachute. Damage to both sections was minimal.

Three items that failed during the flight (pitch gyro, video transmitter, and DME) were removed from the payload. These items have been sent to the respective manufacturers to determine the nature of the failures. (See Failure Report, dated July 1984.)

Analysis of the flight data is currently being done by AFGL. The platform was returned to PSL in Las Cruces on 7 June 1984.

3.12 System Delivery

Inventory was conducted 27 March 1985 by AFGL personnel. Some items were returned to AFGL; others remained on the existing contract, No. F19628-81-C-0127. The SHARP platform was delivered to AFGL FOB PSL 11 September 1985.

All Contract Data Requirements List items have been delivered. These include this document, the Final Technical Report, in direct response to CDRL 104, and the R&D Equipment Information Report, in response to CDRL 108, consisting of the following reports:

- Subsystems Overview
- Pointing Subsystem
- Ground Command System
- Ground Support System
- Telemetry Encoder Functional Description
- Surge System Deliverables
- Wiring Manual

4.0 DOCUMENTATION

Documentation for the SHARP program included bi-monthly technical status reports and monthly Cost/Schedule Status Reports (C/SSRs). In addition, the Physical Science Laboratory generated test plans and test reports, as required by the Contract Data Requirements List (CDRL). (Ref. Figure 2, Documentation Milestones.)

4.1 Status Reports

Bi-monthly technical status reports were prepared by the Systems Development Section of the Physical Science Laboratory (PSL) at New Mexico State University (NMSU) and submitted to the U.S. Air Force Systems Command at Hanscom Air Force Base, Massachusetts, in direct response to the interim reporting requirements of Contract No. F19628-81-C-0127, as modified by Contract Modification P00008 (Section 3.C).

The interim status reports, submitted on the 15th and at the end of every month, contained a narrative of the work performed and the technical status of each cost account.

4.2 C/SSR

The Cost/Schedule Status Report (C/SSR) was submitted monthly to the Air Force Geophysics Laboratory for the SHARP program. It was prepared under Contract No. F19628-81-C-0127 specifically in response to the Contract Data Requirements List (CDRL), Line Item 117.

4.3 Pointing Test Plan

The Pointing Test Plan for the SHARP was generated in November 1983 in response to the Contract Data Requirements List, Line Item 118.

The purpose of this test was to verify that the SHARP met the pointing specifications outlined in the Interface Control Document (SD-838-1034, September 1983) when subjected to simulated balloon flight conditions.

4.4 Pointing Test Report

The Pointing Test Report was dated 22 December 1983, in response to an AFGL letter dated 19 December 1983.

This report stated that the purpose of the test was to validate certain parameters as well as to determine total integrated motion during a stare period.

The Pointing Test Report affirmed that the platform was configured to support the test and that the following capabilities existed and were functional:

- Slew rate of the payload at one degree per second.

MILESTONE	STOP DATE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY
STATUS REPORTS	Bi-Monthly	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲	▲ ▲
C/SSR	Monthly	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
POINTING TEST PLAN	Nov.					▲								
POINTING TEST REPORT	Dec. 22						▲							
TEST FLIGHT PLAN	Mar. 15									▲				
TEST FLIGHT REPORT	Mar. 27									▲				
DEVELOPMENTAL FLIGHT PLAN	Mar. 20									▲				
DEVELOPMENTAL FLIGHT REPORT	July 27													▲
FINAL REPORT DRAFT	July 27													▲

Figure 2. Documentation Milestones

- Motion of the sensor plate in the azimuth (360 degrees), elevation (-10 to 180 degrees), and roll (+-10 degrees) axes within the required limits.
- Ability to stare at a selected target for a three-minute period without drifting more than three arc minutes.
- Ability of the platform to compensate for drift over the selected target.
- Ability of the platform to compensate for motions in all three axes.
- Ability to point at worse case targets (due north and due east) and maintain stare modes.

4.5 Test Flight Plan

The R&D Test and Acceptance Plan, BAMM Flight Test, dated 15 March 1984, was submitted specifically in response to the Contract Data Requirements List (CDRL), Line Item 110.

The test plan covered all the activities involved in the test flight of the SHARP platform, commencing with the pre-flight checkout (which started on the day preceding the expected launch) and continued through the actual flight operation. The plan described the associated procedures involved in pre- and post-launch activities.

4.6 Test Flight Report

The test flight was originally scheduled for 14 February 1984 but was delayed until 16 February 1984 because of a component failure in the Utah State University radiometer that was to fly aboard the SHARP. After delays due to ground support equipment and surface winds, the platform was launched at 0715 MDT on 16 February.

The test flight report, dated 27 March 1984, consisted of detailed performance reports on the various subsystems and elements of the platform during the flight. It included graphs and plots of the real-time performance data and an analysis of that data. A summary of the platform performance based on all the gathered data was included. Also contained in the appendices were the command log and Control Room log.

A "quick-look" report on the test flight (PSL Document SD-838-1092) was prepared by PSL and submitted to AFGL on 21 February 1984.

4.7 Development Flight Plan

The R&D Test and Acceptance Plan for the BAMM Data Flight was generated by PSL on 20 March 1984. It covered all the activities involved in the data flight of the SHARP platform, commencing with the pre-flight checkout (to start on the day preceding the expected launch) and continuing through the actual flight operation.

The associated procedures were divided into pre- and post-launch sections. The post-launch activities reflected the PSL requirements for SHARP operation and strawman procedures for the acquisition of data to be defined by AFGL.

4.8 Development Flight Report

The data flight was originally scheduled for 24 May 1984 but was delayed until 1 June 1984 because of surface weather. The Data Flight Report was generated by PSL in July 1984 and submitted in direct response to the Contract Data Requirements List (CDRL), Line Item 113, as modified by Contract Modification P00013.

4.9 Final Report, Draft

The Final Technical Report (Draft Manuscript) was dated July 1984. It was generated by the Physical Science Laboratory of New Mexico State University under Contract No. F19628-81-C-0127 in direct response to CDRL 104. It covered SHARP program events and documentation.

4.10 Final Report

This Final Technical Report is dated September 1985.

In response to the AFGL memo of 7 May 1985, all R&D Equipment Information Reports (draft copies) have been corrected per AFGL instructions, including the Surge, Inc., Deliverables. Technical questions have been addressed and legibility of documentation has been improved.

The final C/SSR reflects the additional labor and materials expended on this documentation.

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