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ENGINEERING SERVICES IN SUPPORT
OF SOUNDING ROCKETS

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November 1979

Final Report for Period 1 July 1977 - 30 November 1979

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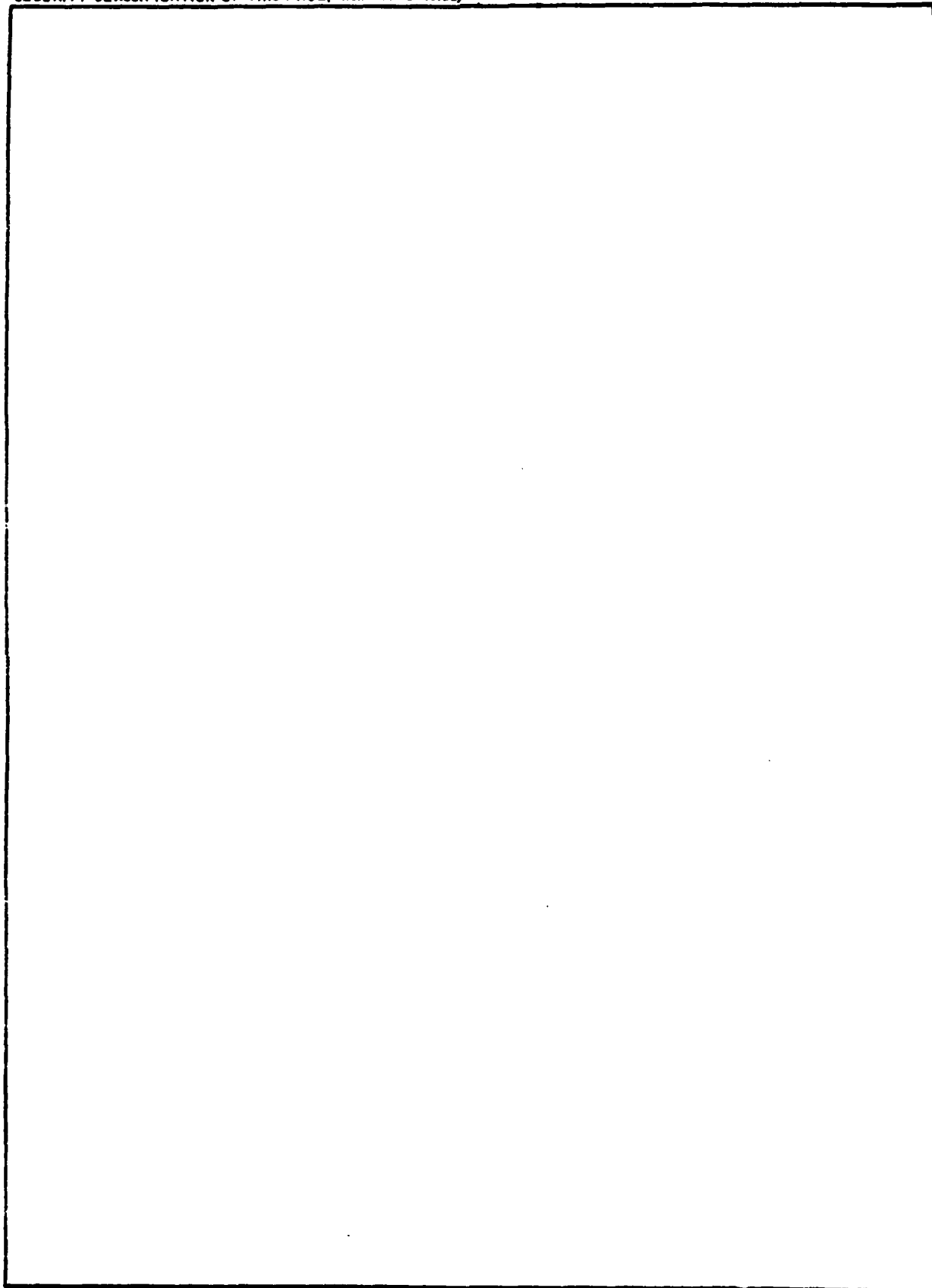
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I. INTRODUCTION

Contract F19628-77-C-0182 provided for engineering launch support to review for technical adequacy and compliance with policies and procedures the assembly and preparation for flight of the sounding rockets listed in the "AFGL Rocket Probe Program" schedule issued quarterly.

Where technical adequacy was in question, analytical and empirical studies were to be performed to verify new or alternate methods or develop devices as directed by the contracting officer.

This final report is being submitted in compliance with the Line Item 0002 of the Contract Statement of Work.

II. IN-PLANT

Sub-Line Item 0001AA - Analyze sounding rockets and payloads for technical adequacy and compliance with policies and procedures as directed by the Contracting Officer or his authorized representative.

Ten tasks under Sub-Line Item 0001AA were authorized:

A. TASK A

Prepare a 2-D trajectory per AFGL Drawing E9795 for an Astrobee F, with a payload weight of 375 lb. up to and including the despin housing.

The 2-D trajectory analysis was performed and copies of the computer run were transmitted to AFGL. As estimated gross payload of 415 lb. was assumed and standard Astrobee F drag coefficients were used, which yielded a peak altitude of 163 statute miles. A possible thermal problem was identified. (Reference: Letter 9590:SR0-0396, J. A. Mattice to R. F. Walters, dated 6 September 1977).

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II. IN-PLANT (cont.)

B. TASK B

Determine dispersion circle radius for a Castor-Lance sounding rocket (AFGL Drawing D9993), given a Sandia Shroud with Astrobee 1500 fins substituted for the present shroud and fins. Determine roll rate to minimize pitch-roll coupling and determine stability of the second stage at second stage ignition.

Dispersion of an Astrobee/Lance Vehicle (AFGL Drawing D9993 except Astrobee 1500 Rear End Kit) with ZIP payload as defined in AFGL Sketch 45, flown from NRL 12 ft rail launcher at Woomera, Australia was determined. Basic vehicle characterization data was generated which converted the original Castor-Lance data, both aerodynamic and inertial, to represent the Astrobee/Lance with a ZIP payload. Flight simulation data generation and analysis resulted in system impact dispersion predictions which were transmitted to AFGL. (Reference: Letter 3530:EPM:0047, J. P. Taylor to Distribution, dated 13 February 1978).

C. TASK C

Prepare 2-D trajectories on Aerobee 170 payload with a nozzle extension, based on AFGL Sketch C-77-119 with an estimated payload weight of 750 lb.

The 2-D trajectory analysis was performed. Results and copies of the computer runs (5) were transmitted to AFGL. The calculations for the heavier payloads gave an indication of the sensitivity to future changes in the payload weight. (Reference: Letter 9590:SRO-0431, J. A. Mattice to R. F. Walters dated 10 November 1977).

D. TASK D

Perform an aeroelastic evaluation to determine the structural and aerodynamic stability of the rocket and the vehicle. AFGL Sketch C-77-119, Revision A, defines the payload under consideration.

II. D. TASK D (cont.)

An aeroelastic evaluation of the Aerobee 170 vehicle with an AFGL payload described by AFGL Sketch C-77-119, Revision A, was made. The vehicle/payload configuration was analyzed for the A-170 critical load condition, booster burnout, and found to be adequately stable and structurally adequate. AFGL field operations was so informed, and the system flown.

E. TASK E

Perform analysis and preliminary design of an interstage, delta velocity to define parameters, trade-offs, and performance capability. The interstage shall be analyzed to a 400 lb baseline, minimum. (Reference: NRL Report No. 3001-13).

This task was stopped before work was initiated at ASC. (Reference: ESD/PPR letter dated 1 November 1977).

F. TASK E

To provide a final design for a kick-stage assembly using the baseline configuration as outlined in NRL Report No. 3001-13, ARIES-Kick Stage, dated June 1977, which forms a part of Section F, Description/Specifications, of this contract. (Reference: ESD/PPR letter dated 16 August 1978).

Design work was initiated as directed. The detail design effort was 25% complete by December 1978 when work was stopped due to the lack of adequate funding and required interface data. No further work was done on this task.

G. TASK F

Perform analysis and engineering design to convert an Aerobee 200 standard four fin tail can to a tail can with ejectable fins required for sustainer recovery. Determine requirements of tail can to achieve an unstable sustainer prior to sustainer recovery. Perform design testing and modify two (2) standard four (4) fin tail cans to tail cans equipped with ejectable fins.

II. G. TASK F (cont.)

An analysis was performed and requirements established to achieve an unstable sustainer prior to sustainer recovery. Detail drawings were made to convert an Aerobee 200 standard four fin tail can to a tail can with severable fins. The design incorporates an aluminum plate to hold two strands of silver-sheathed HNS linear shaped charge (LSC) which are initiated with a single detonator. The SS-15-J LSC, 12046-1 detonator and their interface are the same as used on the flight-proven 3-fin Recoverable Aerobee. This concept permits installation of the LSC after the fin-cant is set and installation of the detonator immediately before launch (in the tower).

A data package was prepared and sent to WSMR Range Safety personnel describing the newly designed 4-fin severance system that was proposed for AFGL flight A04.606-1. A copy of the data packaged was transmitted to AFGL. (Reference: Letter 3530:EPM:0095, J. A. Mattice to L. C. Briggs, dated 30 March 1978)

In April 1978 a fin-severance test was successfully conducted at the ALRC Physics Lab. An informal report was prepared and transmitted to AFGL together with still photos showing the test setup and results. (Reference: Letter 3530:EPM:0154, J. A. Mattice to R. F. Walters, dated 28 April 1978)

In support of flight A04.606-1 a test to investigate the long-term (several days) effect of a localized spring force on the cork insulation bonded to the vehicle recovery system cover plate was completed. This test showed that the proposed AFGL separation system could be flown without a significant degradation of the vehicle recovery system cover plate. Results were transmitted to AFGL. (Reference: Letter 3530:EPM:0110, J. A. Mattice to R. F. Walters, dated 6 April 1978).

Two flight sets of the 4-fin severance system configuration, P/N 5000376-9, were delivered to AFGL/WSMR (one set in April 1978 and one set in May 1978).

II. IN-PLANT (cont.)

H. TASK G

Modify four (4) fin assembly ASC P/N 1369250-12 or P/N 1369290-13 into "Modification, Four Fin Severance" ASC P/N 5000375.

One flight set of AF GFM fins and tail can was modified as directed and shipped to AFGL/WSMR 12 July 1979.

I. TASK H

Provide support as requested by the Contract Manager for the Preparation and launch of AFGL sounding rockets from WSMR for the period ending 30 September 1978. This support may include, but not limited to, vehicle build-up and checkout support at the launch site as well as flight validation and performance calculations at the Sacramento Plant.

Support was provided as requested.

J. TASK I

Evaluate the payload configuration per attached AFGL Sketch CB-3 with regard to rigid body static margin. Evaluate pitch and roll frequencies for the given configuration.

A static margin analysis for the Castor-Lance/ZIP payload configuration was performed as directed. The first stage indicated a minimum static stability margin of 1.6 calibers at about 24 seconds. Second stage minimum margin was found to be 0.6 calibers at ignition, well below the generally accepted minimum of 1.5 calibers.

Results of the analysis were transmitted to AFGL. (Reference: Letter 3510:OPM:0023, J. P. Taylor to R. F. Walters, dated 28 November 1978).

II. IN-PLANT (cont.)

L. TASK L

Determine procedure and provide fabrication drawing for installation of support for ejectable launch lugs on the sounding rocket for A0.4.703.

Engineering support was provided for the relocation of the launch lugs on AFGL flight A04.703-1, which flew successfully. No drawing changes were made due to limited funding.

III. FIELD SUPPORT

Sub-Line Item 0001AB - Assemble, inspect assembly and support launch of sounding rockets at various launch sites as directed by the Contracting Officer or his authorized representative.

Four tasks under Sub-Line Item 0001AB were authorized:

A. TASK F

Task F is hereby extended under subparagraph a. below to cover the following additional work thereunder:

"a. Perform field services for modified fin installation at WSMR, New Mexico. Services required that one (1) person travel from Sacramento, California, to WSMR, New Mexico, and return for seven (7) days within the period 8 May 1978 to 31 May 1978."

One engineer, Mr. J. A. Mattice from the Aerobee project office traveled from Sacramento to WSMR and back. Support was provided during preflight preparation and launch for Flight A04.606-1 which was the first flight of a 4-fin version of the Recoverable Aerobee.

III. FIELD SUPPORT (cont.)

B. TASK J

Participate in assembly, checkout, and launch of AFGL sounding rocket vehicles at Chukuni Range Site, Red Lake, Ontario, Canada, in support of Project Solar Eclipse 79. Travel is authorized for Mr. Edward Highfield from Cape Kennedy, Florida to Range and return to start point. Duration of travel not to exceed 28 days, commencing 1 February 1979.

Support at CRS was provided by Mr. Highfield for 3 launches, A10.802-1, A10.802-2 and A07.712-2 on 26 February 1979.

C. TASK N

Participate in assembly, checkout and launch preparation of AFGL sounding rocket vehicles at White Sands Missile Range (WSMR), New Mexico. Travel is authorized for Mr. Edward Highfield from Cape Kennedy, Florida to WSMR and return. Duration of travel for Mr. Highfield to be period from 23 July through 16 August 1979.

Support at WSMR was provided by Mr. Highfield for 2 launches, A08.705-2 and A08.706-2 on 14 August 1979.

D. TASK O - Provide the following flight hardware:

<u>Aerojet Part No.</u>	<u>Title</u>	<u>Quantity</u>
SG 2000535-1	Helium Shut Off Valve	3
R 3806C-XXX	Helium Flex Hose	3
SG 200576-1	Helium Cross Manifold	2
1184043-1	TCA Protector	2
1164086-1-SS	Riding Lugs	12
1115677-1	Despin Cable	8
1103709-AL	Despin Weight	8
1184050-1	Recovery System (refurb kit)	2

III. D. TASK 0 (cont.)

Prior to initiating procurement during detailed definition of the parts requested, it became evident that AFGL had intended to repay Aerobee 170 hardware borrowed from NASA. However, the list of borrowed NASA hardware was far greater than the Task 0 list. ASC discussed the differences with AFGL and informally transmitted a ROM cost summary, parts list and one set of drawings for ASC part numbers shown on the parts list. The cost summary was an estimate of costs to support nine AFGL Aerobee flights, three of which had been flown. Included are costs to stretch the three recovered A-170s to the A-200 configuration plus refurbishing related components to obtain six additional flights. The cost summary also includes costs for hardware borrowed from NASA to support the three A-170s already flown.

Procurement was not initiated due to the lack of direction and adequate funding.

E. ENGINEERING FIELD SUPPORT

For period from 1 July 1977 through 30 November 1979, engineering field support was provided for the preparation and launch of sixteen (16) sounding rockets. All field activities originate from ASC Field Office located at White Sands Missile Range, New Mexico. Additional launch support was provided by Mr. Ed Highfield. Support was provided for launches at Chukuni Range Site in Canada, and at White Sands Missile Range.

A total of sixteen (16) vehicles of the following types were prepared and launched:

Aerobee 150	- 2
Aerobee 170	- 4
Astrobee F	- 2
Nike-Tomahawk	- 3
Niro	- 2
Paiute-Tomahawk	- 3

IV. ATTITUDE CONTROL SYSTEM

Sub-Line Item 0001AC - Refurbish, modify, test and service one GFP Attitude Control System (ACS), Aerojet Liquid Rocket Co. Part No. 1117600-34 (Mark II) and one GFP Pneumatic Assembly, P/N 1372181, as follows:

A. (a) Refurbish and modify the ACS to perform the following maneuvers: Point the longitudinal center line of the payload in an up vertical attitude at an allowable tolerance of plus or minus ten (10) degrees, then point to a horizontal attitude at the same tolerance, then point to a down vertical attitude at the same tolerance. There is no azimuth requirement.

Item (a) was 90% completed.

B. (b) Provide an Aerobee 170 pneumatic system compatible with the ACS.

Item (b) major component refurbishment was completed. System was not assembled.

C. (c) Helium or argon gas will be utilized for the pneumatics. Determination of the gas to be used will be made 90 days prior to launch. It will be classified as government furnished material.

No action required.

D. (d) Locate the roll, pitch and yaw jets in the recovery extension. The recovery extension will be government furnished material.

Item (d) was completed.

E. (e) The refurbished ACS will be subjected to functional system tests, environmental tests, calibration and simulated flight on the air bearing facility.

No action; waiting for item (a).

IV. Attitude Control System (cont.)

F. (f) Provide one (1) engineer for one (1) meeting at AFGL to determine ACS-Payload interface requirements.

Item (f) was completed.

G. (g) Provide one (1) engineer for seven (7) working days at AFGL for ACS-System integration.

No action: Waiting for customer direction.

H. (h) Provide one (1) engineer for ten (10) working days at White Sands Missile Range, New Mexico, for ACS launch support services.

No action: Waiting for customer direction.

V. FABRICATION

Sub-Line Item 0001AD - Fabricate, modify and test as follows:

Four tasks under Sub-Line Item 0001AD were authorized:

A. (a) Fabricate three (3) sets of hardware required to modify Aerobee 170 Sounding Rocket sustainers into Aerobee 200 sustainers. Install and modify two (2) GFP Aerobee 170 sustainers into Aerobee 200 sustainers.

Work not started due to insufficient funding.

B. (b) Perform flow tests, leak tests, inspection and assembly, and verify that modified sustainers will satisfy specifications of Aerobee 200 sustainers.

Not started: Held for Item 0001AD(a) hardware modification and funding.

C. (c) Provide three (3) sustainer recovery systems.

Three (3) sustainer recovery system (P/N 1184050-19) were fabricated as directed and shipped to AFGL/WSMR 11 July 1979.

D. (d) Provide six (6) thin wall chamber nozzle extensions (ASC P/N 1184067-15), two (2) TCA Protectors (ASC P/N 1184083-1).

Procurement not initiated due to insufficient funding.

VI. REPORTS

Launch reports for the following flights were submitted.

<u>ASC Report No.</u>	<u>AFGL Flight No.</u>	<u>Launch Site</u>
2895LR-01	A03.509-1	WSMR
-02	A07.707-1	WSMR
-03	A10.705.1	WSMR
-04	A04.602	WSMR
-05	A31.603	WSMR
-06	A04.606-1	WSMR
-07	A03.604	WSMR
-08	A04.711	WSMR
-09	A08.708-1	WSMR
-10	A10.802-1	Chukuni, Ontario, Canada
-11	A10.802-2	Chukuni, Ontario, Canada
-12	A07-712-2	Chukuni, Ontario, Canada
-13	A31.702	WSMR
-14	A08.705-2	WSMR
-15	A08.706-2	WSMR
-16	A04.703	WSMR

Vehicle Code

03	Aerobee 150
04	Aerobee 170
07	Niro
08	Nike-Tomahawk
10	Paiute-Tomahawk
31	Astrobee F

VII. LEVEL OF EFFORT

The required level of effort was

Inplant - 4682

Outplant - 1874

Level of effort provided was

Inplant - 4820 (Est. 75 hours for Nov.)

Outplant - 1730