


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**AMERICAN
SCIENCE** 
AND ENGINEERING

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FINAL REPORT

**ALPHA AND X-RAY
SPECTROMETERS
APOLLO LUNAR ORBITAL
SCIENCE PROGRAM**

CONTRACTS: NAS9-9982 AND NAS9-9983

**CASE FILE
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PREPARED FOR

**NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS**

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ASE-2818

FINAL REPORT:

ALPHA AND X-RAY SPECTROMETERS
APOLLO LUNAR ORBITAL
SCIENCE PROGRAM

Contracts: NAS9-9982 & NAS9-9983

Prepared for:

National Aeronautics & Space Administration
Manned Spacecraft Center
Houston, Texas

By:

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23 September, 1971

Approved:



M. R. Hoes
Program Manager

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ABSTRACT

This report is a descriptive summary of how the requirements specified under Article I of Contracts NAS9-9982 and NAS9-9983 were satisfied by the Contractor, American Science and Engineering, Inc. Since the two contracts resulted in one integrated system comprising an Alpha-Particle Spectrometer and an X-ray Spectrometer, this report describes the activities and deliverable items of the two contracts.

1.0 INTRODUCTION

This report is submitted in compliance with and fulfills the requirements of Contracts NAS9-9982 and NAS9-9983, Article XV, Para. C.

The above contracts provide for the contractor to supply and support integrated X-ray and Alpha-Particle Spectrometer Systems as part of the overall NASA Apollo Lunar Orbital Science Program. The two spectrometers, in conjunction with a Gamma-Ray Spectrometer (supplied by another contractor) comprise a team effort by several groups of scientists to determine the geochemical characteristics of the lunar surface by studying high energy radiation emanating from the lunar surface from the vantage point of an orbiting spacecraft.

The ultimate scientific objectives are to produce a chemical map of a significant fraction of the lunar surface. Correlation of this map with visible surface features, other chemical data and other information on the physical nature of the surface will provide some insight into the evolutionary and dynamic processes that have been taking place on the Moon. The particular relevance of the chemical information is that it bears on the origin of the lunar matter, the past thermal history, the dispersal of material across the lunar surface, subsurface features involving anomalous chemical abundance and certain transient phenomena, such as gas releases.

2.0 SCHEDULE OF DELIVERABLE ITEMS SUMMARY

In accordance with Contracts NAS9-9982, NAS9-9983, Article I - Scope of Work, ASE has supplied the necessary supplies, services and facilities, and performed all necessary work to design, develop, fabricate, test, checkout, support and deliver the items as listed in Article I.

Item 1

Mockup - Envelope mockups of the combined X-ray/Alpha Spectrometer package and Solar Monitor were delivered to North American on 14 November 1969.

Item 2

Mass Mockup - Mass mockups of the Spectrometer Processor Assembly (SPA) and Solar Monitor Assembly (SMA) were designed, fabricated, assembled and exposed to various engineering environmental tests. Following exposure to launch-level vibration, the mass mockups were delivered to NASA on 27 February 1970.

Item 3

Prototype Unit - Acceptance Testing and Customer Acceptance of the Prototype Instrument was concluded on 22 June 1970 with the instrument being shipped to North American Rockwell, Downey, California on 6 July 1970 for ATEE Lab integrated electrical compatibility tests with other major elements of the SIM.

Item 4

Flight Unit #1 - Flight Unit #1 Acceptance Test was conducted and successfully concluded on 24 December 1970. The instrument was shipped to KSC for integration with the SIM.

On 10 February 1971, Flight Unit #1 was returned to AS&E for retrofit of the EMI Filter and replacement of six Alpha detectors, both in

accordance with approved ECP-18. During this activity, NASA/MSC directed AS&E to perform a thermal retrofit of Flight Unit #1 and Flight Unit #2 to protect these instruments from the extremely high heating rates caused by the impingement of the RCS Plumes. Activities leading up to this retrofit was a formal presentation to the CCB at NASA/MSC on 18 February 1971 and submission of ECP-21A on 18 March 1971 which was subsequently approved on 8 March 1971.

Prior to completion of the thermal protection retrofit of Flight Unit #1 and during alignment of the Alpha Spectrometer, Alpha detectors 2, 5 and 6 failed. The cause of the failure could not be immediately identified because the condition of the Alpha detectors in Flight Unit #1 could not be ascertained; MSC directed AS&E to replace Alpha Spectrometer #1 with Alpha Spectrometer #2.

The interchange of the Alpha Spectrometers between Flight Unit #1 and Flight Unit #2 required that Flight Unit #1 be designated as Flight Unit #1A and the Flight Unit #2 be designated as Flight Unit #2A.

Because Flight Unit #2 was returned to AS&E for the thermal retrofit modification on 22 March 1971, the interchange of the Alpha Spectrometers was made possible. Flight Unit #2 prior to the interchange was subjected to additional testing to close out a Discrepancy Report generated at KSC related to noise transients on the Alpha LVPS thermistor circuit and spurious counts in the X-ray data registers.

With the interchange of Alpha Spectrometers accomplished and post-manufacturing test completed, the delta acceptance test of Flight Unit #1A was started on 1 April 1971.

The acceptance test was conducted in accordance with P132-140/2, Rev. G. Results of the testing are indicated on the attached chart

(see Figure 1) entitled, "Apollo Lunar Spectrometers Flight Unit #1 Retrofit and Substitution of Alpha Flight #2 for Flight #1."

Flight Unit #1A was returned to KSC on 12 April 1971.

Item 5

Flight Unit #2 - Flight Unit #2 successfully completed acceptance testing on 21 January 1971. In accordance with ECP #17, the Final Checkout Test (FCT) was not performed in order that an EMI Filter and some wire rerouting might be accomplished. Following this rework a Delta Acceptance Test was performed and successfully concluded on 6 February 1971. This instrument was then shipped to KSC for installation in the SIM.

Flight Unit #2 was returned to AS&E on 22 March 1971 at which time the Flight Unit #2 Alpha Spectrometer was substituted for Flight Unit #1 Alpha Spectrometer. As a result of this interchange, Flight Unit #2 was redesignated as Flight Unit #2A.

On 5 May the thermal retrofit of Flight Unit #2A was completed; the post-manufacturing verification test was satisfactorily completed, and the acceptance test of Flight Unit #2A commenced. The acceptance test was conducted in accordance with P132-140/2, Rev. G. The results of this testing are indicated on the attached chart (see Figure 2) entitled, "Apollo Lunar Spectrometers Flight Unit #2A Retrofit and Substitution of Alpha Flight #1 and Alpha Flight #2.

Item 6

Qualification Unit - The Qualification Unit was accepted 13 November 1970 and in serial fashion two test programs were undertaken: a Qualification Test followed by a Delta Qualification Test. Qualification testing was successfully concluded on 18 February 1971. Details of the qualification testing may be found in Volumes I and II of ASE-2640, Qualification Test Report.

APOLLO LUNAR SPECTROMETERS

Flight Unit No. 1 - Retrofit (Per ECP's 18 and 21) & Substitution of Alpha Flight #2 for Alpha Flight #1

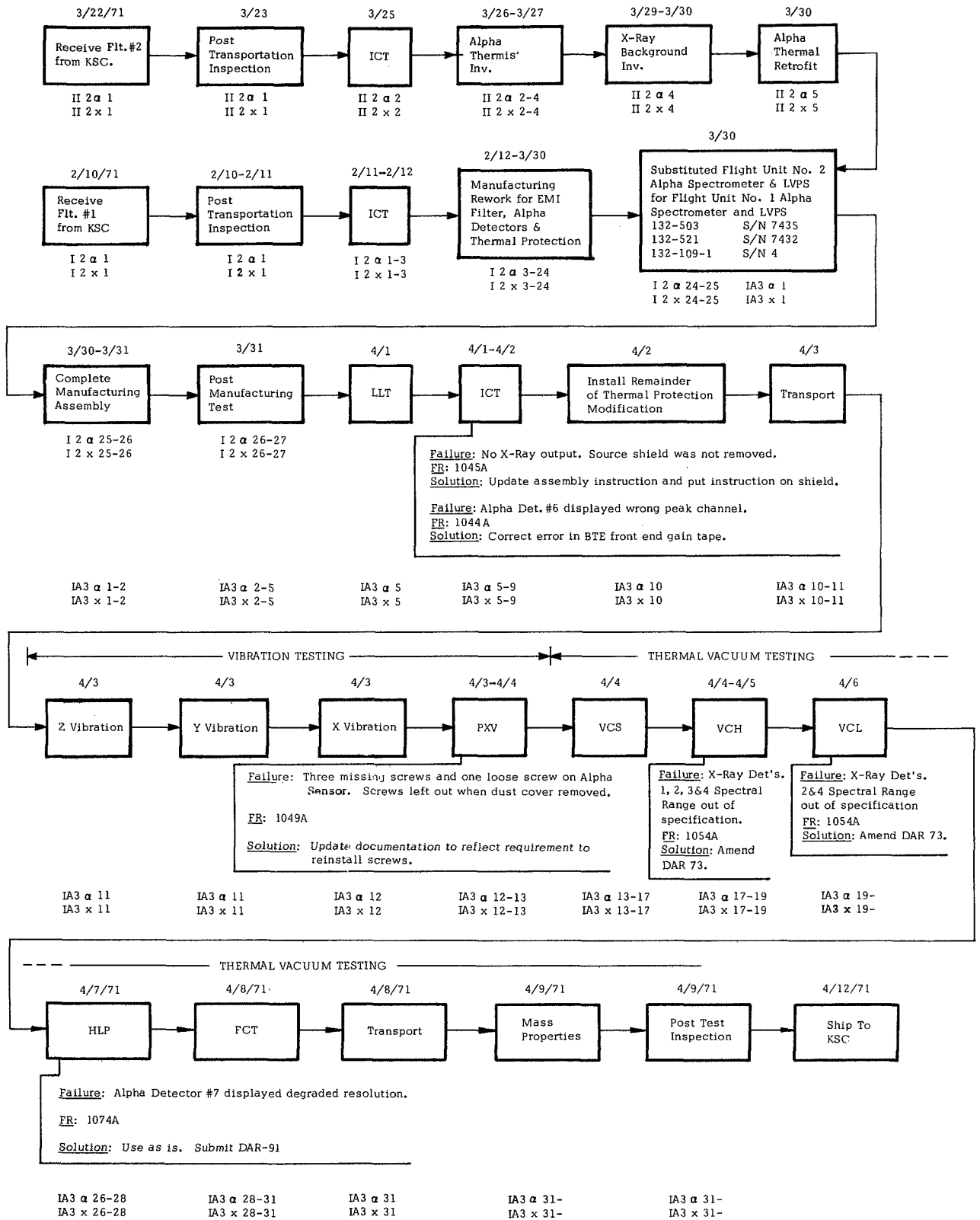
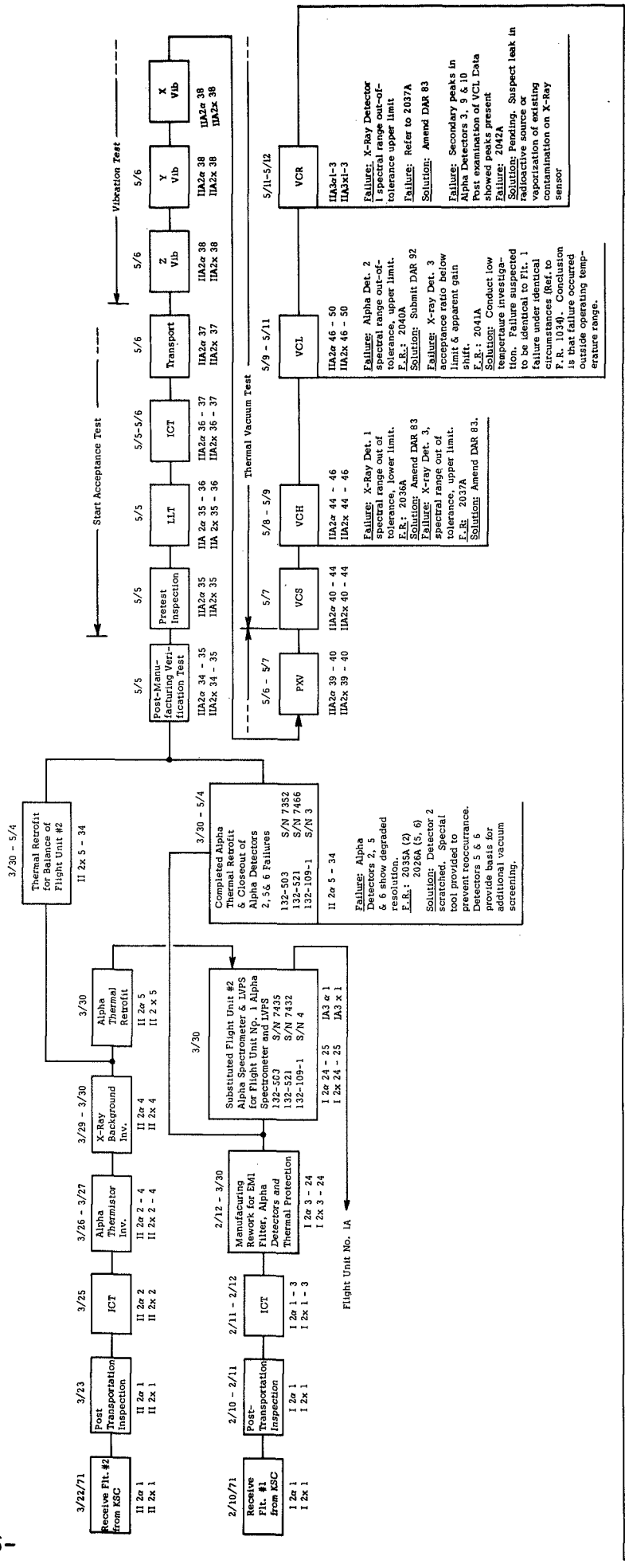


Figure 1

APOLLO LUNAR SPECTROMETERS

FLIGHT UNIT NO.2A-RETROFIT (PER ECP'S 18 AND 21) & SUBSTITUTION OF ALPHA FLIGHT #1 FOR ALPHA FLIGHT #2



3/22/71 Receive Flt. #2 from MSC
II 2x 1
II 2x 1

3/23 Post Transportation Inspection
II 2x 1
II 2x 1

3/25 ICT
II 2x 2
II 2x 2

3/26 - 3/27 Alpha Thermistor Inv.
II 2x 2 - 4
II 2x 2 - 4

3/29 - 3/30 X-Ray Background Inv.
II 2x 4
II 2x 4

3/30 Alpha Thermal Retrofit
II 2x 5
II 2x 5

3/30 - 5/4 Thermal Retrofit for Balance of Flight Unit #2
II 2x 5 - 34

3/30 Complete Alpha Flight #2, Thermal Vacuum Test & Closeout of Alpha Detectors
2, 5, 6 Failures
132-503 S/N 7352
132-521 S/N 7466
132-109-1 S/N 3
II 2x 5 - 34
Failures: Alpha Detectors 2, 5 & 6 show degraded resolution.
F.R.: 2035A (2) 2026A (5, 6)
Solution: Detector 2 scratched. Special tool provided to prevent reoccurrence. Detectors 5 & 6 provide basis for additional vacuum screening.

2/10 - 2/11 Post-Transportation Inspection
I 2x 1
I 2x 1

2/11 - 2/12 ICT
I 2x 1 - 3
I 2x 1 - 3

2/12 - 3/30 Manufacturing Rework for EM1 Filter, Alpha Detectors and Thermal Protection
I 2x 3 - 24
I 2x 3 - 24

3/30 Substituted Flight Unit #2, Alpha Spectrometer & LVPS for Flight Unit No. 1 Alpha Spectrometer and LVPS
132-563 S/N 7435
132-521 S/N 7432
132-109-1 S/N 4
I 2x 24 - 25 IA3 x 1
I 2x 24 - 25 IA3 x 1

5/12-5/13 FCT Except for Tables VIB & VII
IIA3x3-5
IIA3x3-5
IIA3x5-7
IIA3x5-7
Failure: Total PHA counts on alpha detectors 9510 above limit
Solution: Refer to FR 2042A
Failure: Caused by leak in radioactive source or vaporization of existing contamination on X-ray sensor. Submit DAR #3.

5/13-5/15 Investigation of Radioactivity Leak
IIA3x 8-11
IIA3x8-11
Failure: See FR 2042A
Solution: Radioactive leak found in external calibration fixture. No leaks found in spectro-meters. Submit DAR #9. Rebalance of test program.

5/15 FCT per DAR 94
IIA 3x11-14
IIA3x11-14
Failure: Total PHA counts on Alpha Detectors 3, 9, 6, 10 Above limit as defined in DAR 93
Failure: 2042A
Solution: Revise DAR 93

5/16 Mass Properties
IIA3x14
IIA3x14
IIA3x14-
IIA3x14-

5/17 Post Test Inspection
IIA3x14-
IIA3x14-

5/18 Ship to RSC

5/5 Post-Manufacturing Verification Test
IIA2x 34 - 35
IIA2x 34 - 35

5/5 Pretest Inspection
IIA2x 35
IIA2x 35

5/5-5/6 LIIT
IIA 2x 35 - 36
IIA2x 36 - 37

5/5-5/6 ICT
IIA2x 36 - 37
IIA2x 36 - 37

5/6 Transport
IIA2x 37
IIA2x 37

5/6 Z Vib
IIA2x 38
IIA2x 38

5/6 Y Vib
IIA2x 38
IIA2x 38

5/6 X Vib
IIA2x 38
IIA2x 38

5/6 - 5/7 PVV
IIA2x 39 - 40
IIA2x 39 - 40

5/7 VCS
IIA2x 40 - 44
IIA2x 40 - 44

5/8 - 5/9 VGH
IIA2x 44 - 46
IIA2x 44 - 46
Failure: X-Ray Det. 1 spectral range out of tolerance, lower limit.
F.R.: 2036A
Solution: Amend DAR 83
Failure: X-Ray Det. 3 spectral range out of tolerance, upper limit.
F.R.: 2037A
Solution: Amend DAR 83.

5/9 - 5/11 VCL
IIA2x 46 - 50
IIA2x 46 - 50
Failure: Alpha Det. 2 spectral range out of tolerance, upper limit.
F.R.: 2040A
Solution: Submit DAR 92
Failure: X-Ray Det. 3 acceptance ratio below limit & apparent gain shift.
F.R.: 2041A
Solution: Conduct low temperature investigation. Failure suspected to be identical to FR 1 for the same detector circumstances (ref to F.R. 1034). Conclusion is that failure occurred outside operating temperature range.

5/11-5/12 VCR
IIA3x1-3
IIA3x1-3
Failure: X-ray Detector 1 spectral range out of tolerance upper limit
Failure: Refer to 2037A
Solution: Amend DAR 83
Failure: Secondary peaks in Alpha Detectors 3, 9 & 10 Post examination of VCL Data showed peaks present
Failure: 2042A
Solution: Pending. Suspect leak in vaporization of existing contamination on X-ray sensor

Figure 2

Item 7

Flight Unit #3 - Flight Unit #3 was cancelled by MSC in accordance with CCN #13S.

Item 8

Flight Unit #4 - Flight Unit #4 was cancelled by MSC in accordance with CCN #13S.

Item 9

Ground Support Equipment No. 1 - The (BTE) bench test equipment #1 was completed in time to support the Prototype instrument acceptance test. This system was subjected to additional acceptance testing per MSC direction during August 1970.

Item 10

Ground Support Equipment No. 2 - BTE #2 was completed during April 1970 and was subjected to the additional acceptance testing as above during September 1970.

Item 11

Ground Support Equipment No. 3 - BTE #3 was completed during May 1970 and was subjected to the additional acceptance testing as above during September 1970.

Item 12

Documentation - All documentation as required by Exhibit C of NAS9-9982 and NAS9-9983 was supplied at times consistent with the schedule of Exhibit C and program requirements.

Item 13

Monthly and Final Reports - The requirements of Item 13 will be fulfilled with the acceptance of this final report.

Item 14

Financial Management Reports - These reports were supplied

consistent with the requirements of Article XVI of the referenced contracts .

Item 15

Integration and Prelaunch Support - Field support both at Downey, California and Kennedy Space Center was supplied to the extent of 13 man-months .

Item 16

Principal Investigator's Report - The PI's report is in-process and will be submitted upon completion.

Item 17

Astronaut Mockup - A high fidelity instrument mockup was delivered to the NAR February 1970 in accordance with CCN #135 .