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16763- 9 -Preliminary
EXH C. PAR 3.1.6.2

CR 115299

PARTICLES AND FIELDS SUBSATELLITE PROGRAM

FINAL REPORT

OCTOBER 1971

CASE FILE COPY

Prepared by TRW Systems for:
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
Under Contract NAS9-10800

Prepared By Harry J. Horn
Harry J. Horn

Approved By Thomas H. Pedersen
Thomas H. Pedersen
P & F Project Manager
Small Satellites Department

OPEN

EE17

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1. INTRODUCTION

This final report for the Particles & Fields Subsatellite Program is prepared and submitted in accordance with Contract NAS 9-10800, Exhibit C, Paragraph 3.1.6.2, and Document Summary Table Item #9. The basic purpose of the program is to provide three subsatellites with one for launch with Apollo 15, and one for launch with Apollo 16. At this time all three subsatellites have been completed except for a few minor changes, and the Flight #1 subsatellite has been successfully placed in orbit from the Apollo 15 CSM with all systems performing satisfactorily. The Flight 2 subsatellite is scheduled for launch on March 17, 1972. The Qualification Unit subsatellite has successfully completed its qualification testing.

2. BRIEF SYSTEM DESCRIPTION

The Particles and Fields Lunar Subsatellite and its mission are briefly described on the following pages. This is done primarily through the use of pictorial illustrations.

The basic P&F mission is to investigate two fundamental problems of space physics: the formation and dynamics of the Earth's magnetosphere, and the boundary layer of the solar wind as it flows over the Moon. The spacecraft system provides a means of making measurements of energetic particles and magnetic fields while in lunar orbit utilizing the moon as a large absorber. The P&F Subsatellite also provides the additional capability of making precise phase-locked two way doppler measurements, through the lunar orbiting subsatellite. This can be done over an extended period of time and without velocity correction disturbances. Analysis of this doppler data permits mapping of the Moon's gravitational field and development of the lunar mass model.

Figure 1 illustrates the mission concept by showing the Earth's magnetic field at the Moon, with an orbiting P&F Satellite, passing through the magnetotail. The satellite stores data as it passes behind the Moon and transmits this data to a NASA Earth station when it is in view of the station.

Figure 2 pictures the subsatellite in orbit just after separation from the CSM and after the booms have deployed.

Figure 3 shows the spacecraft in lunar orbit while it is communicating with an Earth station. Communication includes dumping of stored scientific data from the satellite's digital memory and receipt of commands for spacecraft control. The satellite is shown with its spin-axis and dipole pattern antennas approximately normal to the ecliptic. This attitude is required for orientation of the magnetometer, and for most favorable RF linkage with ground stations. The spin-axis is aligned by selectively orientating the Apollo vehicle at the time of separation.

Figure 4 pictures the subsatellite in lunar orbit performing its mission.

Figure 5 is a drawing of the satellite while mated to the launch assembly and to the deployment mechanism which pre-positions the satellite to the CSM mold line along guide rails just prior to separation.

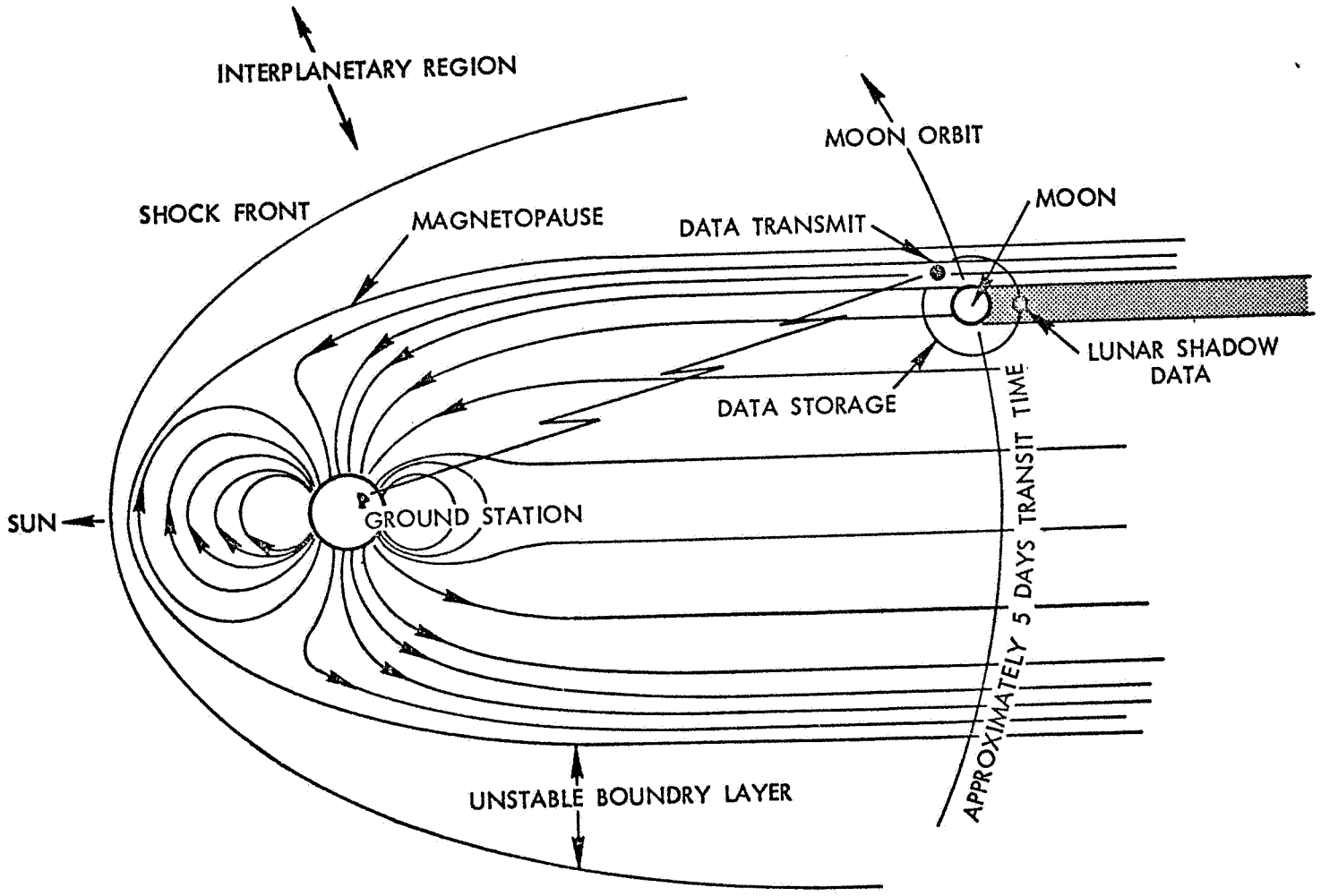


Figure 1. Mission Concept

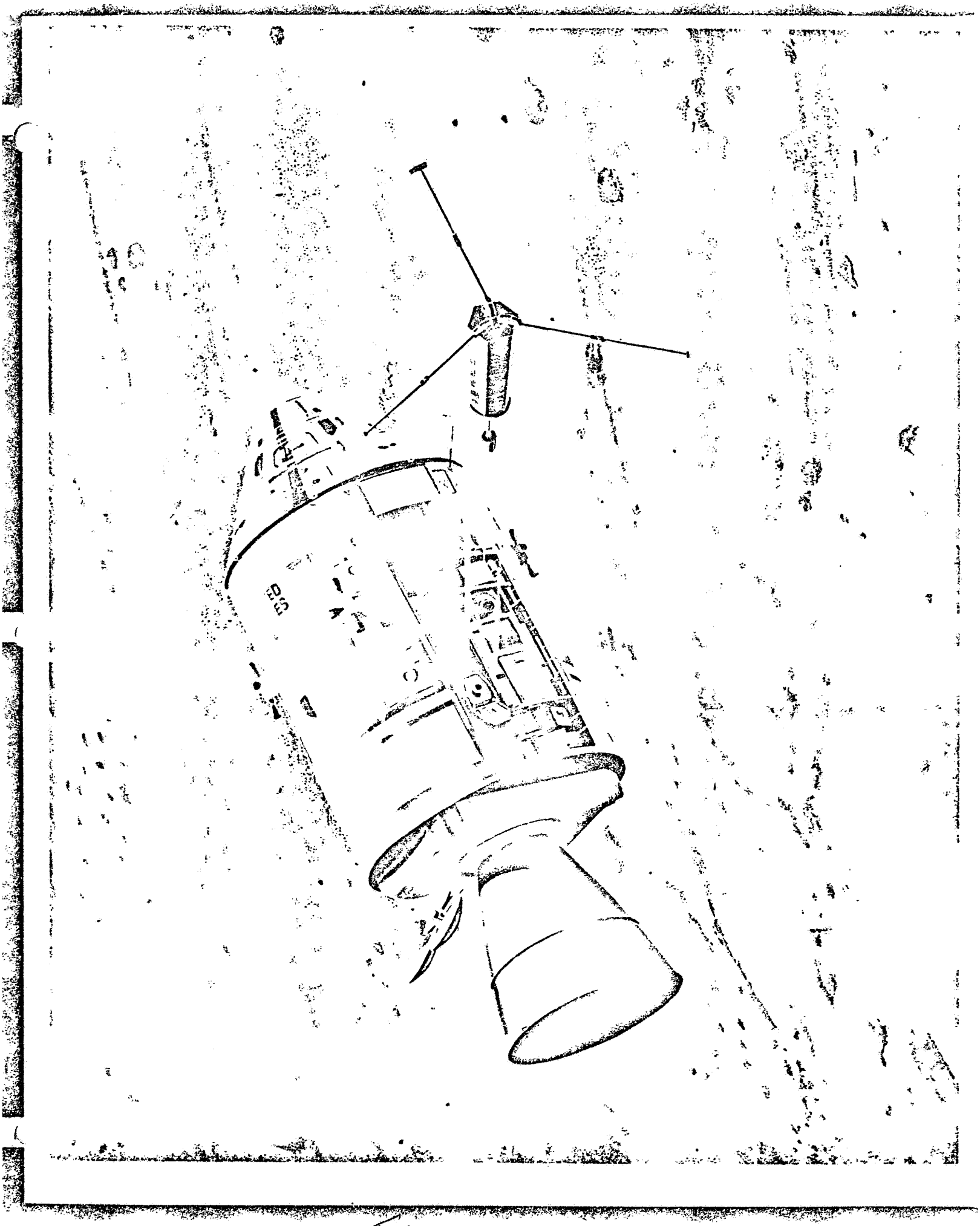


Figure 2

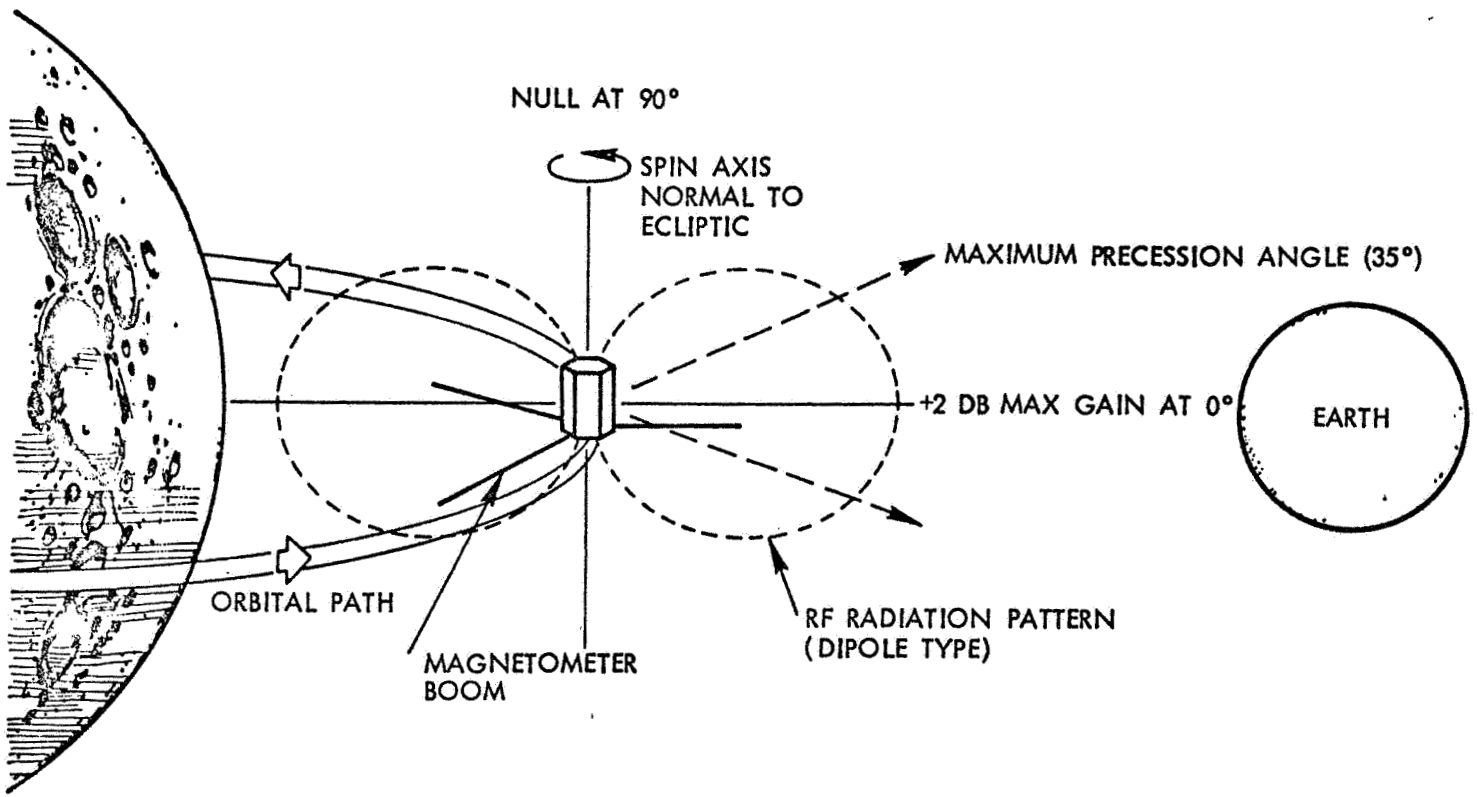
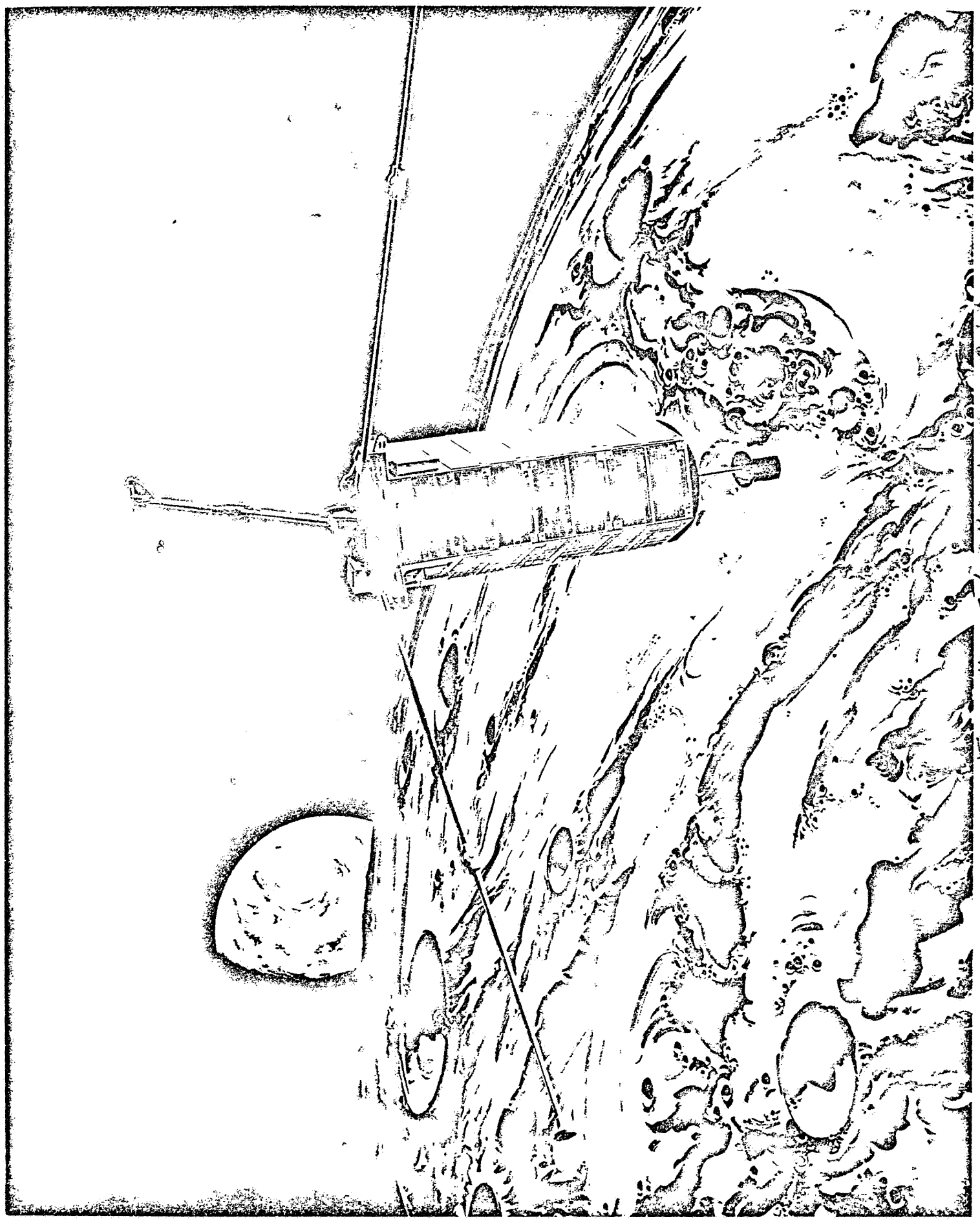


Figure 3 P&F Satellite In Lunar Orbit



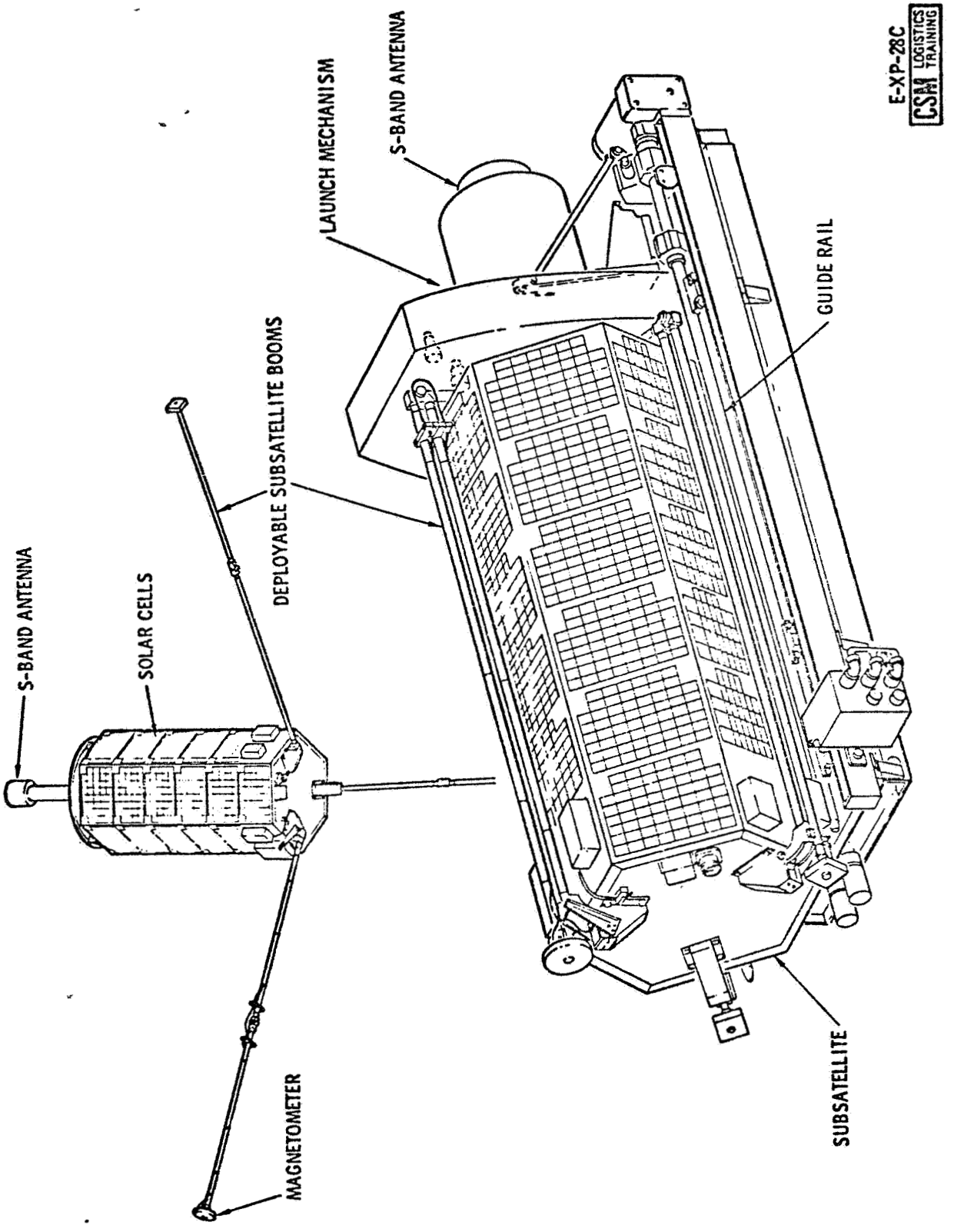


Figure ~~2.11-27~~. 5 Subsatellite With Launch Mechanism

Figure 6 is a photograph of the Flight #1 P&F Subsatellite and its electrical ground support equipment.

Figure 7 is a photograph of the Flight #1 P&F Subsatellite with two solar panels removed. It shows the interior configuration of the subsatellite and includes labels to identify the individual boxes.

Figure 8 shows the subsatellite location while stowed in the Apollo Scientific Instrument Module (SIM). In this configuration it is contained within a protective enclosure.

The photographs of Figure 9 illustrate the prepositioning operation which is performed just prior to separation. The equipment shown is the High Fidelity Mock-up of P&F Subsatellite in the NASA/MSC Apollo 15 SIM Bay Trainer.

Figure 10 is a photograph of the P&F system Mechanical GSE in use. The subsatellite is attached at both ends to the Installation Handling Fixture (GSE item) which is being used in its horizontal configuration. This fixture is providing the means of attaching the subsatellite to a lifting device and a hydra-set. The satellite is being positioned horizontally for attachment to the Rotation Fixture (GSE item). The Rotation Fixture has been rotated to its 90° configuration. The subsatellite has just been moved from the vibration table.

Figure 11 is a simplified block diagram of the satellite system. The basic subsystems are the Particles Experiment Subsystem (PES), Fields Experiment Subsystem (FES), Communications and Phase-Lock Tracking System, Data Handling and Storage, Sun Sensor and Sectoring Logic, Electrical Power, and Structural and Launch Platform.

Table 1 provides a summary of system features.

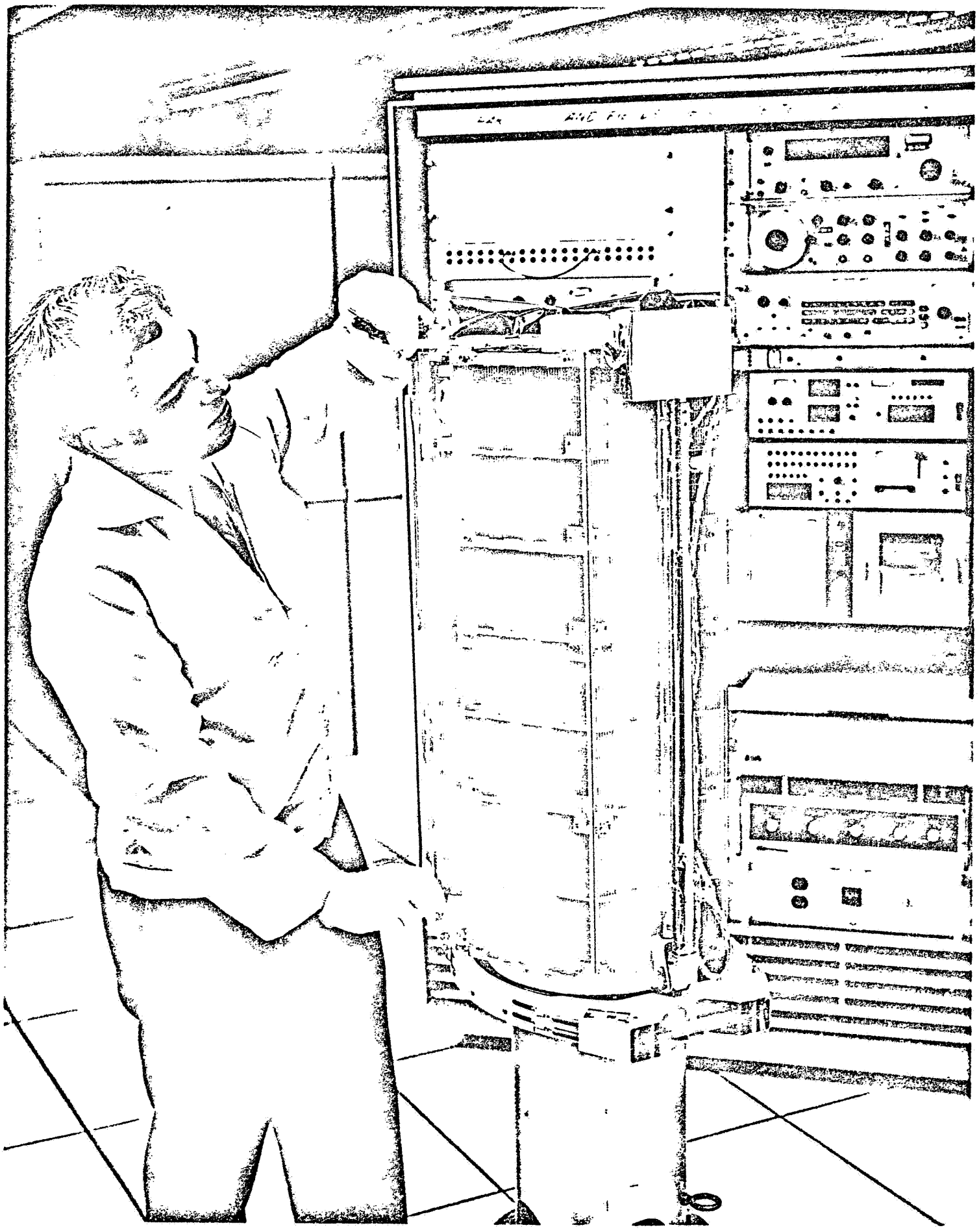


Fig 6

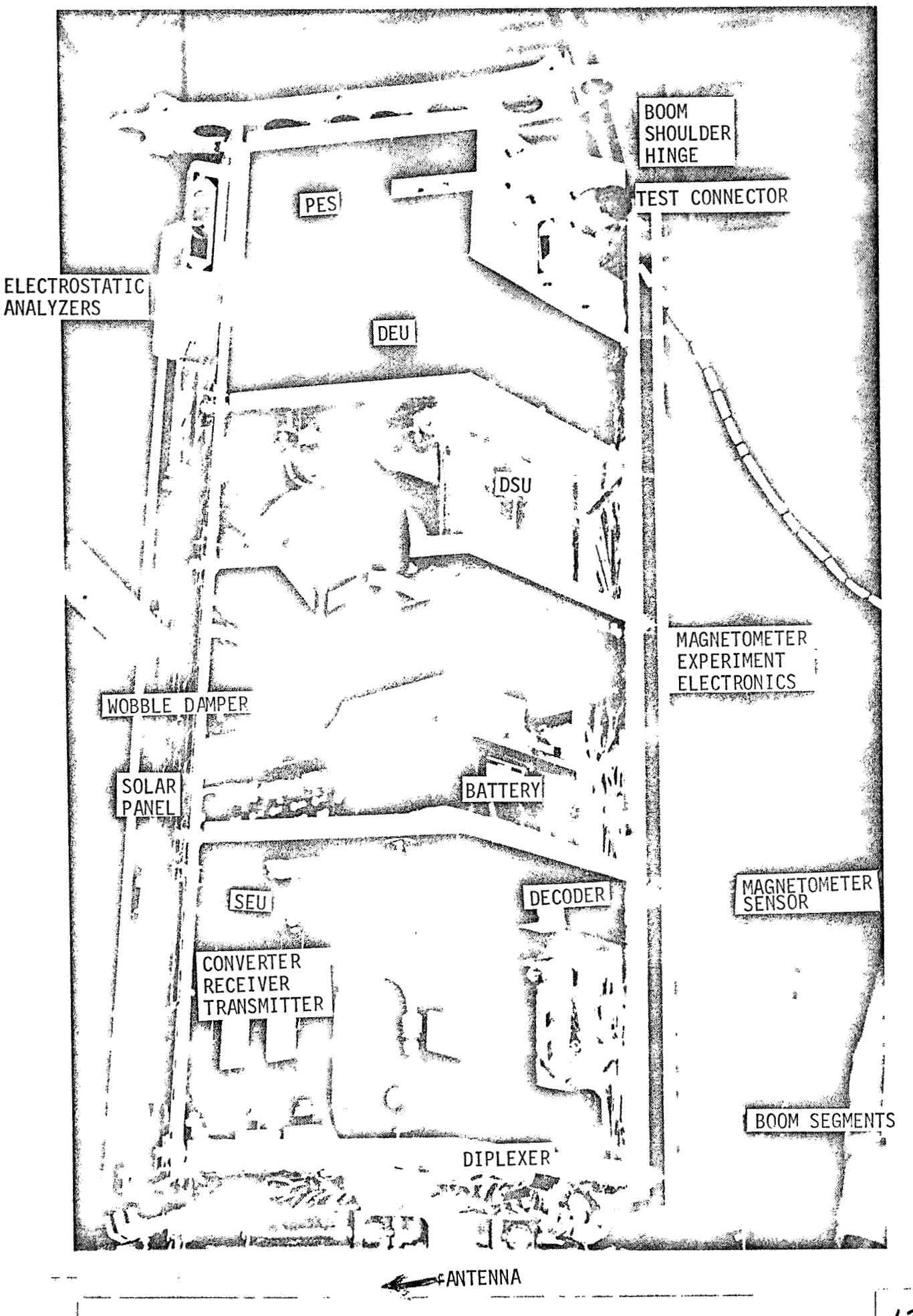


FIGURE 7. FLIGHT #1 SUBSATELLITE INTERIOR CONFIGURATION

J-MISSION SIM BAY
SM112/113 COMMON

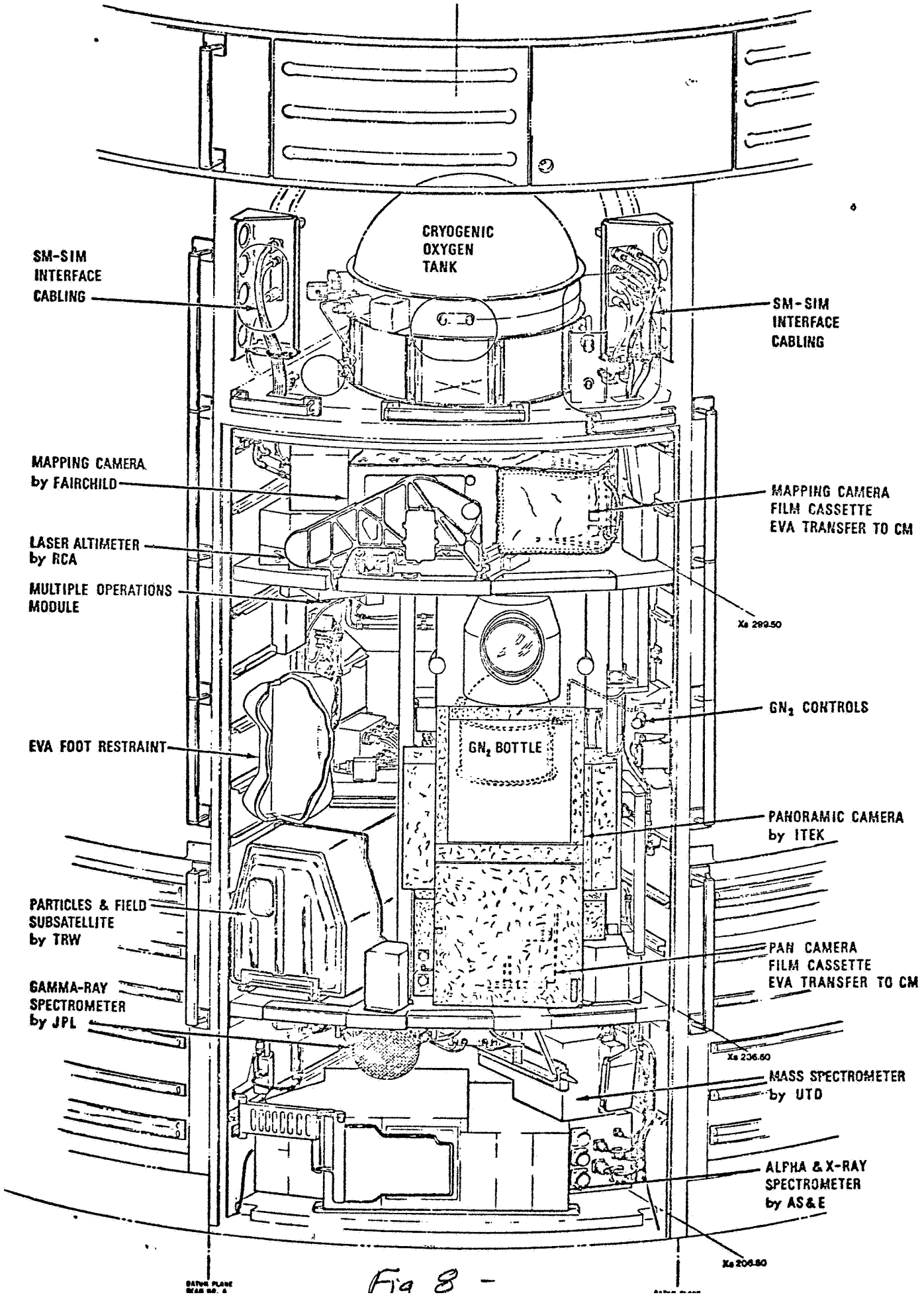
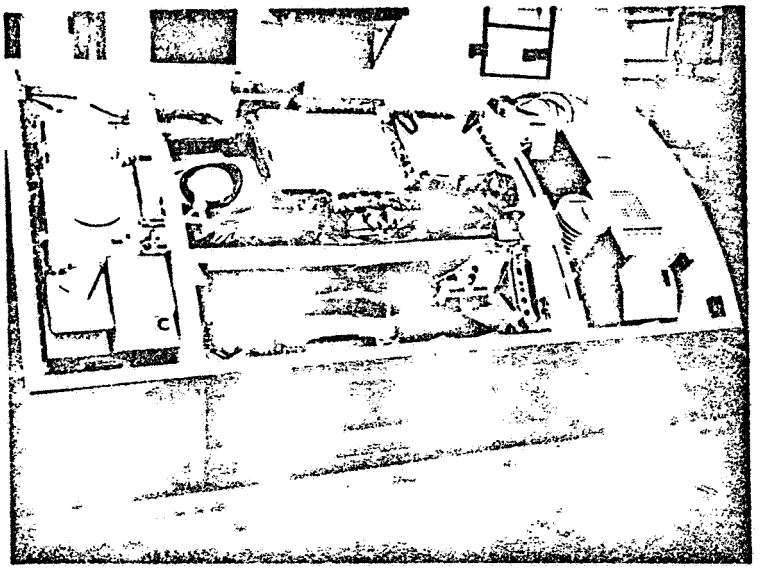
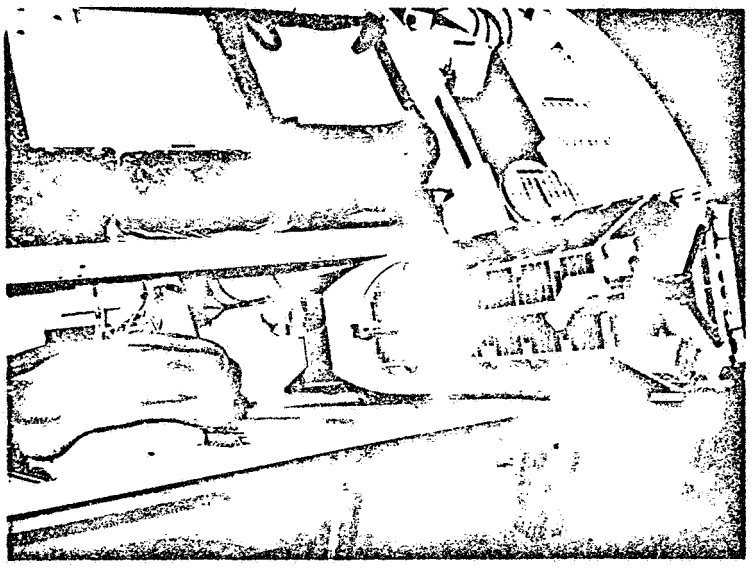
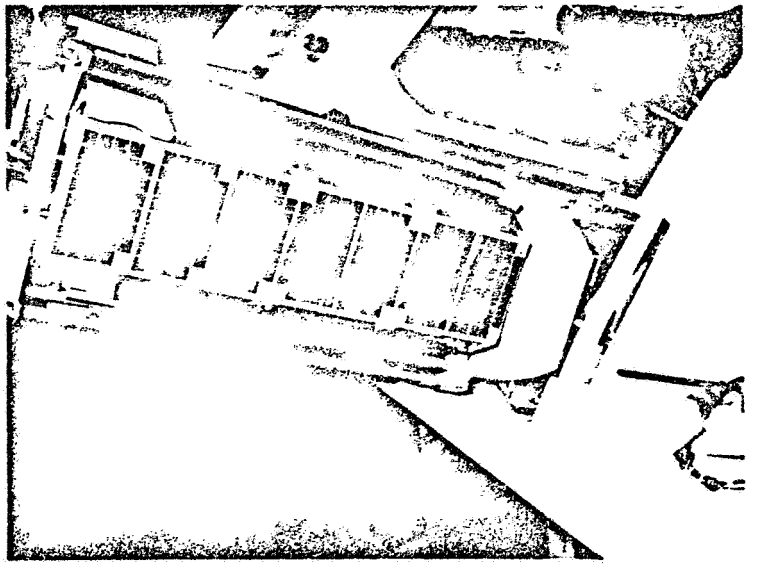


Fig 8 -







PARTICLES & FIELDS SUBSATELLITE
HIGH FIDELITY MOCK-UP
IN NASA/MSC APOLLO 15 SIM BAY TRAINER

Figure 9

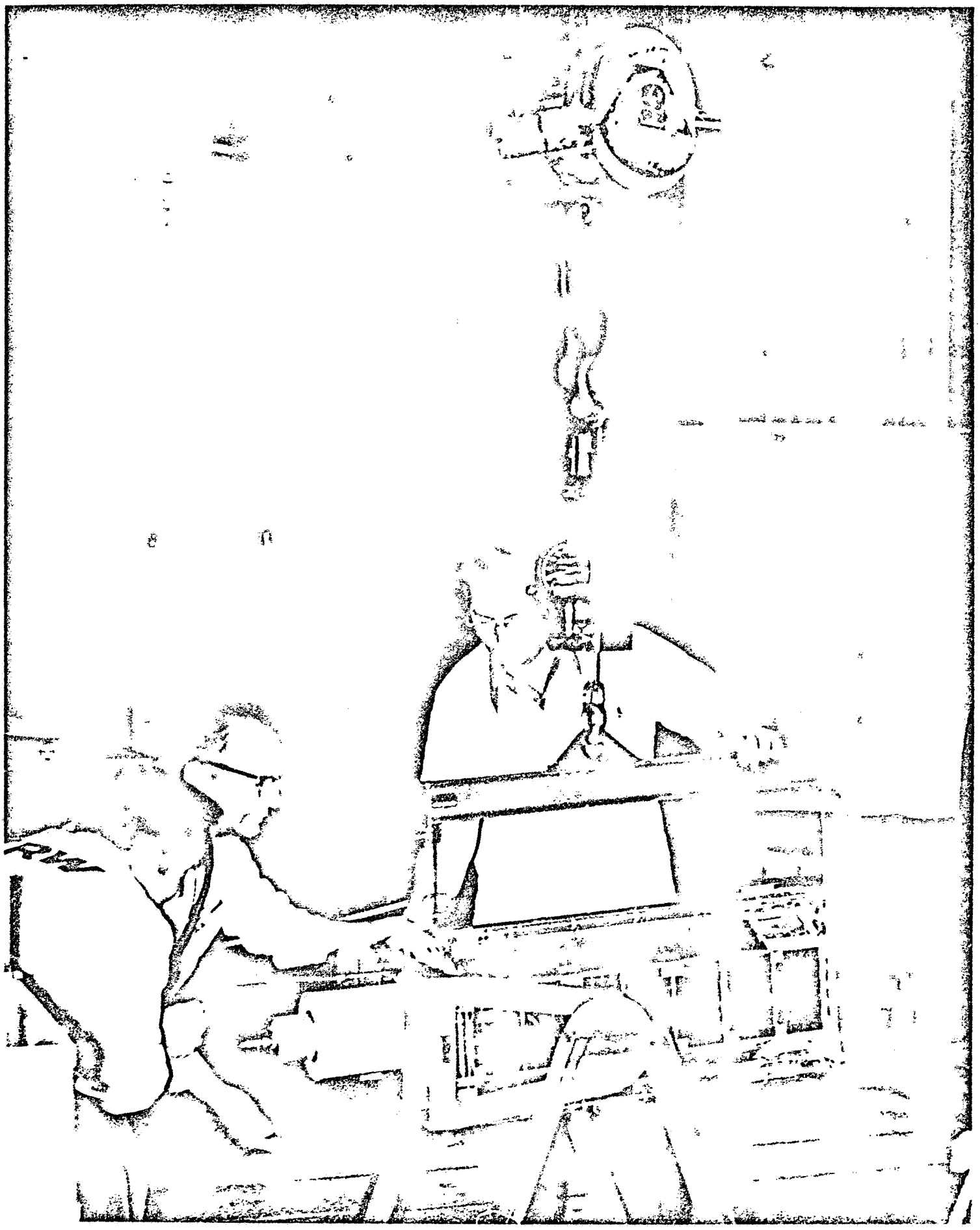


Figure 10

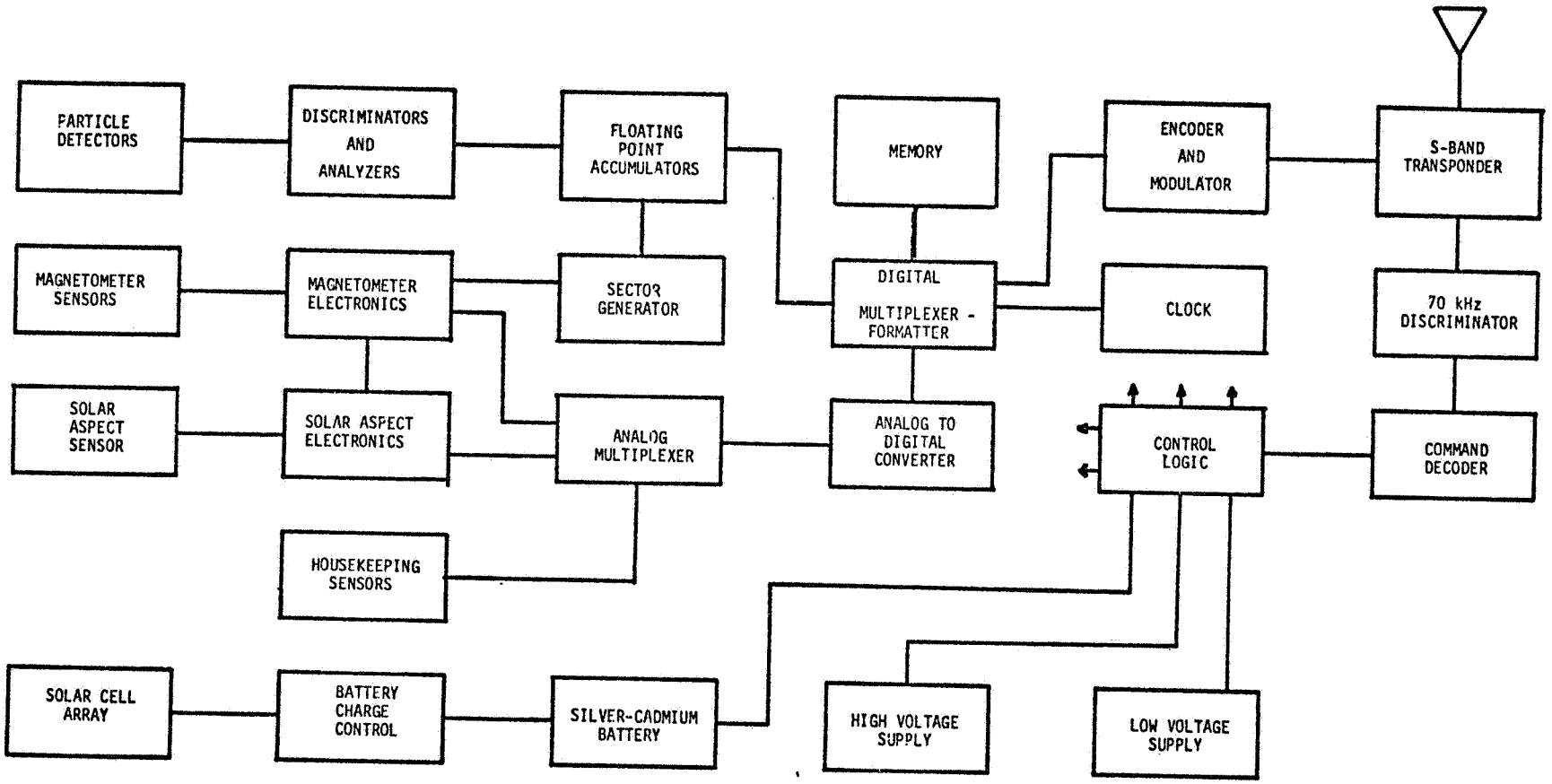


Figure 11. S-Band P&F Satellite System Block Diagram

P&FS PCN-1

TABLE I.- S-BAND PARTICLES AND FIELDS SUBSATELLITE SUMMARY ~~AND~~ OF FEATURES

80.37

General

Spacecraft size	Hexagonal prism, 14-inch diagonal by 30 inches long
Spacecraft weight	90 pounds, approximated
Total launch weight	105 pounds, approximated
Orbit	Lunar (Apollo)
Orbit period	119 min, 61% sunlit
Method of launch	Apollo SIM
Attitude stabilization	Spin at 12 rpm, normal to ecliptic plane

93.38

Payload

Basic measurements	Particles and magnetic fields, Doppler
Instruments	Solid state detectors Electrostatic analyzers Fluxgate magnetometer Coherent S-band Transponder

Communication

Transponder	240/221 phase-locked turnaround ratio
Downlink frequency	2282.5 MHz or 240/221 x Uplink
Radiated power	1.0 watt ~~nominal~~
Transmitted bit rate	128 bps ~~nominal~~
Modulation	PCM/FSK/PM square wave subcarrier (NRZ-M)
Telemetry data subcarrier frequency	32,768 Hz
Uplink frequency	S-Band (2101.8 MHz)
Command format	MSFN Digital
Command subcarrier frequency	70 KHz

Data handling

Data storage	Core memory ~~(Pioneer F model)~~
Storage capacity	49,152 bits
Read-in rate	8 or 16 bps
Read-out rate	128 bps ~~nominal~~
Data dump period	8 minutes 32 seconds

Electrical power

Solar cell array output	24 watts at 17 volts
Battery (AgCd)	11-Cell, 10 A-h
~~Duty cycle~~	~~Continuous operation~~

3. CHRONOLOGY OF KEY EVENTS

MAY 1970

A. S/C Hardware Contract Signed

B. TRW PDR - May 14, 15

C. ATC, Time Zero Subcontracts signed.

D. Zero Gravity Trainer launch platform delivered.

E. Delivery of Q.A., Rel., Safety, CADM, EMC, & Mag. Cleanliness Plans

JUNE 1970

A. ATC - PDR on June 4, 5

B. Time Zero PDR on June 18

C. Delivery of Zero Gravity Trainer Subsatellite

D. Test firing of NASA supplied pyro cartridges.

JULY 1970

A. TRW CDR - July 14, 15.

B. Fields Experiment CDR - July 29

AUGUST 1970

A. Particles Experiment CDR at ATC - August 4, 5

B. Successful breadboard command decoder compatibility test at MSC, August 28.

SEPTEMBER 1970

A. Mass Model Vibration tests successfully completed.

B. Final EMC analysis completed.

OCTOBER 1970

A. Mass Model deployment test complete.

B. Thermal design & analysis of orbit performance completed.

C. Qual, Flight 1, Flight 2, Launch Platform hardware complete, Qual Structure complete.

KEY EVENTS (Continued)

NOVEMBER 1970

A. Spacecraft System breadboard tests completed.
B. Mass Model Separation test completed.
C. Flight 1, Flight 2 structures complete.
D. High Fi mockup deliveried to MSC.
E. Qualification Decoder, Qual Antenna passed Qual tests.
F. BC/S passed acceptance tests.

DECEMBER 1970

A. Successful completion of MSFN compatibility tests with qual subsatellite at Houston - December 30.
B. Qual DSU completed Qualification Tests
C. Qual DEU completed Qualification Tests
D. Qual Transponder completed Qualification Tests
E. Qual SEU completed Qualification Tests
F. Flight 1 SEU completed Acceptance Tests

JANUARY 1971

A. Successful completion of MSFN compatibility test with qual subsatellite at KSC - January 6.

B. Flight 1, Flight 2 Decoder completed Acceptance Tests
C. Flight 1, Flight 2 DSU completed Acceptance Tests
D. Flight 1 Transponder completed Acceptance Tests*
E. Flight 1, Flight 2 Antenna completed Acceptance Tests
F. Qual, Flight 1, Flight 2 Solar Panels completed Acceptance Tests.

FEBRUARY 1971

A. Qual, Flight 1 Subsatellite outgassing bake complete.
B. Qual, Flight 1, Flight 2 Sun Sensors completed Acceptance Tests
C. Qual Battery completed Qualification tests **
D. Flight 2 SEU completed Acceptance Tests.

* Flight 1 transponder retested in March 71.

** A second qual battery was built and requalified.

KEY EVENTS (Continued)

MARCH 1971

A. Qual Spacecraft Phase one Acceptance Review (except PES), March 8 - March 12.
B. Flight 1 Transponder retest acceptance completed.
C. Qual FES (001) passed Qualification Tests.
D. Flight 2 DEU (003) completed Acceptance Tests.

APRIL 1971

A. Flight 1 Spacecraft Phase One Acceptance Review (except PES), April 6, 7.
B. Qual, Flight 1 Spacecraft Test program initiated with inoperative high voltage systems (Qual PES engineering model, Flight 1 PES-2-2).
C. Flight 2 Transponder completed Acceptance Tests. FES 003 passed "super" Qualification Tests.
D. Flight 2 FES (S/N 003) installed in Qual Spacecraft.
E. Qual FES (S/N 001) installed in Flight 1 Spacecraft.
F. Flight 1 Battery (005) completed Acceptance Tests.

MAY 1971

A. Qual PES completed Qual program with High Voltage operational.
B. Flight 1 PES completed Acceptance program with High Voltage operational.
C. Particles Experiment (PES) Acceptance Review - May 7.
D. Flight 1 Spacecraft completes Acceptance program.
E. Qual Spacecraft completes Qualification program.
F. Flight 1 Spacecraft Phase Two Acceptance Review - May 26.
G. Flight 1 Spacecraft shipped to KSC - May 29
H. Redesigned Battery (006) Qual tests completed.

JUNE - JULY 1971

A. Flight 2 (002) FES completed Acceptance Tests.
B. Flight 2 (003) Battery completed Acceptance Tests.
C. Flight 2 PES (2-4) completed Acceptance Tests.
D. Qual Spacecraft Phase Two Acceptance Review - June 21
E. Flight 2 Spacecraft Phase One Acceptance Review - June 21
F. PES Flight 2 Acceptance Review - June 29

KEY EVENTS (Continued)

JUNE - JULY 1971 (Continued)

G. Final Battery Charge completed on Flight 1 Spacecraft on pad at Cape Kennedy, July 16, 1971.
H. Flight Two Spacecraft completed Acceptance Test program.
I. Flight Two Spacecraft Phase Two Acceptance Review - July 21, 22.
J. Flight Two Spacecraft put into storage - July 23.

4. DELIVERY ACCOMPLISHMENTS

Hardware delivery accomplishments are tabulated below by Contract Item number. The Zero-G Training Unit Subsatellite was added via Contract Change Authorization #1.

Item No.	Contract Reference	Item	Required Delivery Date	Actual Delivery Date
1	Exhibit "A" Par. 3.3	Zero-G Training Unit Launch Platform Unit	5-13-70	5-21-70
NN	Exhibit "A" Par. 3.3	Zero-G Training Unit Subsatellite	6-8-70	6-8-70
2	Exhibit "A" Par. 3.2	Hi-Fidelity Mock-up of the Subsatellite including Launch Platform	9-15-70	9-18-70
3	Exhibit "A" Par. 3.1	Flight Launch Platform No. 1	1-15-71	5-28-71
4	Exhibit "A" Par. 3.1	Flight Subsatellite No. 1	5-7-71	5-28-71
5	Exhibit "A" Par. 3.1	Flight Subsatellite No. 2 Including Launch Platform	1-4-72	Not Yet Done
6	Exhibit "A" Par. 3.1	Flight Subsatellite No. 3 Including Launch Platform (To be used in Qualification Testing)	5-28-71	6-24-71
7	Exhibit "A" Par. 3.4	Ground Support Equipment	4-23-71	5-28-71
8	Exhibit "A" Par. 3.5	Test Equipment	At Contract Completion	Not Yet Done
9		Development Test Model (Residual)	At Contract Completion	Not Yet Done

5. DOCUMENTATION ACHIEVEMENT

Achievement of contractual documentation requirements are described in this section of the final report, and are presented in the same order as listed in the Contract Documentation Summary Table, Exhibit C, by Item Number.

ITEM NO.

1&2 All P & F Subsatellite Program Contract End Item (CEI) specifications together with required and actual submittal dates, and latest issue information, are listed below. The Mechanical GSE CEI specification was requested at a later date by MSC, to replace EQ1-398A and to incorporate additional equipment, and had no specific required submittal date. The first and final Mechanical GSE specification submittal was on 5 March 1971.

CONTRACT END ITEM SPECIFICATIONS

Document No.	CEI Specification	Req'd Submittal		Req'd Submittal	
		Prelim	Final	Prelim	Final
SY1-36C/SCN-8	P & F Subsatellite System	5/4/70	6/30/70	5/14/70	6/11/70
EQ1-398A	Insertion Fixture (Superceded by EQ1-408)	5/4/70	6/30/70	5/14/70	7/13/70
EQ1-408NC	Mechanical GSE	no required dates		3/5/71	3/5/71
EQ3-387D	Battery Charger/Simulator	5/4/70	6/30/70	5/14/70	6/11/70
EQ15-2A	High Fidelity Mockup	5/4/70	6/30/70	5/14/70	7/13/70
EQ15-3A	Zero Gravity Trainer	5/4/70	6/30/70	5/14/70	7/13/70

3 Engineering Change Proposals (ECPs) are called out in the Contract on an "as required" basis. All ECP's to date, together with their submittal dates, are listed on the attached ECP table.

4 Specification Change Notices (SCN's) are called out in the Contract on an "as required" basis, with both preliminary and final submittals listed on the attached SCN table.

5 Specification Change Logs are called for in the Contract on an "as required" basis. These have been submitted as part of each preliminary and final SCN, and are included in each affected specification immediately after the title page.

ECP SUMMARY LIST

ECP #	DATE	TITLE
001	8/26/70	Sunshades for Analyzers
002		Attitude Determination System
002A	9/3/70	Attitude Determination System,Rev.A
003	8/7/70	Antenna Phase Measurements
004	8/21/70	Subsatellite Changes
005	9/22/70	Antenna Hat & Radome
006	9/22/70	Automatic Transmitter Turnoff
007	2/5/71	Additional Launch Support for Launch #1
008	2/25/71	Subsatellite Test Tape
009	10/23/70	Expanded Test Program
010	3/2/71	Subsatellite Changes
011	1/26/71	Product Assurance Changes
012	12/9/70	MSFN Compatibility Tests
013	1/28/71	Zero Gamma & ADC Reference Voltages
014	3/9/71	Mission Study Support to NAR
015	7/2/71	Sustaining Operation Support
016	2/26/71	Magnetometer Changes
016 Mod	3/11/71	Magnetometer Changes
017	8/27/71	F2 Launch Support
018	6/9/71	Particles Analyzer Calibration at Berkeley
019	4/19/71	Boom Damper Modification
020	4/22/71	Battery Internal Design Change
021	4/19/71	Magnetometer Thermal Env. Mod.
022	4/19/71	Subsatellite Thermal Changes
022A	5/13/71	Subsatellite Thermal Changes
023	4/29/71	BC/S Changes
024	5/12/71	Battery Electronics Cover
025	5/20/71	FES Internal Electronics MOD
026	5/22/71	PES Reliability Logic Change
027	6/4/71	PES High Voltage Power Supply Parts
029	Not Used	---
030	7/16/71	Additional KSC Operations Support for Flight 1
031	6/21/71	PES HV Power Supply Parts (704 Module)
032	9/1/71	DEU Accumulator Design Modifications
033	9/24/71	Magnetometer Gain Changes
034	10/4/71	Subsatellite Thermal Redesign for Lower Temperature of Solid State Telescopes

P&F SCN SUMMARY LIST

SCN	SUBMITTAL DATE		MSC APPROVAL
	Prelim.	Final	Date
SCN-1/EV3-12A (Acc. Test Spec)	3/5/71	6/25/71	3/19/71 (-37)
SCN-1/EV3-9A (Qual. Test Spec)	3/5/71	6/25/71	3/19/71 (-37)
SCN-1/16763-18B (Cert. Plan)	3/5/71	6/25/71	3/19/71 (-37)
SCN-1/16763-42A (P&I Spec)	3/5/71	5/21/71	3/19/71 (-37)
SCN-2/EV3-12A (Acc. Test Spec)	4/30/71	-	Revision Req'd
SCN-2/16763-18B (Cert. Plan)	4/30/71	-	Revision Req'd
SCN-1/SY1-36C (ECP-001)	4/30/71	5/21/71	5/14/71 (-65)
SCN-2/SY1-36C (ECP-002)	4/30/71	5/21/71	5/14/71 (-65)
SCN-3/SY1-36C (ECP-016)	4/30/71	5/21/71	5/14/71 (-65)
SCN-2/16763-42A (P&I Spec)	5/3/71	5/21/71	5/14/71 (-64)
SCN-4/SY1-36C (ECP-004)	5/4/71	5/21/71	5/14/71 (-65)
SCN-2A/EV3-12A	5/12/71	5/26/71	5/25/71 (-75)
SCN-2A/16763-18B	5/14/71	6/25/71	5/21/71 (-70)
SCN-2/EV3-9A	5/18/71	5/26/71	5/25/71 (-74)
SCN-5/SY1-36C (Temp)	5/25/71	7/12/71	5/27/71 (-80)
SCN-3/16763-18B (Cert Plan)	5/26/71	6/25/71	5/27/71 (-81)
SCN-6/SY1-36C (Update SSD Geom. Factor)	6/9/71	7/8/71	6/27/71 (-91)
SCN-4/16763-18B (Cert Plan)	6/9/71	7/8/71	6/27/71 (-91)
SCN-3/EV3-9A (Super Qual for FES)	6/11/71	7/8/71	6/27/71 (-91)
SCN-7/SY1-36C (Mag. Repeatability Deleted)	6/25/71	7/12/71	7/2/71 (-94)
SCN-3/EV3-12B (extended STV for F2)	6/28/71	7/20/71	7/13/71 (-97)
SCN-1/16763-40B (Meas. List)	7/20/71	8/13/71	7/27/71 (-L90)
SCN-8/SY1-36C (Doc. Rev. Ltrs.)	7/20/71	8/13/71	7/27/71 (-L90)

Item No.

6 Engineering drawings were submitted in the form of 35mm microfilm aperture cards as directed in MSC TWX EE17/70-122. A complete listing of the drawings was provided to both NASA MSC and KSC in "Tab" runs in the Acceptance Data Packages. Transmittal lists and periodic summary lists of drawing submittals were also made. There are approximately 800 drawings presented in approximately 1300 microfilm cards. Scientific Instrumentation drawings by ATC and Time-Zero (to the piece part level) were sent to NASA in paper print form.

7 Monthly progress reports started with the month of May, 1970 and continued through the month of June/July 1971. This last report covered the month of June plus that portion of July until the 23rd, at which time the formal acceptance testing of Flight #2, and the last acceptance review were completed, and the level of program effort was substantially reduced to approximately a sustaining level. The scientific instrumentation reports covering ATC and Time-Zero activities were included in the basic report until and including the September 1970 report; for subsequent months the ATC and Time-Zero reports were sent directly to MSC, as requested in MSC TWX #EE17/70-122. Submittals were required on the 15th of the month following the reporting period. As the program progressed and the documentation load became very heavy, program progress reports were assigned very low priority because of the heavy schedule pressures and many on-site meetings held at TRW by NASA, which reduced the need for prompt progress report delivery.

8 Monthly financial management reports started with the report due 22 June 1970, and continued through the report due 22 September 1971. These were submitted on NASA 533 forms and included quarterly reports. Submittals were required on the 22nd of the month following the reporting month, and were typically made on or close to that date.

9 Preliminary and final versions of the final report were required. The preliminary submittal was required on 1 October 1971 and was made on 29 October 1971. The final submittal was required on 15 November 1971 and will be made about

10 Review minutes were required in two parts, A and B, with Part B covering review meeting action item disposition. Part B minutes were required one month after each review and these were supplied for the first 3 reviews, namely the PDR, June review, and CDR. Thereafter MSC requested that subsequent Part B submittals be replaced by submitting each issue of the more frequently updated informal TRW Action Item Log which was done during the remainder of the program. Part A minutes were submitted shortly after the meetings to the MSC Experiment Manager for preliminary review. Formal submittals were made following incorporation of his suggested changes. Reviews were held each month from May 1970 through January 1971 and Part A minutes were submitted for each.

Item No.

11 Reports were required and submitted following each Acceptance Review as listed below.

Date	Acceptance Review
3/8-12/71	Qualification Unit Phase One C.A.R.
4/6-7/71	Flight #1 Phase One C.A.R.
5/7/71	PES Flight #1 C.A.R.
5/26-28/71	Flight #1 Phase Two C.A.R.
6/21-24/71	Flight #2 Phase One and Qualification Unit Phase Two C.A.R.
6/29-30/71	PES Flight #2 C.A.R.
7/21-22/71	Flight #2 Phase Two C.A.R.

12 Acceptance data packages were submitted for all units (subsystems) and spacecraft each at the applicable acceptance review. Corrections or changes were identified during the reviews and subsequently incorporated. Data packages are listed on an attached table together with the submittal dates for the corrected packages.

13 Material review records were submitted at the acceptance reviews as required as part of the applicable data packages (see Acceptance Data Package Summary List).

14 The Failure Mode & Effects Analysis (FMEA) submittal was originally required on 5/4/70 but this was changed by MSC direction to be 6/30/70. Actual first submittal was made 7/1/70. The final issue is a B revision.

15 Failure reports were made on NASA/MSC Failure Investigation Action Report (FIAR) forms. FIAR's were submitted both individually at the time of each failure, and as part of the applicable acceptance data package. Reports were required 24 hours after failure. In general failure reports were telephoned to MSC within 24 hours and this was followed by an initial submittal of the FIAR form. To date 109 FIAR's have been submitted and these are listed in the attached 3 page FIAR Summary Table.

Item No.	
16	Failure Analysis Reports (FAR's) were submitted as required as part of update FIAR's (see FIAR Summary List).
17	Corrective Action Reports were submitted as part of the final FIAR forms (see FIAR Summary List).
18	Certification Plan submittal was required on 6/4/70 with actual first submittal on 6/24/71. The latest is Revision B with SCN-4.
19	Development Test Plan submittal was required on 6/4/70 with actual first submittal on 6/15/70. The latest issue is Revision B.
20	Qualification Test Specification submittal was required 2 months prior to test. Actual first submittal was on 9/15/70. The latest issue is Revision B with SCN-3.
21	Acceptance Test Specification submittal was required 2 months prior to test. Actual first submittal was on 9/15/70. The latest issue is Revision B with SCN-3.
22&23	Preinstallation Acceptance Test Specifications and Integration and Prelaunch Test Requirements Package required submittals for these items were 9/15/70 but this was delayed by agreement with MSC (refer to customer review meeting minutes). Following subsequent TRW documentation support activities it was agreed with Mr. Jack Johnson the MSC Experiment Manager that the requirements for Items 22 and 23 had been fulfilled by TRW letters #8230.14-52 and 8230.14-50, both of 7 December 1970. These provided detailed inputs and corrections to Mr. Richard Bohlman of NASA/KSC on the NASA P & F Subsatellite Pre-launch Checkout document #TCP-KL-6007-LM10, dated 27 November 1970, prepared by Grumman Aerospace Corporation, and to Mr. George Doland of NASA/MSC on the NASA P & F Subsatellite/MSFN Systems Compatibility and Performance Test Procedure #HASD No. OB3069, dated 18 November 1970, prepared by Lockheed Electronics Company.
24&25	Qualification & Acceptance Test Procedures submittals were required 2 weeks prior to test (qual), and 1 month prior to test (acceptance). The contract initially required only end item level procedures but submittal of unit level procedures was added later. Early versions of the more important procedures were submitted to MSC in printed paper form for early review, then again when any changes had been incorporated. Subsequently they were submitted as 35 mm microfilm aperture cards and updated as revisions were made. The procedures were also submitted to MSC as part of the acceptance data packages. Procedures are listed on the attached unit level and spacecraft level procedure summary lists. Procedures by the major subcontractor ATC and Time-Zero

P&F UNIT LEVEL TEST PROCEDURES
AVAILABLE IN MICROFILM FILE

HC-00K-01/1C	P and F Subsatellite Assembly Magnetic Properties Procedure
HC-01Q-01/NC	Ordnance Qualification/Lot Acceptance Test Procedure
HC-06A-01/A5	Command Decoder Acceptance Test Procedures
HC-06A-02/B2	DEU Unit Acceptance Test Procedure, A7
HC-06A-03/A	DSU Unit Acceptance Test Procedure, A4
HC-06A-04/A2	S-Band Receiver Acceptance Test Procedure
HC-06A-05/A1	S-Band Transmitter Acceptance Test Procedure
HC-06A-06/A4	S-Band Transponder Acceptance Test Procedure
HC-06C-01/A2	Command Decoder Functional Test Procedure (Plus Attachment I & Attachment II)
HC-06C-02/A2	DEU Functional Test Procedure
HC-06C-03/A2	DSU Functional Test Procedure
HC-06C-04/NC	Command Decoder Functional Board Test
HC-06C-05/NC	Functional Test Procedure for the Hat Assembly
HC-06Q-01/A2	Command Decoder Qualification Test Procedure
HC-06Q-02/A7	DEU Unit Qualification Procedure
HC-06Q-03/A4	DSU Unit Qualification Test Procedure
HC-06Q-04/A1	S-Band Transponder Qual Test Procedure
HC-06T-01/A1	Functional Test Procedure for the OMNI Dipole Array Antenna
HC-09A-01/A5	Battery Charger/Simulator Acceptance Test Procedure, P&F
HC-09H-01/NC	S-Band Transmitter Calibration Procedure
HC-09H-02/A1	S-Band Test Transmitter Calibration Procedure
HC-09Q-01/A	Battery Charger Simulator EMI Qualification Test Procedure 16
HC-12A-03/A	SEU Acceptance Test Procedure, A1
HC-12C-01/A7	SEU Functional Test Procedure
HC-12C-02/A2	Transponder Converter Electrical Test Procedure
HC-12H-01/A1	DEU Tester Calibration Procedure
HC-12H-02/A1	Calibration Procedure Resistive Load Bank, Converter
HC-12Q-03/A	SEU Qual Test Procedure, A1
HC-12T-01/A2	SEU Component Select-In-Test Procedure
HC-14A-01/A1	Acceptance Test Procedure, Battery Assembly
HC-14B-01/A1	Activation and Formation Procedure, 10 AH Cell
HC-14C-01/A*	Solar Panel Functional Bench Test
HC-14C-02/C	Functional Bench Test Procedure, Battery Assembly
HC-14F-01/A	Battery Fabrication Test Procedure, A3
HC-14K-01/NC	Solar Array Panel Magnetic Properties Procedure
HC-14K-02/NC	P&F Magnetic Properties Procedure, Solar Array
HC-14Q-01/B1	Battery Qualification Test Procedure
HC-14R-01/NC	
HC-14R-02/A	Cost Acceptance and Selection, A1
HC-16A-01/C1	Magnetic Fields Experiment Acceptance Test Procedure
HC-16A-02/NC	Particles Experiment Subsystem (PES) Acceptance Test Procedure
HC-16Q-01/B1	Magnetic Fields Experiment Qualification Test Procedure
HC-16Q-02/NC	Particles Experiment Subsystem (PES) Qualification Test Procedure
HC-17A-01/A1	Sun Sensor Acceptance Test Procedure
HC-17C-01/B	Sun Sensor Electronics Board Functional TP
HC-17C-02/NC	Sun Sensor Unit Functional Test Procedure
HC-17H-01/A2	Sun Sensor Optical Alignment Procedure
HC-17Q-01/A2	Sun Sensor Qualification Test Procedure
HC-19H-01/NC	SEU Test Set Calibration Procedure

P&F SPACECRAFT LEVEL TEST PROCEDURES
LATEST ISSUE LIST

PROCEDURE NUMBER	TITLE	DATED
HC-21A-01	SUBSATELLITE ACCEPTANCE VIBRATION	3/4/71
	Released Version (N/C)	3/17/71
	Rev. A - B1	4/19/71
	Rev. B - C1; C2; C3; C4; C5	4/21/71
	Rev. C - D1	
HC-21K-01	MAGNETIC CLEANLINESS MEASUREMENTS	2/17/71
	Rev. A - B1; B2; B3	
HC-21M-01	MECHANICAL ASSEMBLY & DISASSEMBLY - A1; A2	12/2/70
HC-21M-02	LAUNCHER/SUBSATELLITE RIGGING - A1	3/11/71
HC-21M-03	HOISTING & HANDLING	5/24/71
HC-21M-04	STORAGE PROCEDURE	6/8/71
	Rev. A	
HC-21Q-01	SUBSATELLITE QUALIFICATION VIBRATION	3/1/71
	Released Version	3/17/71
	Rev. A	4/19/71
	Rev. B - C1; C2	5/16/71
HC-21S-01	INTEGRATION & FUNCTIONAL TEST	12/12/70
	Rev. A	2/24/71
	Rev. B - C1; C2; C3; C4; C5; C6	
HC-21S-02	BOOM ALIGNMENT	12/4/70
	Released Version (N/C)	3/1/71
HC-21S-03	MASS PROPERTIES MEASUREMENT	12/16/70
	Released Version (N/C)	3/1/71
	Rev. A - B1	3/18/71
HC-21S-04	INTEGRATED SYSTEMS TEST	1/28/71
	Released Version (N/C)	3/22/71
	Rev. A	4/2/71
	Rev. B	4/9/71
	Rev. C	4/30/71
	Rev. D - E1; E2; E3	5/15/71
	Rev. E - F1	
HC-21S-05	SUBSATELLITE LIMITED FUNCTIONAL - A1	4/23/71
	Rev. A - B1; B2; B3; B4; B5; B6	
	Rev. B - C1	6/14/71
HC-21S-06	SOLAR THERMAL VACUUM - A1; A2; A3; A4	3/31/71
	Rev. A - B1; B2; B3	
	Rev. B - C1; C2; C3; C4	
HC-21T-01	LEAKAGE RESISTANCE TEST FOR HARNESS	
HC-21T-02	BATTERY CHARGING & DISCH (IN SIM)	
HC-21T-03	BATTERY CHARGING & DISCH (NOT IN SIM)	

submitted in printed form, and are also in the acceptance data packages. ATC and Time-Zero procedures are listed below:

ATC

a) ATC PES Acceptance Test Procedure, TP 1141-014
b) ATC Subassembly 13 Telescope Electronics Precalibration Measurments Test Procedure, TP 1141-014

TIME-ZERO

a) T-Z Acceptance Test Procedure, Apollo Subsatellite Magnetometer, S 10070019
b) T-Z Calibration Procedure, Apollo Subsatellite Magnetometer, S 10070026

26 Preinstallation Acceptance Test Procedures requirement was satisfied by the work described under Items 22 and 23 above.

27 Scientific Instrumentation Calibration Procedures submittes were required 2 weeks prior to calibration. These are as follows:

a) Foil Calibration Procedure, Parylene N, TP 1141-016
b) Telescope Subassemblies 11 and 12, TP 1141-11 & 12
c) Curved Plate Analyzer Subassemblies 1, 2, 3 & 4
d) Telescope Noise Counting Rate Adjustment, TP 1141-017
e) Particles Subsystem Calibration, TP 1141-013

28 No item 28 was given in the Contract

29 Qualification Test Reports were to be submitted by 5/15/71 and were submitted as part of the acceptance data packages (refer to the acceptance data package summary list).

30 Calibration Data Reports submittals were required at the phase two acceptance reviews. Submittals were as follows:

	Submittal Date
Flight #1 Subsatellite Calibration Data Report, 16763-30-01	5/26/71
Qualification Unit Calibration Data Report, 16763-30-03	6/16/71
Flight #2 Subsatellite Calibration Report, 16763-30-02	7/29/71

31 Experiment Support Requirements submittal was required to be made at the CDR, and actual submittal was at the CDR.

32 Spares Requirements was mutually agreed with MSC as not applicable to the Subsatellite program.

33-39 Submittal of documentation items 33 through 39 was required to be 5/4/70. However contract go-ahead was not obtained until 5/15/70, therefore submittals were made at that time, as listed below:

	DOCUMENT (Latest Revision)	REQUIRED SUBMITTAL DATE	ACTUAL DATE
33	Quality Assurance Plan (Rev. B)	5/4/70	5/15/70
34	Reliability Plan (Rev. C)	5/4/70	5/15/70
35	Configuration Management Plan (NC)	5/4/70	5/15/70
36	System Safety Plan (NC)	5/4/70	5/15/70
37	EMC Control Plan (NC)	5/4/70	5/15/70
38	Magnetic Cleanliness Plan (NC)	5/4/70	5/15/70
39	Development Schedule (NC)	5/4/70	5/15/70
40	Measurement List (Rev. B, SCN-1)	7/14 (CDR)	7/14/70
41	Command List	7/14 (CDR)	5/15/70
42	Subsatellite/MSFN P&I Specification (REV. A SCH-2)	7/14 (CDR)	7/14/70

43 Operational Data Book requirement is considered to have been sat isfied by the considerable support provided to NASA MSC, particularly to Flight Operations Directorate (FOD), in the form of supply of input material, review and correction of material, meetings, and telephone discussions by both the TRW Redondo Beach personnel and by the TRW resident representative at MSC, during preparation of the MSC documents P&F Subsatellite Systems Handbook, Console Handbook, and others.

44 Parts and Materials List submittal was required on 6/30/70, and was made on that date. The latest issue is Revision C.

No #. Others important whose submittal was not initially required but was added later included the subsystem equipment specifications as listed below (latest issue is show):

Subsystem Level Equipment Specifications

EQ3-290 NC	Battery Assembly, P&F
EQ4-892 D	Particles Experiment Subsystem, P&F
EQ4-893 D	Fields Experiment Subsystem, P&F
EQ4-918 NC	Command Decoder, P&F
EQ4-919 NC	Digital Electronics Unit (DEU), P&F
EQ4-945 B	Diplexer, P&F
EQ4-955 NC	Data Storage Unit (DSU), P&F
EQ4-957NC/SCN-1	Sun Sensor Unit, P&F
EQ4-959 NC	Spacecraft Electronics Unit (SEU), P&F
EQ4-960 NC	Antenna Assembly, P&F
EQ4-973NC/SCN-2	Transponder Converter, P&F
SS6-33NC	S-Band Transponder, P&F

6. TECHNICAL PROBLEMS ENCOUNTERED

Technical problems which were encountered during the P & F program together with their solutions are detailed and reported to the MSC on Failure Investigation Action Reports (FIAR's). These are tabulated herein on an attached table. The problems considered to be the most serious are listed below and subsequently described in some detail.

Most Serious Technical Problems

PES High Voltage Problem

Spacecraft Thermal Design

Boom Failure

Boom Damper Leakage

Battery Case Redesign

Diode, Replacement

6.1 PES HIGH VOLTAGE PROBLEM

The most serious technical problem in the P & F Subsatellite program involved arc-overs in the Particles Experiment Subsystem (PES) high voltage supply. This problem was first encountered during the thermal/vacumm portion of the PES unit level qualification testing. It occurred on March 1 just after receipt of the PES S/N 1-1 at TRW from the subcontractors ATC, and was detected when the high voltage dropped to approximately one-half of spec value. Subsequent investigation showed this to be a design problem associated with the potting compound. The 70% High Voltage module was a completely potted unit which suffered voids and cracking of the potting compound opening paths for corona/arcing of the high voltage to ground when the unit was exposed to low temperature and hard vacuum. In the temperature excursion from the curing temperature of 200°F to room temperature, a 2% bulk shrinkage of the C60 material occurs. Subsequent shrinkage occurs during the excursions to 35°F during test. This same shrinkage occurred in other ATC high voltage module applications which had been used successfully on other programs but was not as critical because a substantially smaller volume of this material was used.

Because of the severe schedule pressures which by this time existed in the program, a multiple approach to the problem was undertaken involving a number of potential fixes. The eventual solution to the problem was elimination of the potting material and substitution of conformal coating. The solution additionally incorporated mechanical strengthening of the unit through the use of spot bonding of components which became necessary because of the elimination of the full potting. Solution of this problem required large expenditures of money, extreme compression of the overall spacecraft level test program, and a considerable period of time with delivery of the 1st successful PES on May 7. Two large TRW thermal/vacuum chambers were relocated to ATC for 24 hour usage during the period, and involvement of high voltage experts from TRW and other organizations.

6.2 SPACECRAFT THERMAL DESIGN

The initial engineering solar thermal vacuum tests on the qualification subsatellite indicated in-orbit subsatellite temperatures significantly colder than earlier predictions indicated, and also indicated excessive temperature drop during the 3 1/2 hour eclipse. This proved to be a stubborn problem to solve and required considerable time and effort. The solution consisted of many design changes which increased the general temperature level of the subsatellite and reduced the rate of temperature drop by isolation of the spacecraft interior from the exterior surface. The detail design changes were as follows.

1. Transponder stand-offs changed from aluminum to fiberglass.

2. Heat sink and thermal insulator with washer stand-offs added under Fields Experiment Subsystem Electronics package.

3. Removed white paint from platform #5, the boom brackets, analyzer sun shades, and connector backet, and thermally insulated the platform and mounted equipment with a multi-layer kapton insulating blanket.

4. Aluminum foil tape was added to the outside of the entire DSU and its mating platform and the side of the #3 platform facing the DSU, the cable clamps on the magnetometer boom, the exposed surfaces of the particles experiment, the outside of the sun shades and platform #1 between the antenna and base ring.

5. Fiberglass washers added between the solar array inserts and the equipment platform, and under the bolt heads attaching the solar array.

6. Added a multi-layer mylar blanket to platform #1, covering the inside of the base ring and to the outside of the fiberglass booms. Added a single layer of aluminized mylar covering to the inside of the solar panels.

7. Added a multi-layer kapton insulation blanket wrap to the central portion of the NR-interfacing rail bracket; the exposed rail ends were also covered with aluminized mylar tape.

8. The inside of the particle experiment sun shades were painted black. Also added fiberglass stand-off washers between the sun shades and the curved plate analyzer, and between bolt head and the shades. Added electrical ground straps between the shades and the analyzer housing. The straps were required because of thermal isolation.

9. Added balance weight to platform #3, to statically balance the subsatellite for counterbalancing the changed thermal materials.

6.3 BOOM FAILURE

During thermal-vacuum testing of the Flight #1 P & F Spacecraft, a structural failure occurred in the inboard fiberglass reinforced plastic tube of one of the spacecraft balance booms on April 26, 1971. The tube had failed at a point approximately one foot from the attachment bracket at the spacecraft and was hanging downward at approximately 90°. A second balance boom had a distinct bow in approximately the same location. The failure was of a ductile nature. In the investigation the boom temperature during the test was calculated as reaching 210°F. Also, the boom material was found to suffer a sharp reduction in mechanical properties above 160°F sufficient to result in the bending failure while the 1g environment of an Earth-bound test chamber is applied. Such failures would not be anticipated in orbit because of the zero "g" conditions. The thermal configuration of the booms at the time of the failure was aluminum tape covering the fiberglass tube. Corrective action was to change the thermal covering to be an 8-layer, 1/4-mil thick alumnized Mylar spiral wrap covered with a layer of 2-mil aluminized Mylar, Mylar side outwards. During the test after the fix boom temperatures were 29°F at the center of the inner segment and thus the problem was solved.

6.4 BOOM DAMPER LEAKAGE

A leak developed in the boom damper of the qualification subsatellite during an engineering solar thermal vacuum test. The oil was seen in the upper platform inside the boom brackets. This failure was written up in FIAR #TRW-PFS-0072 of April 8. The problem was localized to the low coefficients of friction teflon seal covers of the secondary piston allowing fluid to leak past the O-ring and out of the assembly at low temperature. These seals are located over the O-rings. The cause of the damper leakage is attributed to relative separation between the piston shaft and the teflon seal covers which was intensified at reduced temperatures (see Figure 1a). This is explained by noting that the piston shaft contracts at reduced temperatures whereas the teflon O-Ring assembly remains relatively unchanged leaving a small gap. The corrective action was to remove the teflon seals from the secondary piston, replace the existing cap with a new part which will accommodate a static seal against the cylinder and redundant O-Ring against the main piston shaft. The cylinder was refaced to provide for the static seal. Lock-wire holes were plugged with epoxy. Lock-wiring of the fill-screws and nut were removed and epoxy fillets were added to prevent loosening during vibration. These changes were made to all P & F units.

6.5 BATTERY CASE REDESIGN

Corrosion was found on the Flight #1 Battery Assembly after it had successfully completed the functional portion of its unit level acceptance tests and prior to integration into the Flight #1 sub-satellite (Failure Investigation Action Report (FIAR) #TRW-PFS-0063). The corrosion was due to a small amount of electrolyte leakage. When the case was opened it was found that cell #8 had ruptured and had a "y" shaped crack completely across the header. Also cells 7 and 9 may have had hairline cracks. The cracks were found by milling the header and using a tracer. The case was not hermetically sealed but had a screwed on cover and was completely filled with an encapsulant. The leakage was found under the cover. Corrective action was the addition of a fiberglass header onto the cell pack prior to encapsulation, and also change of the encapsulant from PR4-2-2 to the less brittle RTV 8113 (PR4-1-1).

6.6 DIODE REPLACEMENT

A diode failure occurred during the thermal/vacuum portion of acceptance testing of DSU S/N 001 on November 18, 1970. At +100°F error segments of 8 words read "0"'s instead of "1"'s every 64 words indicating the output data was not the same as the data which had been entered. Investigation indicated that two diodes, CR21 and CR58, both of the same type (PT4-2311), failed open. This was attributed to mechanical overstressing of the parts by the hi-temp shrink sleeves due to incorrect application of heat during the manufacturing process. As a result, the procedure was changed to require a closed-loop heat gun, and the use of a different type of sleeving. The analysis was not completely conclusive such that there remained the possibility that the cause might be the part itself, therefore the type of diode, and the dio e manufacturer were also changed as a precautionary measure. All PT4-2311's were replaced by FHA 600's (screened by TRW) in all flight units, and in the qualification unit DSU. This change was particularly significant because of the number of these diodes used throughout the P & F System.

TABLE 4. TECHNICAL PROBLEMS ENCOUNTERED

FIAR NO.	DATE OF FAILURE	UNIT SERIAL NO.	DESCRIPTION OF FAILURE
0001	10/29/70	Rcvr 001	Coherent Drive Level Low
0002	10/30/70	Xmtr 001	Low Voltage at A2Q3
0003	11/03/70	Rcvr 001	Intermodulation Not 15db Below
0004	11/12/70	DSU 001	Error Lite-Vib
0005	11/18/70	DSU 001	Readout Incorrect, PT4-2311 Open
0006	11/21/70	DEU 001	Data Not Shifting, C1276 Short
0007	11/24/70	DSU 001	Error Lite During X-Vib
0008	11/24/70	DEU 001	Incorrect Readout, C1276's Shorted
0009	11/25/71	Xpndr 001	+28V Current Went to Zero
0010	11/27/70	DSU 001	Improper Vib Inputs
0011	11/28/70	DSU 001	Memory Address Stopped
0012	11/30/70	Rcvr 001	Threshold Center Frequency High
0013	12/7/70	DEU 001	Vibration 30° Off Required Axis
0014	1/7/71	Batt Assy 001	Protection Circuit Did Not Work
0015	1/10/71	Batt Assy 001	Protection Circuit Did Not Work
0016	12/30/70	Xpndr 002	Intermodulation Too High
0017	1/4/71	SEU 002	Incorrect Output
0018	1/23/71	Batt Assy 001	Reverse Current Thru Shunt
0019	1/27/71	Batt Assy 001	Regulator Switching Erratic
0020	2/2/71	Sun Sensor 001	Sensitivity Out of Tolerance
0021	2/2/71	Sun Sensor 003	Sensitivity Out of Tolerance
0022	2/2/71	Sun Sensor 004	Sensitivity Out of Tolerance
0023	1/29/71	DEU 003	Improper Output
0024	2/11/71	Batt Assy 004	Protection Circuit Inoperative
0025	1/27/71	Antenna 002	Power to Acquire is High
0026	2/22/71	FES 002	Incorrect Response
0027	2/27/71	PES 001	Potential Mechanical Overstress
0028	2/27/71	PES 001	C1-A1 Frequency Shift
0029	3/2/71	PES 001	High Voltage Dropped
0030	2/2/71	Xpndr 003	Reference TDR 58471
0031	2/18/71	DEU 003	X-Axis Intermittent Output Error
0031	2/23/71	DEU 003	X-Axis Intermittent Output
0032	3/3/71	Xmtr 003	Low Power Board Output Intermittent
0033	3/5/71	SEU 003	Low Voltage Of 0.98 mV; Should Be 1.00 mV Min.
0034	3/8/71	FES 003	Noise on Output Lines (Time Zero)
0035	1/7/71	Antenna 002	Pattern Repeatability Out-Of-Spec
0036	12/4/70	Antenna 002	Axial Ratio High
0037	12/11/70	PES 1-1	Anal #1 - Lack of Electron Counting
0038	1/17/71	PES 1-3	Anal #3 - Test Input Wire Reversed
0039	1/20/71	PES 1-1	Anal #3 - No Output From 404 Discriminator
0040	1/20/71	PES 1-1	Anal #4 - No Output From 406 Discriminator

TABLE 1. TECHNICAL PROBLEMS ENCOUNTERED (Continued)

FIAR NO.	DATE OF FAILURE	UNIT SERIAL NO.	DESCRIPTION OF FAILURE
0041	1/23/71	PES 1-1	Anal #3 - Peak Energy Shifts Lower
0042	1/25/71	PES 1-1	Experiment Model 112 Has No Output
0043	1/25/71	PES 1-1	Anal #3 - No Output from Model 405
0044	2/1/71	PES 1-1	Anal #4 - High Voltage Output Incorrect
0045	2/3/71	PES 2-2	Telescope #11 - Shield/Vac. Chamber Resistance Too High
0046	2/4/71	PES 2-3	Anal #1 - Count Rate Problem Due to Test Equipment
0047	2/23/71	PES 1-1	Experiment Test Interruptions Due to Bad Data
0048	2/23/71	PES 2-2	Experiment PCU Failed
0049	2/25/71	PES 2-2	Experiment DS 2 Shorted
0050	3/12/71	Antenna 001	Axial Ratio High
0051	3/15/71	PES 001	Experiment 3.75 kv Output Shorted to Ground
0052	3/22/71	FES 002	Sensor Assembly Out of Spec
0053	3/22/71	FES 003	Sensor Assembly Out of Spec
0054	3/24/71	PES 001	At - 35°F and 2.5×10^{-8} Pressure High Voltage Erratic
0055	3/27/71	PES 001	At - 78°F and 5×10^{-8} Pressure High Voltage Erratic
0056	2/25/71	PES 1-1	Mechanical and Electrical Out of Spec Condition
0057	3/21/71	PES 1-1	No Analog #1 Logic Output
0058	2/18/71	PES 2-2	Analog #3 - +4.6 Volt Line Shorted
0059	3/9/71	PES 2-2	PES - Corona Discharge at Vacuum
0060	3/21/71	PES 2-2	PES - High Volt Incorrect
0061	3/28/71	PES 2-2	PES - Channel A Oscillates at PCU Rate
0062	3/28/71	PES 2-2	PES - Fund. s/b $<$49mV for DSU +5V is 54 mV
0063	3/31/71	Batt Assy 002	KOH Seeping From Battery Case
0064	4/3/71	PES 2-2	H.V. Does Not Turn-On and +37V Line Shorted
0065	4/5/71	PES 2-2	H.V. Erratic
0066	4/2/71	Xmtr 003	
0067	3/19/71	Batt Assy 002	Cell #8 Voltage Low at Pre Vibration Test
0068	4/2/71	FES 001	Noise Level Above Spec Requirements
0069	11/24/70	DSU 001	
0070	4/2/71	SS 001/Batt 001	Smoke Was Observed From Battery Assembly (R42 & 33)
0071	4/1/71	SS 001/Batt 001	Battery Assembly 10 & 12 Blown
0072	4/8/71	SS 001/Damp.Assy 4,5&6	Damper Assemblies Leaking Oil
0073	3/3/71	SS 001	Battery Assembly & DEU BOnd Resistance Over 50Ω
0074	4/10/71	PES 2-2	P-P Ripple Spikes & Power Supply Low Volt
0075	4/10/71	PES 2-2	Unable to Obtain A1 (300V) & (1000) Volts
0076	4/10/71	PES 2-2	HV Arcing at -35°F/Vacuum
0077	4/13/71	PES 2-2	HV Oscillation at -36°F in Vacuum
0078	4/18/71	Batt Assy 005	Board A8, Connect J1, Pins 34 & 35 Reversed
0079	4/20/71	SS 002	Battery Overheated Due to Facility Air Cond. Problem
0080	4/21/71	PES 2-3	A3 (Module 403) Has No Output

TABLE 1. TECHNICAL PROBLEMS ENCOUNTERED (Continued)

FIAR NO.	DATE OF FAILURE	UNIT SERIAL NO.	DESCRIPTION OF FAILURE
0081	4/26/71	SS 002/Boom Assy	Boom Assembly Arm Bent
0082	4/27/71	PES 2-3	Telescope B Assembly 12 Threshold Too High
0083	4/28/71	SS 002/GSE	Word 30 Error due to GSE Frequency Drift
0084	5/1/71	PES 2-3	Chassis Gnd. 8 mΩ S/B >100mΩ; Anal #1 Damaged
0085	5/4/71	PES 2-3	No CA-HY Due to Mod 706 Shiled Shorting
0086	4/21/71	PES 2-3	Analog #3 Mod 403 Noisy or No Output Due to Corona
0087	5/5/71	PES 2-3	Gross Power Consumption Due to Damaged Resistors
0088	5/4/71	PES 2-3	Analyzer Plate Voltage Out of Spec
0089	5/9/71	PES 2-2	All Power Went to "0" While Approaching Qual. Vib
0091(a)	5/8/71	SS 002/DEU 002	DEU Count Error S (A+B) 5
0092	5/15/71	SS 001/FES 003	Faulty Calibration Reading Due to Cold Solder Joint
0093	5/8/71	PES 2-2	Out of Spec Voltages/Spec to be Rev.
0094	5/21/71	SS 002/Batt Assy 005	Fuses F9 & F12 Blown Due to Mishandling
0095	5/20/71	SS 001/Boom Assy 004&005	Lateral Boom Offset Out of Spec (reqmt too tight)
0096	5/21/71	SS 001/Batt Assy 001	Fuse F12 Blown Due to Mishandling
0097	6/13/71	PES 2-4	E_A & E_B Out of Spec Due to Operator Error
98	5/16/71	SS 001/FES 003	Incorrect Bonding of Washer to S/C
0099	6/12/71	Antenna 001	Incorrect Test Signal From GSE
0100	6/16/71	PES 2-4	G1 & G2 Grounds Shorted Due to Pinched Wire
0101	6/16/71	PES 2-4	"A" Telescope Exhibits Excess & Erratic Noise
0102	6/22/71	PES 2-4	A1 & A2 HV Erratic Due to Manufacturing Mishandling
0103	6/24/71	PES 2-4	Calibration Mode Inoperative Due to Bad IC
0104	6/30/71	PES 2-4	HV Too Low at -25°F Due to Poor Diode Mounting
0105	7/7/71	SS 003/PES	PES 5V Line too Low Due to GSE Line Losses
0106	7/8/71	SS 003/Batt Assy 003	Fuses F2 & F8 Blown Due to Handling Accident
0107	7/19/71	SS 003/DEU 002	No Low Telescope Counts
0108	7/20/71	SS 003/PES 2-4	High Telescope Counts - Temperature Sensor
0109	8/24/71	SS 003/DEU 002	No DEU Counts Between 16-31 (ECP #032)

7. SPACECRAFT TEST HISTORY

7.1 Qualification Unit Test History

On completion of fabrication the main structural elements of the subsatellite (substrates, platforms, booms, etc.) were assembled toegther for verification of the mechanical interfaces. The subsatellite was delivered to the integration and test laboratory in this assembled state on November 25, 1970. Here it was disassembled on December 2, kits prepared for a later and more complete assembly, and the substrates sent to the solar panel fabrication shop for the mounting and wiring of the solar cells.

Prior to commencing the integration of the Qualification subsatellite, the top platform (#5) was sent to the engineering test shop for proof loading of the lifting fixture mounting inserts that are bonded into this platform.

With the return of the top platform, the build-up and integration of the subsatellite was started on December 8. The main electrical harness was installed after the antenna, transponder subsystem, command decoder, Subsatellite Electronics Unit (SEU), and Digital Electronics Unit (DEU) had been mounted. The absence of the Digital Storage Unit (DSU), the particles and fields experiments, and a power subsystem severely limited the integration and test activities. However, the installation of the "breadboard" particles experiment power supply did permit integration and test of the transponder and partial data system.

This testing was completed on December 16 to the point that the subsatellite was capable of being used for a compatability test with the MSFN system. It was transported to MSC Houston, on December 17 for the first part of this compatibility test and to KSC on January 4 for the final part of the test, returning on January 9. The spacecraft used for these tests was a partially completed unit but was quite satisfactory for these tests. The unit employed an engineering model PES and did not contain the DSU, Battery Assembly, or FES. These tests included uplink command channel SNR; sub BER and MRR, and downlink SNR and BER. Primary concern was general communications compatability with the MSFN ground station network, and the ability to communicate with the P&F Subsatellite while in lunar orbit from stations using 30-foot antennas. The testing at MSC indicated operation with 30-foot antennas would be marginal. However actual operation of the Flight #1 P&F in lunar orbit confirmed satisfactory operation with even the uncooled paramp 30-foot sites.

~~(1-9-71)~~ When the subsatellite was returned to the integration and test laboratory at TRW the DSU was available for integration, this was done on January 12 and a functional test of the data system performed, including a compatibility check with the TRW ground support equipment (GSE) i.e. the PCM decommutation equipment.

~~(1-14-71)~~ The fields experiment was the next unit available for installation and integration on January 13, and this was followed four days later by the battery assembly i.e. battery, charge control electronics, and shunt assembly, which were also integrated.

~~(1-26-71)~~ Prior to performing further functional tests, the subsatellite was returned to the wiring bench for the installation of the separation harness and micro-switch assembly. When the installation was completed the earlier portions of the functional tests were repeated, the battery was serviced, and "dry runs" were performed on the telemetry calibration procedure.

~~(2-9-71)~~ On completion of these tests the fields experiment (S/N 1) was removed on February 9 from the subsatellite and returned to the vendor for retest and calibration checkout at UCLA. At the same time the sun sensor (S/N 003) was received and subsequently installed in the subsatellite.

~~2-71)~~ In the course of the earlier functional tests and on further battery checkout, it was found the overvoltage protection circuits were inoperative. The battery was removed from the subsatellite and returned to the unit engineer for further investigation. This investigation showed that several transistors in the inoperative circuit were "blown" (see TDR 60579). As this was the "engineering model" battery it was not returned to the subsatellite but was at a later date replaced by the actual qualification battery (S/N 001).

The "breadboard" particles experiment power supply was also removed from the subsatellite at this time and the remainder of the subsatellite, along with the boom assemblies, installed in a thermal-vacuum chamber and exposed to a "bake" test* for 60 hours at 140°F±5 in a vacuum of $5X10^{-5}$ torr to out-gas unapproved materials on February 12. The solar array panels for this subsatellite were also exposed to the same "bake" test, but in a separate chamber.

After the "bake" test the subsatellite was further disassembled to allow rework of the platforms. This rework consisted of filling the platform edges with an epoxy filler and drilling vent holes into it when it had hardened. Inserts for mounting balance weights were also bonded into several of the plaforms at this time. The subsatellite was then reassembled and final installation of the available "black boxes" made, including bonding resistance measurement and torque value verification.

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During March the qualification battery (S/N 001) and the fields experiment (S/N 001) were installed in the Qualification Unit subsatellite as they become available, and with the aid of the "breadboard" particles experiment power supply final integration and functional testing of the incomplete assembly was started.

While awaiting delivery of the particles experiment the corrosion damaged antenna (known since unit test, but integrated pending further disposition) was removed from the subsatellite and replaced with the antenna (S/N 003) from the F-2 subsatellite. The S/N 001 antenna was returned to the unit engineer for refurbishment. Also, during this period the subsatellite was installed in the solar thermal-vacuum chamber and used in the checkout and "dry run" of the test set-up.

When a Particles Experiment (S/N 001) was finally received it had an inoperative high voltage system and only a portion of the particles analyzer functioned. Therefore the integration of this experiment was somewhat limited, but it did permit completion of the subsatellite assembly and integration on April 2. At this time the fields experiment was also changed, with experiment S/N 001 being replaced by experiment S/N 003. In parallel with this integration activity the thermal instrumentation was installed.

On completion of an integrated system test the Qualification subsatellite was installed in the 30 foot solar-thermal-vacuum chamber and the thermal proof phase of the qualification solar-thermal-vacuum test started. This test was aborted on the third day when the temperature data indicated unsatisfactory thermal conditions within the subsatellite.

When the subsatellite was removed from the thermal-vacuum chamber the post test inspection showed small pools of oil on the top surface of the subsatellite. Further inspection indicated that the oil had apparently come from the boom damper assemblies. These assemblies were subsequently removed from the subsatellite and sent to an engineering test laboratory for further investigation. The investigation confirmed the damper leakage and recommended a modification to the damper assembly. This modification was made, the damper assemblies retested, and on verification of the leak test results the assemblies returned to the subsatellite.

In parallel with this work the qualification battery was removed from the subsatellite and reworked to incorporate modifications that provided the capability to monitor, via "hardline", the battery temperature and the shunt curves. Also, the experiment was removed from the subsatellite and returned to the respective vendor for rework; the fields experiment for a tuning modification and the particles experiment for incorporation of a working high voltage power supply.

The qualification subsatellite remained inactive for a period while further thermal proof tests were performed on the Flight 1 subsatellite. As a result of these tests, major thermal modifications were made to the qualification subsatellite to correct its thermal design. At the same time the reworked battery and particles experiment were reinstalled in the subsatellite. However the rework on the particles experiment had been unsuccessful and the high voltage power supply was still inoperative. Also, as the fields experiment was at

this time still undergoing retest, a "dummy" experiment, representative as a thermal model, was installed in its place in the subsatellite.

During May the reassembly of the qualification unit subsatellite was followed by the installation of thermal instrumentation, the performance of a limited functional test, and finally installation into the 30 foot chamber for a repeat test of the thermal proof phase of the qualification thermal-vacuum test.

The thermal proof test was discontinued after the performance of only eight orbits and an extended eclipse where the data showed that the thermal design modifications had been successful in correcting the earlier thermal problems. The subsatellite was then removed from the chamber and the particles experiment and "dummy" fields experiment removed from the subsatellite.

When the reworked and retested fields experiment (electronics S/N 003 and sensor S/N 005)were received back from the vendor they were reinstalled in the subsatellite and the assembly closed-up, "bagged", and mounted horizontally in the NAR fit check tool for the performance of a special battery service test. The test was to establish the likely temperature margin available in the SIM Bay when the battery is being charged and discharged in that location. The results of this test indicated that provisions should be made to ensure a flow of cool dry air in the SIM Bay to keep the subsatellite cool during battery servicing.

The formal qualification test program began when a particles experiment (S/N2-2) with a working high voltage power supply was finally received. When this experiment was installed and integrated, the fields experiment was also fully integrated, functional testing completed, power profile measurements and telemetry calibrations repeated, and the subsatellite closed-out. During the close-out the vibration instrumentation was installed and final minor thermal modifications made to "trim" the thermal design for the required orbital temperatures. However, prior to the close-out it was found that the magnetometer Bp axis inflight-calibrate circuit was not functioning and the electronic unit had to be returned to the vendor for repair. This was accomplished the same day, as the problem was found to be the fault of a cold solder joint.

On completion of this work an integrated systems test was performed on the subsatellite, then the subsatellite was moved to the engineering test bay for a pre-vibration measurement of the balance boom position. This was followed by a 3-axis acceptance level vibration test, during which the Z-axis had to be performed twice to resolve instrumentation problems with the micro-switch monitors.

After the completion of the acceptance vibration test a limited functional test was performed. When the data from this test was verified as good the subsatellite was exposed to a further 3-axis vibration, this time to qualification levels. This test was also followed by a limited functional test, and then the positions of the balance booms again measured to verify that they maintained their position within the allowable tolerance, in spite of exposure to prolonged vibration levels.

During the post-vibration measurement of the deployed balance boom positions it was found that the vibration test had caused damage to the boom retaining bracket. But as the bracket was not damaged to the point of causing a premature boom release it was not considered a failure. However, further investigation was continued in the problem, including a special vibration test with the mass model subsatellite.

While the investigation continued on the mass model subsatellite, the qualification subsatellite was thermally instrumented and installed in the 30 foot chamber for the start of the qualification solar-thermal-vacuum test. This test ran, at vacuum, for over 200 hours and was very successful, with no problems being experienced and the particles experiment high voltage power supply remaining stable throughout the test.

The qualification test program was completed with the performance of the final integrated systems test. This test was also successful and a review of the data showed the subsatellite to have met the requirements of the qualification test program.

Key events in integration and test of the qualification unit P&F Subsatellite were:

Date	Event
25 Nov. '70	Received Quad spacecraft structure from manufacturing
2 Dec.	Disassembled structure per HC-21M-01 NC
4-13 Dec.	Partial assembly and integration in preparation for MSFN Testing.
13-16 Dec.	Performed engineering run on procedure HC-215-01
17 Dec.	Shipped partially assemble Qualification spacecraft to MSC, Houston for MSFN Compatibility Test. The S/C contained an engineering model PES, and did not contain the DSU, FES, or Battery Assembly

Date	Event
18-31 Dec.	Engineering MSFN Compatibility Tests at MSC
4 Jan	Shipped S/C to KSC
5-6 Jan	Performed Engineering test of TCP-KL-6007-LMID
6 Jan	S/C returned to TRW
12 Jan	Installed PS4 SN001
12-15 Jan	Performed Engineering run of HC-21S-01
18 Jan	Installed Battery Assembly SN 004
2-11 Feb	Performed engineering run of HC-21S-01
12-15 Feb	60 hour thermal/vacuum "bake-out" of S/C for outgassing
2 Mar.	Install Battery S/N 001
4 Mar.	Install Engineering Model PES
4 Mar.	Install FES S/N 001
9 Mar.	Start Test Procedure HC-21S-01A
22 Mar.	Replace Antenna S/N 001 by S/N 003
24 Mar.	Install Wobble Damper S/N 004
25, 26 Mar.	Perform Engineering Compatibility Check Out of Thermal Vac (Mfg - non Funct.)
26 Mar.	Remove FES S/N 001 for RTV Mods
30 Mar.	Remove Engineering Model PES
31 Mar.	Install FES S/N 003
1 April	Installed PES S/N 1-1 (non-flight, HV-inop)
1,2 April	Performed remainder of HC-21S-01A
3,4 April	Performed Eng. Run of HC-21S-04 (Mfg. Test)
4-8 April	Performed Qual T/V HC-21S-06-Thermo Phase (Eng. Test)
8,9 April	Performed Solar Array Evaluation with S/S in T/V (non-op)
29 April	Installed modified booms

Date	Event
5,6 May	Perform engrg run on HC-21S-05A (Mfg. Test) with Non-Flt, HV-Inop PES SN1-1.
6-8 May	Perform Thermo Phase HC-21S-06 (Eng. Test).
10 May	Remove PES S/N 1-1.
13, 14 May	Perform Eng. Run on HC-21T-03 (Mfg. Test) without PES.
15 May	Installed operative PES S/N 2-2 and started formal test program on Qualification Unit S/C.
15-17 May	Performed HC-21S-01B.
17-18 May	Performed HC-21S-04D.
18 May	Performed HC-21S-02NC.
18 May	Performed HC-21M-02NC.
19 May	Performed 3 Axis Accpt. Vib. HC-21A-01B.
19 May	Performed HC-21S-05A.
19, 20 May	Performed HC-21Q-01NC.
20 May	Performed HC-21S-05A.
20 May	Performed HC-21S-02NC.
21-30 May	Performed Solar T/V HC-21S-06B1.
31 May	Performed HC-21S-04D.
31 May	The Qualification Program is Completed.

7.2 FLIGHT #1 TEST HISTORY

The Flight #1 spacecraft structure was received from manufacturing November 25, 1970. The structure was disassembled per HC-21M-01 on December 2, and then EO "A5" was incorporated into the -2 platform to facilitate the new battery configuration

Assembly and integration of this subsatellite commenced on 11 January as predicted in last month's report. All available units were integrated, which included the "breadboard" particles experiment power supply, an engineering model sun sensor, and the engineering model battery, but excluded the particles and fields experiments. This build-up permitted the performance of preliminary functional tests, which were completed on 3 February. Following this, the subsatellite was disassembled to accomplish rework of the equipment platforms. This rework consisted of filling the platform edges with epoxy to provide solid faces, and drilling vent holes in these faces to permit venting of the honeycomb structure.

During February the separation harness and microswitch assembly was installed and a "fit check" made with the solar array assembly. Further modifications were made to the main electrical harness to monitor the battery temperature and shunt buss current.

Mechanical work performed on the subsatellite consisted of "shaving" protruding platform inserts and installing other inserts in the upper and lower platforms to accommodate the attachment of balance weights.

This subsatellite was also "baked" for over 60 hours starting February 13 to help reduce possible contamination from outgassing materials.

After the "bake" test the Flight #1 subsatellite was re-assembled and used for engineering tests on various power system anomalies (oscillation and instability) seen on the Qualification subsatellite during its test program. No problem was found on the Flight #1 system and subsequently the problems on the Qualification system were traced to test condition constraints. During this period of time, "blown" transistors were found in the engineering model battery circuit boards: this problem was also found on the Qualification battery and was eventually traced to battery bench test grounding problems

Integration continued after this test on Flight #1 when the sun sensor and fields experiment became available for installation. This continued integration was likewise performed with "breadboard" particles experiment power supply installed in the subsatellite.

During April power profile measurements, power system calibrations, and magnetometer system checks were performed and battery charging operations verified using the Flight #1 subsatellite with the breadboard PES installed.

While awaiting delivery of the particles experiment and the Flight #1 battery the thermal modification resulting from the thermal proof test on the qualification subsatellite were installed.

When the particles experiment (S/N 2-2) was delivered the high voltage power supply was inoperative, however, this did not prevent it from being integrated in accordance with the procedure. The Flight #1 battery (S/N 005) was also integrated at this time and was found to have the shunt current monitor and battery temperature monitor wired incorrectly. This was reworked by reversing the respective pin connections. The incomplete sections of the integration procedure were completed at this time and telemetry calibrations and system functional testing begun. Also, the power profile measurements were rechecked.

The formal acceptance test program now started with a DCAS inspection of the subsatellite prior to its closeout with the installation of the solar panels. This was followed with the first integrated systems test, which, because of a failure with the laboratory airconditioning, had to be interrupted to allow the subsatellite battery to cool after it had reached its allowable temperature limit. The ambient temperature at this point had reached approximately 85°F.

On completion of the integrated systems test the subsatellite was mated to the Flight #1 launcher assembly, fit checked with the NAR tool, and mounted on the vibration table. The subsatellite completed its three axes acceptance level vibration with no problems evident, other than fixture mating difficulties.

Following a post-vibration limited functional test the subsatellite was demated from its launchers, further thermal taping modifications made, and the thermal test instrumentation installed.

Instead of performing only the acceptance phase of the solar-thermal-vacuum test on the Flight #1 subsatellite, it was agreed between TRW and MSC, to expose it first to the thermal proof phase to determine the effectiveness of the new thermal system modifications. Four orbits in each of the -Cos, + Cos, and Normal Inclination configurations were planned, but as the test progressed it became necessary to increase the number of orbits to eight for each configuration, to allow the subsatellite to thermally stabilize. However, during the fourth orbit of the Normal Inclination phase (twentieth orbit in the test) it was observed that the magnetometer boom was bent.

At this point it was decided to terminate the Normal Inclination orbits and to abort the test on completion of the extended eclipse. This was done and after chamber pump-up the failed boom was examined, then removed from the subsatellite, and subsequently found to have melted at the point of failure.

As a result of this failure, and further errors in the predicted versus test temperatures, resulting from the test, further thermal modifications were made to the subsatellite. The thermal instrumentation was increased on the replaced magnetometer boom and all booms jacketed with a mylar blanket. The subsatellite was again installed in the 30 foot thermal-vacuum chamber and again exposed to thermal proof phase tests. After seven orbits had been completed in the +Cos inclination configuration and two orbits had been completed in the Normal inclination configuration, it was decided that the thermal design was now correct for those configurations and that the extended eclipse could begin.

On completion of the extended eclipse the test was terminated and after the post-test checks were completed the S/N 2-2 particles experiment was removed from the subsatellite and returned to the subcontractor (ATC).

While awaiting delivery of a new particles experiment (with an operative high voltage power supply) a special battery check was made to verify battery charge procedure HC-21T-02. Also during this time further small thermal modifications were made to "trim" the system to the most current predicted temperature requirements.

During the integration of the new particles experiment (S/N 2-3) it was observed that the current being drawn from the particles experiment on +7.8V line was approximately 40% greater than that recorded during the initial integration. Subsequent investigations traced the problem to a failed accumulator circuit in the digital electronic unit (DEU S/N 002). The defective unit was removed from the subsatellite and replaced by the Flight 2 unit (S/N 003).

On completion of the integration of the particles experiment and the DEU, the power profile measurements, telemetry, calibration, and data system functional checks were repeated. Following this the subsatellite was prepared for another integrated systems test. However, this test was aborted when it was found that the flight battery (S/N 005) had an operational buss of approximately 11.6V (compared with approximately 13.2V on the Qualification battery) and could not tolerate operating in an almost fully charged state in the integrated systems test configuration without tripping the under-voltage circuit (11.0V). Further tests were performed on the battery/power subsystem, and after much discussion concerning the battery operating points, it was agreed that the test could be best performed with the battery in a partially discharged state. This was done, and the integrated systems test completed successfully; although some difficulty was experienced with the flux tank test set-up;

and once again the test was also interrupted to allow the battery to cool after it had reached its temperature limit.

After a lengthy data review the subsatellite and launcher were mated, aligned with the NAR tool, and installed on the vibration table. However, after only one vibration run, in the x-axis, direction was received to discontinue the test and to remove the particles experiment from the subsatellite for rework, to replace a zener diode. This was done, but before rework commenced on the experiment, direction was again received, this time to continue with the test and not to rework the experiment. Therefore the experiment was reinstalled in the subsatellite, functionally checked; and the subsatellite reinstalled on the vibration table. After a repeat of the post-x-axis functional test the acceptance vibration test continued for the Z and Y axes.

On completion of the vibration and limited functional tests the subsatellite was demated from the launcher and prepared for the acceptance thermal vacuum test. During these preparations a special battery capacity check was performed. Using the fully powered subsatellite as the load, the systems was left operating at a nominal current of approximately 2 amperes until the under-voltage circuit tripped. The elapsed time was recorded and totaled 6 hours and 10 minutes.

The acceptance solar-thermal-vacuum test, the first with an operating high voltage system in the subsatellite, was very successful. However, one extra high temperature soak was added to the end of the test sequence to verify that a data anomaly observed in the first high temperature soak was not a result of the high temperature environment but was the result of a data system operational sequence constraint. This anomaly was conclusively demonstrated later in a special data system operation test, when it was shown that if a Telemetry Store Fast command is sent to the subsatellite while the data system is in Telemetry Store Normal in the automatic cycle mode, it will knock the sub-com counter out of sequence.

After the acceptance thermal-vacuum test the particles experiment was removed from the subsatellite, reworked and retested for the Zener diode change. It was then reintegrated into the subsatellite, a limited functional test performed and the subsatellite transported to the TRW magnetic test facility at Malibu.

At Malibu, the subsatellite was checked for operational stray fields, 25 gauss magnetized, and 50 gauss demagnetized conditions. The test results from these tests show that the subsatellite meets all of the magnetic specification requirements.

After the magnetics tests the subsatellite was prepared for the final integrated systems test. During these preparations two fuses were replaced in the battery system, these had been found to be "blown" prior to the shipping of the subsatellite to Malibu. After replacing the fuses the battery was charged for several hours and then the final integrated systems test commenced. This test was also completed successfully, and after a careful review of the test data the subsatellite was moved to the alignment test area.

The final subsatellite operations consisting of alignments, mass properties measurements, subsatellite/launcher mating, and final battery servicing were performed and the Flight #1 Acceptance Test Program completed.

The subsatellite was shipped to KSC on Saturday, 29 May 1971.

Key events in integration and test of the Flight #1 Subsatellite were:

Date	Event
25 Nov 70	Received S/C structure from mnfg
2 Dec	Disassembled structure per HC-21M-01
11-19 Jan	Assembly and integration of spacecraft
20-26 Jan	Engineering run of procedure HC-21S-01 (Mfg Test)
13-15 Feb	60 hour Thermal/vacuum "bake-out" of spacecraft for outgassing
25 Feb	Engineering run of HC-21S-01A
10 Mar.	Install Antenna S/N 002
26 Mar.	Start 2nd. Engineering Run of Procedure HC-21S-01A
31 Mar.	Install Sun Sensor S/N 001
12 April	Completed Eng. Run on HC-21S-01A (Mfg. Test)
15 April	Installed Wobble Damper S/N 002
17 April	Installed PES S/N 2-2 with inoperative high voltage
16-19 April	Performed HC-21S-01B
20 April	Performed HC-21S-04B (IST)

Date	Event
21 April	Performed Rigging HC-21M-02 N/C
21,22 April	Performed Acceptance Vibration HC-21A-01B
22 April	Performed Limited Functional HC-21S-05 A1
23 April	Performed De Rigging HC -21M-02 N/C
23-27 April	Performed Solar T/V HC-21S-06 N/C
27-29 April	Reworked Booms
29 April	Incorporated Thermo Mods
29 April	Started Solar T/V re-test for booms
1 May	Completed Extended Eclipse and Effort on HC-21S-06NC.
2 May	Removed Particles Experiment S/N 2-2.
7 May	Installed Particles Experiment S/N 2-3 (1st. fully operative PES)
7,8 May	Performed HC-21S-01B
9-11 May	Performed HC-21S-04C
11 May	Performed Mating Per HC-21M-02
12 May	Started HC-21A-01C1 but aborted test for PES S/N 2-3 removal
13 May	Reinstalled PES S/N 2-3,no rework performed
13 May	Performed HC-21 S-01B
13 May	Restarted and completed HC-21A-01C1
13 May	Performed HC-21S-05A
13 May	Performed Demating Per HC-21M-02
14-19 May	Performed HC-21S-06A (Solar Thermal Vac)
19-20 May	Reworked PES S/N 2-3 with Diode Replacement
21 May	Performed HC-21S-01C1
21 May	Performed HC-21S-05A
21, 22 May	Performed HC-21K-01A at Malibu
23 May	Performed HC-21S-04D
24 May	Performed HC-21S-02NC
24-26 May	Performed HC-21S-03B1
27 May	Performed HC-21T-03NC
28 May	Performed HC-21M-01A2
28 May	Performed HC-21M-02NC
28 May	Government Inspected and Accepted
29 May	Shipped to KSC

3.3 FLIGHT #2 TEST HISTORY

The spacecraft structure was received from manufacturing November 25, 1970. Between December 2 and March 12 limited work was done on the structure and solar panels in preparation for mechanical and electrical assembly. The honeycomb platform edges were epoxy filled and drilled and inserts were installed in the upper and lower platforms to accommodate the attachment of mass balance weights. Also, the lower platform and adapter ring were assembled in preparation for mechanical and electrical assembly.

Approximately June 2 when work was completed on the Flight #1 and Qualification subsatellies integration commenced on the Flight #2 unit. The transponder, command decoder, subsatellite electronics unit, digital storage unit, sun sensor, magnetometer electronics, main electrical harness, and wobble damper were installed and the partial assembly placed in a thermal vacuum chamber for a "bake" test . This "bake" test consisted of exposing the subsatellite units for 60 hours to an environment of 140°F ± 5 in a vacuum of 5×10^{-5} torr, to out-gas unapproved materials. The booms and solar panels were "baked" in a separate and earlier test.

On completion of the "bake" test the digital electronics unit and the "breadboard" particles experiment power supply were installed in the subsatellite and electrical integration started. During the integration of the battery and magnetometer a special tape recording was made of the fields experiment output. This tape recording was delivered to UCLA.

When the particles experiment S/N 2-4 was received on July 3 the integration was completed and system functional tests performed. Following this the solar panels were installed, subsatellite closeout performed, and the integrated system test performed to commence the formal acceptance test program for Flight #2.

On completion of the integrated systems test the subsatellite was mated to its launcher and the complete assembly exposed to a 3-axes acceptance vibration test sequence. The subsatellite was then demated from the launcher, thermal instrumentation and test cables were installed, and the subsatellite installed in the 30foot solar-thermal vacuum chamber.

Following a comprehensive 7 day solar-thermal-vacuum acceptance test the subsatellite was transported to the TRW Magnetic Test Site at Malibu. Here it underwent stray magnetic field measurement and demagnetization. After this it was put through the final integrated systems test and finally aligned, balanced, weighed and moments of inertia and position of center of gravity determined.

During the first integrated systems test it was found that the accumulator channel #4 in the DEU did not show any counts lower than 256; during the solar-thermal-vacuum test and the second integrated systems test it was found that channel #6 in the DEU showed excessive counts from the PES telescope when "calibrate" and "test control" modes were activated; also, during the installation and checkout of the subsatellite in the solar-thermal-vacuum chamber two fuses in the battery/test connector interface were blown. Special tests were performed to verify these

discrepancies and a decision was made to complete final preparation of the subsatellite as a back-up subsatellite for Flight #1 and to remedy these problems after the launch of Apollo 15.

A review of all the acceptance test data verified satisfactory performance of the Flight #2 subsatellite (with the noted discrepancies) and showed it to have successfully completed the acceptance test program.

Key events in integration and test of the Flight #2 Unit P&F Subsatellite during June and July were:

Date	Event
25 Nov. 70	Received S/C structure from mnftrg
2 Dec - 12 Mar.	Limited work in preparation for assembly and incorporation of EO
2-4 June	Installed subassemblies in Flight #2 S/C
4 June	Performed engineering thermo/vac bake-out for outgassing (mfg. test)
8 June	Installed DEU & Eng. Model PES
9 June-1 July	Performed engineering run on HC-21S-01B
3 July	Installed PES S/N 2-4
4 July	Completed HC-21S-01B
4-5 July	Performed HC-21S-04E
6-7 July	Performed HC-21A-01C
7 July	Performed HC-21S-05B
8-16 July	Performed HC-21S-06B
17 July	Performed HC-21K-01A
17-18 July	Performed HC-21S-04E
23 July	Flight #2 S/C put into shipping container thus ending formal acceptance test program

8. KEY MEETING SUMMARIES

The customer review meetings which are perhpas the most important held during the P&F program are listed below and summarized in the following paragraphs. Other particularly important meetings included the monthly customer review meetings which were held at TRW.

Date	Meeting
5/14-15/70	P&F System PDR
7/14-15/70	P&F System CDR
8/4-5/70	PES CDR
3/8-12/71	Qualification Unit Phase One C.A.R.
4/6-7/71	Flight #1 Phase One C.A.R.
5/7/71	PES Flight #1 C.A.R.
5/26-28/71	Flight #1 Phase Two C.A.R.
6/21-24/71	Flight #2 Phase One & Qualification Unit Phase Two C.A.R.
6/29-30/71	PES Flight #2 C.A.R.
7/21-22/71	Flight #2 Phase Two C.A.R.

8.1 P&F System Preliminary Design Review (PDR)

The Preliminary Design Review for the Particles and Fields Subsatellite program was held at TRW on May 14 and 15 of 1970. During this meeting the design approach and the system end item specification were thoroughly reviewed and approved with the exceptions noted in the meeting minutes. The resulting detailed design was to be reviewed at the Critical Design Review (CDR). Detailed review of the GSE was not included in this meeting but was to be performed at the June Monthly Management Meeting. Also the detailed design approach for the scientific instrumentation was not reviewed because of the earlier status of these subcontracts and because these subcontracts were not yet signed. However, the baseline for the design of the scientific instruments was reviewed. Exceptions and action items identified or defined in this design review meeting are formally recorded on Review Item Disposition (R.I.D.) forms or as formal action items, with minor action items simply included as items in the meeting minutes. During the meeting on 15 May, MSC announced that the basic P&F contract had just been signed.

8.2 Particles Experiment Subsystem PDR

The Particles Experiment Subsystem Preliminary Design Review (PDR) was held on June 4 and 5, 1970, at the ATC Facilities in Pasadena. The principal purposes were to review the design approach to the Particles Experiment Subsystem as currently configured, and to provide an opportunity for NASA, University of California, TRW, and ATC to reach agreement on an acceptable set of Specifications to be included in the final PES subcontract. Forty (40) RID's were generated during this PDR.

8.3 Fields Experiment Subsystem PDR

The preliminary design review for the Fields Experiment Subsystem was held at Time-Zero Corporation on 18 June 1970 at the time of this meeting the status of the magnetometer electronics design and breadboard fabrication was such that the design breadboard has been built and operated, and the deliverable breadboard is in fabrication now. Ten RID's were prepared, of which six were approved. The remaining four contained cost and schedule impact items and required further consideration by Time-Zero. A suspense date of 26 June 1970 was set for action on the four RID's.

8.4 P&F System Critical Design Review (CDR)

The Critical Design Review (CDR) for the Particles and Fields Subsatellite Program was held at TRW on July 14 and 15. During this meeting the detailed design of the satellite and its GSE except for the scientific instrumentation were thoroughly reviewed and approved with the exceptions noted in the meeting minutes and approval was given for proceeding with fabrication. The detailed design of the scientific instrumentation would be reviewed at its CDR's in about two weeks. The requirements for the scientific instruments were reviewed in this meeting.

Key documents reviewed in detail by MSC during this meeting included the End Item Specification on the flight hardware, SY1-36B, and the Battery Charger/Simulator EQ3-287B, and considered them approved with the exceptions as noted on RID's and action items. Also reviewed were the Quality Assurance Plan #16763-33B, Reliability Plan #16763-34A, the Configuration Management Plan #16763-35, System Safety Plan #16763-36, Electromagnetic

Compatability Control Plan #16763-37-1, Magnetic Cleanliness Control Plan #16763-38, the Development Schedule, Development Test Plan #16763-19, Certification Plan #16763-18, Parts and Materials List #16763-44, FMEA #16763-14, and the Experiment Support Requirements document #16763-31. The Command List #16763-41, and the Measurement List #16763-40 were also reviewed and were approved.

Props for this CDR included a full-scale, three dimensional mock-up used to illustrate the feasures of the mechanical system including the current spacecraft packaging and boom configuration, the full scale antenna range metal mockup, and sample sections of the solar array configuration. A number of tours were conducted for the visitors with one including operation of the DEU breadboard. The general meeting plan provided for a single central main meeting during the morning of July 14 which was followed by ten parallel team meetings for detailed work. Following this was the formal CDR Board meeting for summation and disposition of action items and RID's.

8.5 Fields Experiment Subsystem CDR

The Critical Disign Review for the Fields Experiment Subsystem (FES) was held at Time-Zero Corporation on 29 July 1970. The program status was that the breadboard is in temperature testing, 90% of all parts are in-house and screening of these parts will begin no later than Monday, 3 August 1970. Nine RID's were prepared during this meeting.

8.6 Particles Experiment Subsystem CDR

The Particles Experiment Subsystem Critical Design Review (CDR) was held on August 4 and 5, 1970, at the ATC facilities in Pasadena. The primary purposes of this meeting were to review the instrument design in detail, and plans for implementation thereof; and to resolve any questions or objections to the instrument design and/or specification in order to establish a baseline for proceeding with fabrication of the Qual Unit. Required actions resulting from the CDR were defined in formal action items and RID's.

8.7 QUALIFICATION UNIT PHASE ONE ACCEPTANCE REVIEW (C.A.R.)

An acceptance review of the Qualification Unit Particles & Fields Subsatellite black boxes and the Ground Support Equipment was conducted March 8 through 12, 1971 at TRW. With the exception of the Particles Experiment Subsystem, Black Box Data Packages for the qualification subsatellite were reviewed and corrections to the Data Packages were defined, and the flight subsatellite design as defined by the engineering documentation was frozen. The spacecraft level test procedures were baselined and approval was given for proceeding with subsatellite spacecraft level qualification testing. The Subsatellite GSE, and Acceptance Test Equipment Data Packages were reviewed and conditionally accepted pending a demonstration that the test equipment performs satisfactorily when coupled to the flight hardware. Approval was given to procede with spacecraft level testing with the GSE and Acceptance Test Equipment.

8.8 FLIGHT #1 PHASE ONE ACCEPTANCE REVIEW

An Acceptance Review of the Flight #1 Particles and Fields Subsatellite black boxes was conducted April 6 and 7 1971 at TRW and approval was given for proceeding with Flight #1 subsatellite spacecraft level testing. The Particles Experiment Subsystem (PES) was not included in this Acceptance Review due to a high voltage problem.

The Flight 1 Spacecraft level Acceptance Test Plan was reviewed with the following approved recommendations:

1) Start acceptance testing with the qualification PES and qualification battery. The Flight #1 battery will be installed prior to the final integrated system test.

2) The qual (refurbished) magnetometer will be tested and flown with the Flight 1 subsatellite. The recommendation is pending further stress analysis.

3) Flight 1 PES testing will proceed minus high voltage, if a high voltage failure occurs during acceptance testing.

8.9 PES FLIGHT #1 ACCEPTANCE REVIEW

An Acceptance Review of the Flight #1 Particles and Fields Subsatellite Particles Experiment System (PES) was conducted on 7 May 1971. The Flight #1 PES has S/N 003 constituting the subassemblies having S/N's 2-3. Exceptions to the above are subassemblies of the A4, A1, and A3 Channeltron Decoupler Module and B Telescopes which have S/N's 1-1. The baseline design was frozen as of this review. Approval was given to integrate the Flight #1 PES into the Flight #1 Spacecraft.

8.10 FLIGHT #1 PHASE TWO ACCEPTANCE REVIEW

A final acceptance review of the Flight #1 Particles and Fields Subsatellite was conducted May 26-28, 1971.

The formal review board accepted the serial number 002 Particles and Fields Subsatellite conditionally upon performance of action assigned by the board and upon successful completion of design certification. Two items appeared on the shortage report, unapproved waiver requests HC-W18 and W19. The form DD250 was signed. TRW was directed to ship the unit to the Cape on May 29, 1971.

The Flight #1 Particles Experiment Subsystem (PES) (S/N 2-2) contains two analyzers (A1 & A4), the 433 module of the A3 analyzer and two silicone surface barrier detectors which were exposed to qualification level testing in the Prototype (S/N 1-1) instrument. The affects of this testing on these parts is addressed by an ATC Reliability Analysis Report.
The board found use of these parts in the Flight I PES Acceptable.

8.11 FLIGHT #2 PHASE ONE & QUALIFICATION UNIT PHASE TWO ACCEPTANCE REVIEWS

A Phase I Acceptance review of the Flight II Particles and Fields Subsatellite was held June 21-24, 1971. All Flight II "black boxes" were covered except the Particles Experiment Subsystem (PES). Review of the data revealed the "black boxes" in question to be acceptable. Flight II failure history was reviewed. Nine failures occurred. All have been closed. The Waiver/Deviations summary showed 3 waivers and 8 deviations granted. None were pending. No RID's were presented. The units under review were found acceptable by the board and approval was granted to integrate them into the subsatellite.

Mr. Johnson, the NASA/MSC P&F Experiment Manager, indicated that the subsatellite level data package for the Qualification Unit has been forwarded to MSC and reviewed there. Based on this review the Qualification Unit Particles and Fields Subsatellite was found acceptable. The DD250 was signed. TRW was directed to place the unit in bonded stores.

8.12 PES FLIGHT #2 ACCEPTANCE REVIEW

The Phase I Acceptance Review for the Particles Experiment Subsystem (PES) only of the Particles and Fields Subsatellite was held June 29th and 30th. Data was reviewed June 29th at Analog Technology Corporation (ATC), Pasadena, California. A formal acceptance board was held June 30th via telecon. Part of the board was at MSC in Houston and Part at ATC in Pasadena. The findings of the data review were presented to the formal board. Unit history was summarized. The Deviation/Waiver review indicated two deviations granted, with none pending. Five failures, one open, were shown in the handout material.
A sixth failure which occurred in the final thermal vacuum test, was presented to the board orally. The board found the Flight II (Serial 2-4) PES would be acceptable for integration into the subsatellite upon 1) completion of the Hazard Circuit change and 2) resolution of the low temperature, high voltage regulation problem.

8.13

FLIGHT #2 PHASE TWO ACCEPTANCE REVIEWS

The Phase II Acceptance Review for the Flight II Particles and Fields Subsatellite was held July 21-22, 1971, at TRW, Redondo Beach, California. A number of technically unacceptable items were identified. These occurred late in the testing program. Repair cycle time made immediate corrective action and use of the unit as a backup to the Apollo 15 unit mutually exclusive. Most probable failure mechanisms, failure propagation mechanisms and flight impacts were investigated at length. The technical review team found the flight impacts acceptable for a backup unit and recommended no repairs be started until after Apollo 15 launch. Four subsatellite level failures were reported; two remain open. Applicable waivers and deviations were listed. Twelve were granted; none pending. The technical data review minutes were reviewed for the board. No RID's were presented. The board deferred consideration of a sectoring logic design change until more data is available. The board agreed that this unit should be held in flight configuration in its present condition as a back-up for the Apollo 15 unit. Thereafter corrective action should proceed. The board found the Flight II Particles and Fields Subsatellite to be acceptable conditional upon 1) Completion of open work items, 2) Resolution of the problems discussed in the meeting minutes.

9. FLIGHT #1 IN-ORBIT PERFORMANCE

The P&F Flight #1 Subsatellite was separated from the Apollo 15 CSM in lunar orbit on August 4, 1971 at 1:13 PM PDT. All systems operated satisfactorily and are continuing to operate satisfactorily. A brief description of performance is provided below:

ORBIT

The orbit at injection was 75 by 55 nautical miles. Four days later the orbit was 63 miles circular. The orbit is expected to change to 105 by 15 miles within three months. Many unknowns are associated with the orbital changes. The coherent doppler provided by the S-Band Transponder is used to determine orbital parameters. Triangulation (three station tracking) is also being employed.

COMMUNICATIONS

Tracking and TLM data quality ~~remains~~ and command link has been excellent using 30' uncooled antennae. ~~RF link power budgets were specified for 85' cooled antennae~~. Received signal level on 85' antennae is approximately -134 dBm.

The Apollo FOD (Flight Operations Directorate) has stated the Communications and Command system is one of the best they have worked. The subsatellite has consistently responded the first time a command has been sent.

POWER

The spacecraft power subsystem (solar array/battery/charger) is operating to specification. Typical combinations of operating modes for maintaining power balance is 10 autocycle modes with 1 tracking mode, and 1 charge mode. When maximum tracking is desired the combination is 1 tracking orbit with 1 charge orbit. A tracking orbit is made up of the real time mode when in radio range, then memory mode on the backside of the moon, then data dump once radio range is re-established. During sutocycle mode the transmitter is on approximately 12 minutes during each 120 minute orbit.

MAGNETOMETER EXPERIMENT

Average magnetic field measurements have been in the order of 10 gamma, with some intervals (1 to 2 orbit duration) up to 30 gamma. The magnetometer zero crossing system has been working as designed. The sensor has been able to detect vector direction changes. Close correlation has been obtained with magnetometers on the lunar surface.

PARTICLES EXPERIMENT

All 6 particles detector sensors are working normally and collecting scientific data. The high voltage turn-on was delayed 24 hours as planned to allow the subsatellite to outgas. Turn-on was normal. The range of particles data has been in the order of 0 - 300 counts/second.

TYPICAL AVERAGE ORBIT PARAMETERS (INITIAL)

Spin Speed	- 11.85 RPM	(12.0 design)
Spin Angle Error (initial)	- $\pm 0.5^{\circ}$	(1.5° design)
Wobble	- 0	
Battery Temperature	-	60-75°F
Particle Telescope Temperature	-	58-68°F
Magnetic Sensor Temperature	-	62-65°F

The subsatellite (and Moon) was shadowed by the Earth for 3.5 hours on August 6th. All systems operated normally through the eclipse. The lowest temperatures were about 0°F.

APPENDICES

TO

FINAL

REPORT

PARTICLES AND FIELDS SUBSATELLITE PROGRAM

A. COMMAND LIST

B. MEASUREMENT LIST

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

CODE IDENT 11982

TITLE

PARTICLES AND FIELDS SUBSATELLITE

COMMAND LIST

NAS9-10800
EXH. A, Par. 4.6.4
NO. 16763-41B

DATE 24 September 1970

SUPERSEDING: 16763-41A
11 August 1970

PREPARED BY: J.B. Gardner

APPROVAL SIGNATURES:

E.L. Baines 9/8/70 DATE
E.L. Baines
Data Handling APM - TRW

Darius Hall 10-9-70 DATE
Darius Hall
MSC Contracting Officer

T.H. Pedersen 9/9/70 DATE
T.H. Pedersen
P&F Program Manager - TRW

J.H. Johnson 9/25/70 DATE
J.H. Johnson
MSC Experiment Manager

DATE

DATE

SYSTEMS 1391 REV. 3-67

A-1

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

REVISION RECORD

REV	DATE	AUTHORIZATION	CHANGE	PAGES AFFECTED
Basic	9 July 70	Contract NAS9-10800		
A	11 Aug. 70	CDR direction and subsequent agreement with Mr. J. Johnson/MSC Experiment Manager.	Changes: 1) Change in title of 4 commands 2) Modification of the operation of 2 commands 3) All command descriptions rewritten to be more user oriented (operational rather than functional)	All
B	8 Sept 70	Direction from Mr. Jack Johnson/MSC Experiment Manager	1) Incorporation of MSC's changes 2) Correction of 1 error	iii, iv, 1,4,6, 7-11
	24 Sept 70	MSC direction at Sept Management Review EB E. L. Baines T. H. Pedersen 9/24/70	1) Incorporation of MSC's changes	5,6,11

FOREWORD

Provided herein is the P & F Subsatellite command list. Included are the modulation type, information bit encoding, vehicle address, system address, word format, verification code format, command list, and functional descriptions.

This document has been prepared in accordance with Contract NAS9-10800, Exhibit A, Paragraph 4.6.4, and Exhibit C Document Table Item 41.

Revision A incorporated the changes identified during the Critical Design Review (CDR) of July 14 and 15, and of subsequent agreements with the NASA/MSC Experiment Manager.

B Revision B incorporates NASA/MSC's comments on Revision A made subsequent to the CDR. Changes for revision B are spotlighted by the presence of a "B" indicator in the left hand margin adjacent to the changed line, or top line of a changed paragraph or section. The indicator is not used for minor changes such as typographical error corrections. Revision B also incorporates the changes from MSC & PI review of the first version of Revision B as identified at the September Management Review.

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	1.0	INTRODUCTION AND SCOPE
	2.0	RELATED DOCUMENTATION
	3.0	MODULATION
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	3.2	PSK Composite
	3.3	Signal Polarity
	4.0	INFORMATION BIT ENCODING
	4.1	Vehicle Address Encoding
	4.2	System Address and Data Encoding
	5.0	VEHICLE ADDRESS
	6.0	SYSTEM ADDRESS
	7.0	MESSAGE FORMAT
	7.1	Real-Time Commands
	7.2	Real-Time Command List
	8.0	VERIFICATION CODE FORMAT
	9.0	COMMAND FUNCTIONAL DESCRIPTION
B	10.0	TRANSMITTER INHIBIT FEATURE

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1.0 INTRODUCTION AND SCOPE

This document specifies all of the uplink command interfaces between the NASA MSFN (Manned Space Flight Network) and the Particles and Fields Subsatellite (hereinafter referred to as the Subsatellite). It specifies:

a. Modulation type
b. Information bit encoding
c. Vehicle address
d. System address
e. Word formats
f. Verification code formats (downlink telemetry)
B g. Command list
B h. Functional descriptions

2.0 RELATED DOCUMENTATION

a. MSC. NAS 9-10800	Contract for design, development, fabrication, test, and delivery of flight qualified S-band Particles and Fields Subsatellites.
b. TRW: SY1-36B	Particles and Fields Subsatellite End Item Specification.
B c. TRW: 16763-42	Particles and Fields Subsatellite MSFN Communications System Signal Performance and Interface Specification.
d. TRW: EQ4-918	Equipment Specification - Command Decoder Unit, P & F Subsatellite.

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3.0 MODULATION

3.1 Subcarrier

The Subsatellite is designed to receive digital (subbit) information from the MSFN ground transmitters via S-band (2101.802 MHz). This subbit information (5 subbits equals one information bit) is transmitted by the ground station through the use of phase shift keyed - frequency modulation (PSK-FM) of the 70 KHz S-band subcarrier. The center frequency and the frequency deviations are defined as follows:

S-band Subcarrier

f_o = 70 KHz

$f_o + \Delta f$ peak = 75 KHz

$f_o - \Delta f$ peak = 65 KHz

3.2 PSK Composite

The composite audio (see Figures 1.c., and 1.d.) used to modulate the subcarrier frequency is produced by phase shift keying a 2 KHz information signal (sinewave) in conjunction with a 1 KHz sync signal (sinewave). The digital information is defined as follows:

a. A subbit "one" begins when the positive transition of the 1 KHz sync signal and the 2 KHz information signal cross each other in phase (see Figure 1.a.).

b. A subbit "zero" begins when the positive transition of the 1 KHz sync signal crosses the 2 KHz information signal 180° out of phase (see Figure 1.b.).

c. The subbit period is one millisecond.

3.3 Signal Polarity

The polarity of the overall command system shall be defined as follows:

a. With the composite input voltage waveform shown in Figure 1.c., the frequency-time relationship shall be as presented in Figure 1.e., which shall be recognized by the Subsatellite as a subbit "one."

b. With the composite input voltage waveform shown in Figure 1.d., the frequency-time relationship shall be as presented in Figure 1.f., which shall be recognized by the Subsatellite as a subbit "zero."

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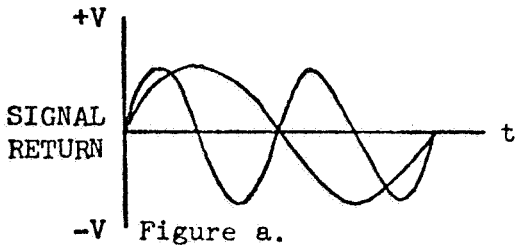

Figure a.
1 KHz SYNC WITH 2 KHz INFORMATION IN PHASE (SUBBIT "ONE")

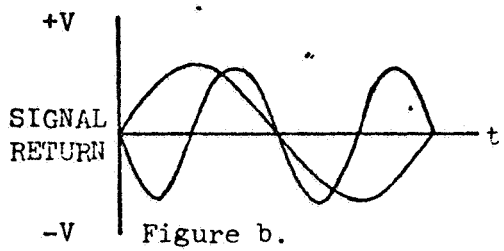

Figure b.
1 KHz SYNC WITH 2 KHz INFORMATION 180° OUT OF PHASE (SUBBIT "ZERO")

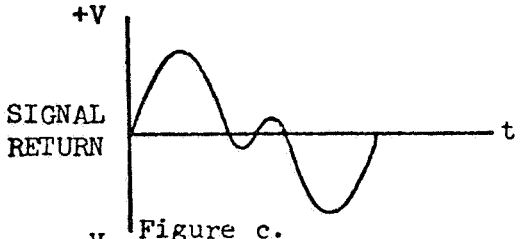

Figure c.
(COMPOSITE INPUT VOLTAGE WAVEFORM FOR SUBBIT "ONE")

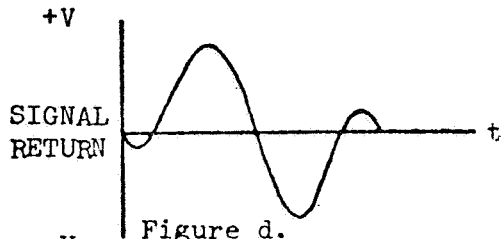

Figure d.
(COMPOSITE INPUT VOLTAGE WAVEFORM FOR SUBBIT "ZERO")

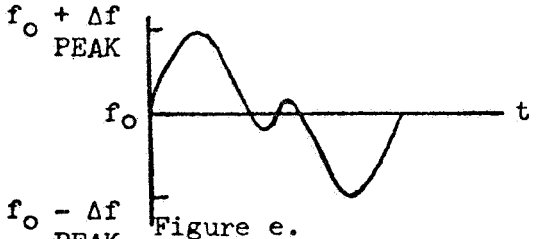

Figure e.
(FREQUENCY-TIME RELATIONSHIP FOR SUBBIT "ONE")

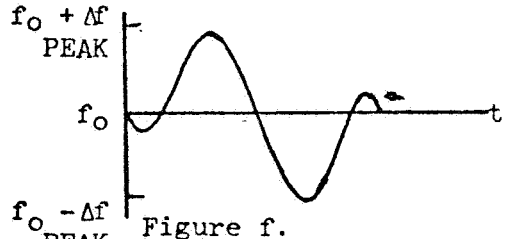

Figure f.
(FREQUENCY-TIME RELATIONSHIP FOR SUBBIT "ZERO")

S-BAND SUBCARRIER

f_o = 70 KHz

$f_o + \Delta f$ PEAK = 75 KHz

$f_o - \Delta f$ PEAK = 65 KHz

FIGURE 1. COMMAND SIGNAL POLARITY

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4.0 INFORMATION BIT ENCODING

4.1 Vehicle Address Subbit Encoding

B The first three information bits transmitted are the Vehicle address and are subbit encoded (5 for 1) as defined in equipment specification EQ4-918.

4.2 System Address and Data Subbit Encoding

B B The next three information bits transmitted (the Systems Address) and the remaining information bits (the Data) are subbit encoded (5 for 1) as defined in equipment specification EQ4-918.

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5.0 VEHICLE ADDRESS

The Vehicle Address for Subsatellite #1 is "010" (octal 2). The Vehicle Address for Subsatellite #2 is "101" (octal 5). Left information bit is transmitted first.

6.0 SYSTEM ADDRESS

The System Address for both Subsatellites is "110" (octal 6). Left information bit is transmitted first.

7.0 MESSAGE FORMAT

7.1 Real-Time Commands

FIGURE 2.

VEHICLE	VEHICLE ADDRESS			SYSTEM ADDRESS			DATA WORD					
	1	2	3	4	5	6	7	8	9	10	11	12
Subsatellite #1	0	1	0	1	1	0	X	X	X	X	X	X
Subsatellite #2	1	0	1	1	1	0	X	X	X	X	X	X

RTC (real-time command) message bits are shifted into the Subsatellite discriminator/decoder serially, bit 1 first and sequentially through and including bit 12 at a nominal rate of 200 message (information) bits per second.

There are a total of 24 commands that are implemented including 5 spare commands and 2 preflight test commands.

B

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7.2 Real Time Command List

	INFO BITS 7	8	9	10	11	12	OCTAL COMMAND*	FUNCTION
	0	0	0	0	1	0	2602	PHA THRESHOLD HIGH
B	0	0	0	1	0	0	2604	PHA THRESHOLD LOW
	0	0	0	1	1	1	2607	CALIBRATE ON
	0	0	1	0	0	0	2610	CALIBRATE OFF
	0	0	1	1	0	1	2615	TRANSPONDER ON
B	0	0	1	1	1	0	2616	TRANSPONDER OFF
	0	1	0	1	0	1	2625	EXPERIMENT/DATA POWER ON
	0	1	0	1	1	0	2626	EXPERIMENT/DATA POWER OFF
	0	1	1	0	0	1	2631	HIGH VOLTAGE OFF
	0	1	1	0	1	0	2632	HIGH VOLTAGE ON
	0	1	1	1	0	0	2634	UNDERVOLTAGE PROTECTION OUT
	0	1	1	1	1	1	2637	UNDERVOLTAGE PROTECTION IN
	1	0	0	1	0	1	2645	REAL TIME DATA MODE
	1	0	0	1	1	0	2646	MEMORY READOUT MODE
	1	0	1	0	0	1	2651	TELEMETRY STORE NORMAL
	1	0	1	0	1	0	2652	TELEMETRY STORE FAST
	1	0	1	1	0	0	2654	SPARE
	1	0	1	1	1	1	2657	AUTOMATIC CYCLE MODE
	1	1	0	0	0	1	2661	SPARE
	1	1	0	0	1	0	2662	SPARE
	1	1	0	1	1	1	2667	SPARE
	1	1	1	0	0	0	2670	SPARE
B	0	1	0	0	0	0	2620	Pre-Flight Test Control-On
B	0	1	0	0	1	1	2623	Pre-Flight Test Control-Off

*Octal commands indicate vehicle address for subsatellite #1. To obtain the octal codes for subsatellite #2, octal 2602, for example, becomes 5602, etc.

Figure 3

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8.0 VERIFICATION CODE FORMAT

B The following codes are transferred by the command decoder to the
B Data Handling System which are injected in the PCM format.

MESSAGE	1	2	3	4
Decoder Standby	0	0	0	0
Valid Command Verified	1	0	1	1

FIGURE 4.

NOTE: Bit 1 (most significant bit) is transmitted first.

9.0 COMMAND FUNCTIONAL DESCRIPTION

The normal subsatellite response to each command is described in this section.

9.1 PHA Threshold High - The minimum threshold of the solid state telescope pulse height analyzer is set to the high level. This raises the minimum detectable particle energy to nominally 20 kev.

9.2 PHA Threshold Low - The minimum threshold of the solid state telescope pulse height analyzer is set to a low value, established on the basis of pre-flight calibrations.

9.3 Calibrate ON - This command performs three functions: 1) The anti-coincidence logic in the electrostatic analyzer is inhibited enabling background pulses to be counted. 2) The discriminator level in the solid state telescope PHA is shifted such that counts from a radio active source are detected. 3) A known magnetic field is applied to the magnetometer sensors as a calibration of the sensor level. The calibrate mode may be used in real time or telemetry store modes.

9.4 Calibrate OFF - The calibrate mode is terminated by this command.

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9.5 Transponder ON - With an uplink signal present, the transmitter turns on in the coherent tracking mode. If the receiver is not locked to an uplink signal, the transmitter turns off automatically. Each time the receiver locks to an uplink signal, the transmitter will turn on, and each time the uplink disappears, the transmitter turns off. This command does not affect the mode of operation of the subsatellite data system. If the subsatellite is already in a data transmitting mode, this command will produce no observable change in operation until the data transmitting mode is terminated.

9.6 Transponder OFF - The transmitter turns off, unless it has also been turned on by a Real Time Data or Memory Read Out command, or is ON in the data transmitting portion of the Automatic Cycle mode. This command does not affect the experiment or data handling system mode of operation.

B

9.7 Experiment/Data Power ON - The low voltage power supply in the particle detector electronics turns on, supplying power to the data handling system and to the scientific instruments. Power applied to the DEU will result in the real time data mode of operation, however, the time required for actuation of the RTD mode may be up to 24 seconds from power turn-on since the DEU performs the mode change at the end of the main frame. Since at initial turn-on, the DEU can be in any mode, including data storage normal, the main frame period may be 2, 12, or 24 seconds long. Thus with this command, the transmitter may come on with modulation at any time from 0 to 24 seconds after command execution.

9.8 Experiment/Data Power OFF - The low voltage power supply in the particle detector electronics turns off, removing power from the data handling system and the scientific instruments. Note that removal of power from the DEU turns OFF the satellite clock and time correlation before and after power interruption will be disrupted. The power off command should only be used when the battery is in jeopardy of being depleted or when power consumption must be conserved for extended tracking operations.

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9.9 High Voltage OFF - The high voltage power supply in the particle detector electronics turns off, removing high voltage from the analyzer plates, the channeltrons and the photomultiplier tubes and thereby deactivating the electrostatic analyzers.

9.10 High Voltage ON - The high voltage power supply in the particle detector electronics turns on, activating the electrostatic analyzers. The high voltage must not be turned on except under very high vacuum or in-flight conditions and is inhibited from turn-on by the shorting plug during pre-flight testing.

9.11 Undervoltage Protection OUT - The undervoltage sensing circuit is inhibited from turning off the transmitter and experiment/data power supply during an undervoltage condition. With this command, the battery is vulnerable to irreversible depletion since load protection is removed. Thus this command should only be sent for emergency diagnostic purposes and as a last resort that risks the end of life of the power system.

9.12 Undervoltage Protection IN - The undervoltage sensing circuit is enabled such that if an undervoltage condition occurs the undervoltage circuit turns off the experiment power supply and the transmitter, if on. With the undervoltage circuit enabled, the battery is protected from irreversible depletion. If an undervoltage condition occurs and the battery voltage subsequently recovers to an operating level, the experiment/data power converter may be turned on by the command sequence octal 26 (Experiment/Data Power Off)
B followed by Octal 25 (Experiment/Data Power On). No response within 24 seconds would indicate the battery is still in an undervoltage condition. If the transmitter was on due to transponder on command when the undervoltage occured, the transmitter can be turned on again if the battery has recovered by Transponder Off command followed by Transponder On. No response to this sequence indicates the battery remains in a low voltage condition. If the battery is in an undervoltage condition, the experiment/data power supply and/or the transmitter can be turned on only by command Undervoltage Protection Out and then the two command sequences given above.

9.13 Real Time Data Mode - The DEU switches to the real time data mode of operation. Note that mode changes within and controlled by the DEU occur at the end of a main frame of data, thus there can be a delay of up to the main frame period of the existing mode when the command was sent which means up to 2 seconds in the MRO mode, 12 seconds in the TSF mode, or 24

9.13 Real Time Data Mode (Continued)

seconds in the TSN mode. The transmitter is switched in (if Off) at the instant of mode change with data modulation. In the RTD mode, the transmitted bit rate is 128 bps and the frame rate is 0.5 frames per second. See the measurement list, document No. 16763-40 for details on the data format. The subsatellite will remain in this mode until commanded into an alternate mode or until an undervoltage condition occurs. With an uplink signal present the downlink signal will be coherent with
B the uplink with the addition of the 32.768 KHz NRZ-M bi-phase modulated subcarrier.

9.14 Memory Read Out Mode - The DEU switches to the Memory Read Out (MRO) mode of operation. The mode change occurs at the end of a main frame of the previous operating mode, thus a delay of up to 24 seconds may occur before the mode change. At the change to MRO mode the transmitter turns on (if off) with data modulation in the stored data format. The subsatellite remains in this mode until the end of memory pulse occurs after 256 main frames of data (512 seconds) and the subsatellite switches to an idling mode with the transmitter off and awaits a command to an active mode. In the idling mode, the scientific instruments and data handling system are powered but the DEU is not processing any data.

9.15 Telemetry Store Normal - The DEU switches to the telemetry store normal (TSN) mode. The mode change occurs at the end of the main frame of the previous operating mode, thus there may be a delay of up to 2 seconds normally, or up to 12 seconds if the previous mode is Telemetry Store Fast. The transmitter will turn off, if on previously, unless the Transponder On (octal 15) command has been sent whereby the transmitter would remain on in the presence of an uplink signal. In the TSN mode, the data is being stored in the memory at an 8 bps rate. The subsatellite remains in this mode for 256 frames of 24 seconds each (6144 seconds) at which time the end-of-memory pulse occurs and puts it into an idling mode.

9.16 Telemetry Store Fast - The DEU switches to the Telemetry Store Fast (TSF) mode in the same manner as with TSN command. In the TSF mode, the data is stored in the memory at 16 bps and the subsatellite remains in this mode for 256 frames of 12 seconds each (3072 seconds) at which time the end-of-memory pulse occurs switching the subsatellite to an idling mode and holds the data until an alternate command is received.

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9.17 Spare

B 9.18 Automatic Cycle Mode - This command initiates the automatic cycle of preprogrammed operation. The automatic cycle consists of four modes in sequence, idling mode, Real Time Data, Memory Read Out and Telemetry Store Normal. The idling mode is the same as Real Time Data, but with the data output and transmitter control output inhibited. The modes shall have periods and sequence as follows:

1.	Idling	256 seconds
2.	Real Time Data	192 seconds
3.	Memory Read Out	512 seconds
4.	Telemetry Store Normal	6144 seconds
		7104

The subsatellite will remain in the Automatic Cycle Mode until an alternate mode command is received or until an undervoltage condition occurs.

9.19 Spare

9.20 Spare

9.21 Spare

9.22 Spare

B 10.0 TRANSMITTER INHIBIT FEATURE

In the event of a receiver or decoder failure in the automatic or Real Time Data mode, a transmitter inhibit is armed and actuated by the most significant bit (msb) of the elapsed time clock. The inhibit circuit is armed by a low-to-high transition of the msb and actuated by the next high-to-low transition after arming. When armed or inhibited, the circuit is cleared by any valid command. The inhibit will occur in a period of 6 to 18 days from receipt of the last valid command. Thus to guarantee that the inhibit will not occur, a valid command must be sent within every 6 day time interval.

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TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

CODE IDENT 11982

TITLE

PARTICLES AND FIELDS SUBSATELLITE

MEASUREMENT LIST

NAS 9-10800
Exh. A, Par. 4.6.4

DATE 29 January 1971

NO. 16763-40B

SUPERSEDING: 16763-40A
24 Sept. 1970

PREPARED BY: J B Gardner/BLM
J. B. Gardner

APPROVAL SIGNATURES:

E L Baines 7/9/70
DATE
E. L. Baines
Data Handling APM

Darius Hall 10-9-70
DATE
Darius Hall
MSC Contracting Officer

T. H. Pedersen 7/9/70
DATE
T. H. Pedersen
P&F Program Manager

J H Johnson 9/25/70
DATE

DATE

DATE

SYSTEMS 1391 REV. 3-67

B-1

NO. 16763-40B

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

REVISION RECORD

Measurement List

REV	DATE	AUTHORIZATION	CHANGE	PAGES AFFECTED
Basic	9 July 70	Contract NAS9-10800		
A	8 Sept 70	CDR direction and subsequent agreement with Mr. J. Johnson/MSC Experiment Manager. 8 Sept. 70 E L Baines E.L. Baines 9/10/70 T.H. Pedersen T.H. Pedersen	Changes: (1) Measurement S15B, High Voltage Monitor - deleted, Channel Code 192A5 is now a spare. (2) Title of Measurement D07B changed (3) Composite List of Measurements added for reference. (4) Information added to measurement List and manner of presentation changed for clarity.	All
	24 Sept 70	MSC direction at Sept Management Review E.L.B. E. L. Baines T.H.P. T. H. Pedersen	1) Incorporation of MSC's changes	4,5,6, 9, 18,23
B	29 Jan 71	ECP-013 1/29 H.J.Horn 2/2/71 S.R.Mayo 2/4/71 T.H.Pedersen	Changes: (1) Use spare channel 192A5 for a zero gamma reference voltage. (2) Use spare channel 2A2 for an ADC calibration voltage. (3) Correction of transposition error (page 14, W19-f0-b1, line2) (4) Added clarification of the floating point accumulator word.	Cover,ii, iii,4,5, 10,14,22 14 7,8, 10-16, 19-21
SCN-1	15 Jul 71	MSC Direction H. Horn B.L. Smith T. Pedersen A. Hartsfield(MSC)	Changes: (1) Update to reference Calibration Report details (2) Minor correction	2,9,10,14 15,17,18,19 iii
	7/27/71	BC341/T184-71/L90 (MSC)		

SYSTEMS 1392 REV. 10-67

(FILE DIRECTLY AFTER COVER SHEET)

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NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL	PAGE 1 OF 9 DATE 7/27/71

CONTRACT NUMBER	ECP NO.	SCN NO.	REVISION
NAS9-10800	NA	1	NC

EXPERIMENT NUMBER	SPECIFICATION NUMBER, TITLE AND DATE
S164, S173, S174	16763-40B; P&F Subsatellite Measurement List

APPROVAL AUTHORITY	FILE OPPOSITE SPECIFICATION PAGE NO.
MSC TWX #BC341/T184-71/L90 of 7/27	iii

SPECIFICATION CHANGE

FORWARD, Page iii:

Last sentence is: .."transportation", should be "....transposition"

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FOREWORD

Provided herein is the P & F Subsatellite Telemetry Measurement List and Format. Included are a summary list of measurements, a single page data format table and a detailed table of measurement data. This detailed table includes such information as measurement accuracy, range, units, description, channel code, sampling interval, and work location for each measurement.

This document has been prepared in accordance with Contract NAS9-10800, Exhibit A, Paragraph 4.6.4, and Exhibit C Document Table item 40.

A Revision A incorporates the changes identified during the Critical Design Review (CDR) of July 14 and 15, and of subsequent agreements with the NASA/MSC Experiment Manager. Revision A also incorporates the changes from MSC and PI review of the first version of Revision A as identified at the September Management Review.

B Revision B incorporates changes of ECP-013 which consist of use of two spare telemetry channels to obtain valuable data from orbit, inclusion of additional clarifying information, plus correction of a transportation error.

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PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

1. SCOPE

Provided herein is the Measurement List of the Particles and Fields Subsatellite. This document includes the list of measurements, the data format, and other pertinent information necessary for the reduction and analysis of the telemetered data.

2. COMPOSITE LIST OF MEASUREMENTS

Table 1 presents a composite list of measurements. Included are the measurement number, the measurement title, the channel code, and the main frame word location. Measurements which have the same word number are either subcommutated or are single bit bi-level measurements which form part of an 8 bit word. Detailed locations are obtained from the measurement list, Table 2.

3. MEASUREMENT LIST

The measurement list is presented as Table 2 and includes the format location, measurement table, measurement number, channel code, the sample interval in each mode, a measurement description, the units, maximum and minimum values, nominal accuracy and comments including scale factors, accumulation times and other relevant information.

3.1 Presentation

The measurement list is presented in blocks of 8 bit words in the order that they appear in the main frame. At the expense of duplication, super-commutated measurements are listed at each word position that they appear. Subcommutated measurements are listed contiguous with the first appearing subcommutated word.

A. Format Location

The format may be considered to be a 32 column by 8 row matrix with a word number designating the column and a frame number designating the row within the matrix. Each element of the matrix is an 8 bit word. When each bit is a separate measurement the bit is so identified. A main frame is considered as one 32 word sequence (row).

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NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL		PAGE 2 OF 9 DATE 7/27/71
CONTRACT NUMBER NAS9-10800	ECP NO. NA	SCN NO. 1	REVISION NC
EXPERIMENT NUMBER S164, S173, S174	SPECIFICATION NUMBER, TITLE AND DATE 16763-40B; P&F Subsatellite Measurement List		
APPROVAL AUTHORITY MSC TWX #BC341/T184-71/L90 of 7/27	FILE OPPOSITE SPECIFICATION PAGE NO. 2		

SPECIFICATION CHANGE

Page 2, Paragraph G. Comments.

Add the following sentence:

Detailed information concerning telemetry calibration data is contained in the individual subsatellite Telemetry Calibration Report documents, No. 16763-30.

The format location is designated by a word number (W_), a frame number (f_), and bit number (b_), when applicable. A "0" following the frame letter or bit letter indicates that the measurement appears in all frames or for all 8 bits respectively. For example, W8-f1/f4/f5/f8/b0 indicates word #8 and that the same measurement appears in frames 1,4,5, and 8 and the -b0 indicates that all 8 bits of that word comprise this particular measurement. Measurements that are sub-commutated or only appear in specific modes are listed separately with the same word number but with the appropriate frame number or mode identification. Like measurements which have a different sample interval, depending on their position in the data format, are distinguished by a separate listing with the appropriate sample interval.

B. Measurement Title

The title designated to the measurement is listed for identification.

C. Measurement Number & Channel Code

The measurement number and channel code are as designated by MSC.

D. Sample Interval

The sample interval lists the period in seconds between recurring samples of the particular measurement. These are listed for each telemetry mode of the subsatellite. In modes where the particular measurement is not sampled directly, not applicable (N/A) is listed. The sample interval is useful in establishing the time scale for data plotting.

E. Measurement Description

The measurement description briefly describes the nature of the particular measurement.

F. Units, Maximum & Minimum Value and Accuracy

The units, maximum and minimum values are listed in the appropriate columns. The accuracy is the nominal measurement accuracy.

G. Comments

The comments include information necessary for and relevant to converting the 8 bit word to engineering or scientific units.

4. DATA FORMAT

4.1 Definitions

A. Measurement Identification

The first letter denotes the subsystem wherein the measurement originates.

D - Data Handling
C - Communications
E - Electrical Power
S - Scientific Instrumentation
T - Sun Sensor

The next two characters are discrete numbers listed sequentially within each subsystem.

The last letter indicates the telemetry format as follows:

D - Dump data format only
R - Real time data format only
B - Both formats

B. Channel Code

The first number is the normal data dump format sample interval in seconds. The letters define the channel type:

A - Analog (0-5VDC)
DP - Digital, parallel
DS - Digital, serial

The last number is the channel code number.

The dash number indicates the bit location for parallel digital words less than 8 bits in length.

4.2 Data Format - The Data Format is presented in Table 3.

TABLE I. COMPOSITE LIST OF MEASUREMENTS

Meas. No.	Measurement Title	Channel Code	Main Frame Word Number
Data System Measurements			
D01B	Sync Word 1	2DP1	W1
D02B	Sync Word 2	2DP2	W2
D03B	Sync Word 3	2DP3-1234	W3
D04B	Subsatellite I.D.	2DP4-5	W4
D05B	Data Format (R/T or Dump)	2DP4-6	W4
D06B	Auto or Manual Mode	2DP4-7	W4
D07B	Calibration (ON or OFF)	2DP4-8	W4
D08B	Elapsed Time, Coarse	192DS1	W10
D09B	Elapsed Time, Fine	192DS2	W26
D10B	Frame Count	2DP3-5678	W3
D11B	Bit Rate	192DP1-4	W10 A
D12B	2.56V Calibration Voltage	2A2	W18
Command System Measurements			
C01B	Command Validity	2DP4-1234	W4
C02B	Receiver Signal Present	2DP5-1	W19
C03B	Receiver Loop Stress	2A1	W17
Science Measurements			
S01D	Magnetometer Transverse Mag. (B_{TM})	24A1	W6
S02D	Magnetometer Time Delay (T_M)	24DS5	W22
S03R	Magnetometer Transverse Out (B_T)	24A1	W6, W22
S04B	Magnetometer Parallel Out (B_p)	24A2	W7
S05B	Magnetometer Range I.D. (R_t)	192DP1-1	W10
S06B	C1 Detector Count	12DS1	W9, W25
S07B	C2 Detector Count	24DS4	W15
S08B	C3 Detector Count	24DS6	W23
S09B	C4 Detector Count	24DS10	W31
S10B	C5 Detector Sector I Count	24DS1	W5
S11B	C5 Detector Sector II Count	24DS3	W13
S12B	C5 Detector Sector III Count	24DS7	W21
S13B	C5 Detector Sector IV Count	24DS9	W29
S14B	Curved Plate Voltage Monitor	192A8	W26
B S15B	Zero Gamma Reference	192A5	W10
S16B	Open Telescope, Channel 1-4 Count	4DS1	W(8,12,16,24,28,32)
S17B	Shielded Telescope, Chan. 1-4 Count	4DS1	W(8,12,16,24,28,32)
S18B	Open Telescope, Channel 2 Count	24DS2	W11
S19B	Shielded Telescope, Channel 2 Count	24DS2	W11
S20B	Open Telescope, Channel 3 Count	48DS1	W14
S21B	Shielded Telescope, Channel 3 Count	48DS1	W14
S22B	Open Telescope, Channel 4 Count	48DS3	W14
S23B	Shielded Telescope, Channel 4 Count	48DS3	W14
S24B	Open Telescope, Channel 5 Count	48DS2	W30
S25B	Shielded Telescope, Channel 5 Count	48DS2	W30
S26B	Open Telescope, Channel 6 Count	48DS4	W30
S27B	Shielded Telescope, Channel 6 Count	48DS4	W30
S28B	Telescope I.D. (Open or Shielded)	192DP1-2	W10

Meas. No.	Measurement Title	Channel Code	Main Frame Word Number
S29B	Open Telescope Det. Temp.	192A9	W10
S30B	Shielded Tele. Det. Temp.	192A10	W26
S31B	Magnetometer Range (R_p)	192DP1-3	W10
S32B	PHA Threshold	192DP1-6	W10
S33B	Spare	192DP1-7	W10
S34B	Magnetometer Temperature	192A1	W10
Sun Sensor Measurements			
T01B	Sun Pulse Delay	24DS8	W27
T02B	Spin Count	192DS4	W26
T03B	Sun Elevation Angle	192DS3	W10
T04B	Sector Period	192DS5	W26
T05B	Sun Sensor Polarity	192DP1-5	W10
Electrical Power Measurements			
E02B	Solar Array Current	192A2	W26
E03B	Battery Voltage	192A3	W10
E04B	Battery Current	192A4	W26
E05B	Battery Temperature	192A7	W10
E06B	Low Voltage Monitor	192A6	W26
E08B	Undervolt. Protection IN/OUT	2DP5-2	W19

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TABLE 2 (16 Pages) PARTICLES AND FIELDS SUBSATELLITE
MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN. CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN. VALUE	ACCURACY	COMMENTS
W1-f0-b1	Sync bit No 1							Fixed Bit Value 1					
-b2	Sync bit No 2							Fixed Bit, Value 1					
-b3	Sync bit No 3							Fixed Bit, Value 1					
-b4	Sync bit No 4	D01B	2DP1	2	2	N/A	N/A	Fixed Bit, Value 0	N/A	N/A	N/A	N/A	
-b5	Sync bit No 5							Fixed Bit, Value 1					
-b6	Sync bit No 6							Fixed Bit, Value 1					
-b7	Sync bit No 7							Fixed Bit, Value 0					Aerospace Data Systems
-b8	Sync bit No 8							Fixed Bit, Value 1					Standard 20 Bit Sync Pattern
W2-f0-b1	Sync bit No 9							Fixed Bit, Value 1					
-b2	Sync bit No 10							Fixed Bit, Value 1					
-b3	Sync bit No 11							Fixed Bit Value 1					
-b4	Sync bit No 12	D02B	2DP2	2	2	N/A	N/A	Fixed Bit Value 0	N/A	N/A	N/A	N/A	
-b5	Sync bit No 13							Fixed Bit, Value 0					
-b6	Sync bit No 14							Fixed Bit, Value 0					
-b7	Sync bit No 15							Fixed Bit Value 1					
-b8	Sync bit No 16							Fixed Bit, Value 0					
W3-f0-b1	Sync bit No 17	D03B	2DP3-1					Fixed Bit, Value 0					
-b2	Sync bit No 18		2DP3-2					Fixed Bit, Value 0					
-b3	Sync bit No 19		2DP3-3					Fixed Bit, Value 0					
-b4	Sync bit No 20	D03B	2DP3-4	2	2	N/A	N/A	Fixed Bit, Value 0					
-b5	Frame Count, Bit 1	D10B	2DP3-5					0 in F1 to F8, 1 in F9 to F16	N/A	N/A	N/A	N/A	4 Bit frame counter.
-b6	Frame Count, Bit 2		2DP3-6					0 in F1 to F4, 1 in F5 to F8					In MRO mode, counts frames
-b7	Frame Count, Bit 3		2DP3-7					0 in F1 to F2, 1 in F3 to F4					read out from memory.
-b8	Frame Count, Bit 4		2DP3-8					0 in F1, 1 in F2, 0 in F3, etc.					
W4-f0-b1	Valid Command Bit 1	C01B	2DP4-1					Valid Command-1 No Command-0					
-b2	Valid Command, Bit 2		2DP4-2					Valid Command-0, No Command-0					Held for 4 frames after command
-b3	Valid Command, Bit 3		2DP4-3					Valid Command-1, No Command-0					was received.
-b4	Valid Command, Bit 4		2DP4-4	2	2	N/A	N/A	Valid Command-1, No Command-0	N/A	N/A	N/A	N/A	
-b5	Subsatellite ID Bit	D04B	2DP4-5					S/C #1, Bit=1, S/C #2, Bit=0					
-b6	Data Format(RTD orMRO)	D05B	2DP4-6					RTD Mode Bit=0,MRO mode,bit=1					
-b7	Automatic or Manual	D06B	2DP4-7					Auto.mode,Bit=1, Otherwise-0					
-b8	Calibrate ON/OFF Bit	D07B	2DP4-8					Calib. ON-1, Calib. OFF-0					

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ORIGINATOR	DATE	TITLE
MJO		

ENGINEERING SKETCH
TRW SPACE TECHNOLOGY LABORATORIES

SK
SHEET 1 OF 16

STL Form 523B (Rev 12 63)

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TABLE 2. PARTICLES AND FIELDS SUBSATELLITE
MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN. CODE	SAMPLE INTERVAL				MEASUREMENT DESCRIPTION	UNITS	MAX. VALUE	MIN. VALUE	ACCURACY	COMMENTS
				RTD	MRO	TSN	TSF						
W5-f0-b0	C5 Detector Sector I Count	S10B	24DS1	2	N/A	24	12	Accumulated count Sector I from C5 detector output	Counts	$2^{19}-1$	0	±3.1%	Accumulation time: TSN mode: 0.5 sector period; TSF mode 0.25 sector period; RTD mode: 50 seconds. Sector I is -45° to +45° of B field vector. MSB 0000·1111 = 0 Counts. Magnitude └Mantissa
W6-f0-b0	Magnetometer Transverse Mag. (B_{TM}) in MRO mode only.	S01D	24A1	N/A	N/A	24	12	Transverse magnetometer magnitude, dual range, 0-50γ and 0-200γ, range bit is W10-f3-b1	Gamma	200	0	2%	Magnitude measurement is in stored data format only.
W6-f0-b0	Magnetometer Transverse out (B_T)- in RTD mode only.	S03R	24A1	1	N/A	N/A	N/A	Transverse magnetometer output, dual range, 0-50γ and 0-200γ, range bit is W10-f3-b1	Gamma	±200	0	2%	Direct sample of transverse output, sampled in real time mode only. Bandwidth is -3db at 0.5 Hz.
W7-f0-b0	Magnetometer Parallel Out (B_p)	S04B	24A2	2	N/A	24	12	Parallel magnetometer output, dual range, 0-50γ and 0-200γ, range bit is W10-f3-b3	Gamma	±200	0	2%	Bandwidth is -3 db at .02 Hz in TSN and TSF modes; Bandwidth is -3db at 0.25 Hz in RTD mode.

B

TABLE 2 PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN. VALUE	ACCURACY	COMMENTS	
W8-f1-b0 -f4 -f5 -f8	Shielded Telescope Ch. 1-4	S17B	4DS1	0.25	N/A	4	2	Shielded telescope, channels 1-4 output	Counts	$2^{19}-1$	Zero	±3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Mantissa Magnitude	B
W8-f2-b0 f3 f6 f7	Open Telescope Ch. 1-4	S16B	4DS1	0.25	N/A	4	2	Open telescope channels 1-4	Counts	$2^{19}-1$	0	±3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Mantissa Magnitude	B
W9-f0-b0	C1 Detector Count	S06B	12DS1	1	N/A	12	6	C1 Detector Counts	Counts	$2^{19}-1$	0	±3.1%	Accumulation Time. TSN mode 2 x sector period TSF mode 1 x sector period RTD mode 1 second MSB 0000-1111 = 0 Counts Magnitude Mantissa	B
W10-f1-b0	Elapsed Time, Coarse	D08B	192DS1	16	N/A	192	96	Binary count of 2^{12} second intervals	2^{12} sec.	$2^{12}(2^8-1)$ Sec	0	0.05%	Msb cycles in 2^{20} seconds (12 days, 3 hrs., 16 m, 16 s), non-resetting.	

NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL		PAGE 3 OF 9 DATE 7/27/71
CONTRACT NUMBER NAS9-10800	ECP NO. NA	SCN NO. 1	REVISION NC
EXPERIMENT NUMBER S164, S173, S174	SPECIFICATION NUMBER, TITLE AND DATE 16763-40B; P&F Subsatellite Measurement List		
APPROVAL AUTHORITY MSC TWX #BC341/T184-71/L90 of 7/27	FILE OPPOSITE SPECIFICATION PAGE NO. 9		

SPECIFICATION CHANGE

Page 9

1) Measurement No. T03B: Change comment to read;

"See Calibration Report for each subsatellite for interpretation of data."

2) Measurement No. S34B, and 3) Measurement No. E03B: Change comment to read:

"See Calibration Report for each subsatellite for exact telemetry calibration range."

TABLE 2 PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO	CHAN CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN. VALUE	ACCURACY	COMMENTS
W10-f2-b0	Sun Elevation Angle	T03B	192DS3	16	N/A	192	96	Elevation of sun above equatorial plane of satellite	Degrees	36°	-36°	± .2°	Angle = (t/T - 1.5/360) T] 960° where t = [(binary count)/1024] ·0.48 ms T = Spin period P = Polarity (+1 or -1) Polarity bit appears on W10-f3-b5
W10-f3-b1	B_t Magn. Range (R_t)	S05B	192DP1·1	16	N/A	192	96	Range of transverse Magnet.	N/A	1	0	N/A	0-50γ range, 1-200 γ range
-b2	Telescope Identifier	S28R	192DP1·2	16	N/A	192	96	Level of Telescope Select	N/A	1	0	N/A	0- Open, 1 - Shielded
-b3	Bp Magn. Range (R_p)	S31B	192DP1·3	16	N/A	192	96	Range of Parallel Magnet	N/A	1	0	N/A	0-50γ range, 1-200γ range
-b4	Bit Rate	D11B	192DP1-4	16	N/A	192	96	Bit rate of stored data	N/A	1	0	N/A	0-8 bps (TSN), 1-16 bps (TSF)
-b5	Sun Sensor Polarity	T05B	192DP1-5	16	N/A	192	96	Sun in upper/lower hemisphere	N/A	1	0	N/A	0 - Upper, 1 - lower
-b6	PHA Threshold Hi/Lo	S32B	192DP1·6	16	N/A	192	96	Threshold level of PHA	N/A	1	0	N/A	0 - Low, 1 - High
-b7	Spare		192DP1·7	16	N/A	192	96						
-b8	Spare		192DP1·8	16	N/A	192	96						
W10-f4-b0	Magnetometer Temp.	S34B	192A1	16	N/A	192	96	Temperature at magnetometer sensor	°C	-18	+50	±1°C	See Calibration Report
W10-f5-b	Battery/Solar Array Volts	E03B	192A3	16	N/A	192	96	Battery & Solar Array Voltage	Volts	17.92	0	2%	Scale Factor: 7 mV per bit

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NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL	PAGE 4 OF 9 DATE 7/27/71

CONTRACT NUMBER	ECP NO.	SCN NO.	REVISION
NAS9-10800	NA	1	NC

EXPERIMENT NUMBER	SPECIFICATION NUMBER, TITLE AND DATE
S164, S173, S174	16763-40B; P&F Subsatellite Measurement List

APPROVAL AUTHORITY	FILE OPPOSITE SPECIFICATION PAGE NO. 10
MSC TWX #BC341/T184-71/L90 of 7/27	

SPECIFICATION CHANGE

Page 10

1) Measurement No. S15B: Change comment to read:

"Output to be used for Zero Gamma reference value. See Calibration Report for each subsatellite for exact nominal value."

2) & 3) Measurement No.s E05B and S29B: Change comments to read:

"See Calibration Report for each subsatellite for exact telemetry calibration range."

TABLE 2. PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS NO.	CHAN CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX. VALUE	MIN. VALUE	ACCURACY	COMMENTS
W10-f6-b0	Zero Gamma Reference Voltage	S15B	192A5	16	N/A	192	96	Analog voltage representing the zero gamma output of the magnetometer	Volts	2 600	2 400	±0.010	Output to be used for Zero Gamma reference value
W10-f7-b0	Battery Temperature	E05B	192A7	16	N/A	192	96	Temperature of Satellite Batt.	°F	+118°	-10°	± 2%	Scale Factor: 0.5°F per bit
W10-f8-b0	Open Telescope Temp.	S29B	192A9	16	N/A	192	96	Detector temperature of open solid state telescope	°C	-40	+40	± 1°	See Calibration Report
W11-f1-b0 -f5	Shielded Telescope Channel 2	S19B	24DS2	2	N/A	24	12	Shielded Telescope, Chan. 2	Counts	$2^{19}-1$	0	±3.1%	Accumulation Times are: TSN mode - 24 seconds; TSF mode - 12 seconds; RTD mode - 2 seconds; MSB 0000-1111 = 0 Counts (Mantissa; Magnitude)

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ORIGINATOR	DATE	TITLE
MJO		

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TABLE 2

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN VALUE	ACCURACY	COMMENTS	
W11-f2-b0 -f6	Open Telescope Channel 2	S18B	24DS2	6	N/A	72	36	Open Telescope, Chan 2	Counts	$2^{19}-1$	0	±3 1%	Accumulation Times are: TSN mode - 24 seconds; TSF mode - 12 seconds; RTD mode - 2 seconds; MSB 0000-1111 = 0 Counts; Magnitude, Mantissa	B
W11-f3-b0 -f7	Open Telescope Channel 2	S18B	24DS2	2	N/A	24	12	Open Telescope, Chan. 2	Counts	$2^{19}-1$	0	±3.1%	Accumulation Times are: TSN mode - 24 seconds; TSF mode - 12 seconds; RTD mode - 2 seconds; MSB 0000-1111 = 0 Counts; Magnitude, Mantissa	B
W11-f4-b0 -f8	Shielded Telescope Channel 2	S19B	24DS2	6	N/A	72	36	Shielded Telescope, Chan. 2	Counts	$2^{19}-1$	0	±3 1%	Accumulation Times are: TSN mode - 24 seconds; TSF mode - 12 seconds; RTD mode - 2 seconds; MSB 0000-1111 = 0 Counts; Magnitude, Mantissa	B
W12-f1-b0 f2 f5 f6	Open Telescope Channels 1-4	S16B	4DS1	0.5	N/A	4	2	Open Telescope, Channels 1-4	Counts	$2^{19}-1$	0	± 3.1%	Accumulation time equals sample interval; MSB 0000-1111 = 0 Counts; Mantissa, Magnitude	B

ORIGINATOR	DATE	TITLE	ENGINEERING SKETCH
			TRW SPACE TECHNOLOGY LABORATORIES
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TABLE 2.

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN. CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX. VALUE	MIN. VALUE	ACCURACY	COMMENTS	
W12-f3-b0 -f4 -f7 -f8	Shielded Telescope Channels 1-4	S17B	4DS1	0.5	N/A	4	2	Shielded Telescope, Chan. 1-4	Counts	$2^{19}-1$	0	±3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Magnitude Mantissa	B
W13-f0-b0	C_5 Detector Sector II Count	S11B	24DS3	0.5	N/A	24	12	C5 Detector, Sector II	Counts	$2^{19}-1$	0	±3.1%	Accumulation time TSN mode 0.5 sector period TSF mode 0.25 sector period RTD mode .50 seconds Sector II is -45° to -90° and +45° to +90° of B field vector MSB 0000-1111 = 0 Counts Magnitude Mantissa	B
W14-f1-b0 -f5	Shielded Telescope Channel 3	S21B	48DS1	8	N/A	96	48	Shielded Telescope, Chan. 3	Counts	$2^{19}-1$	0	±3.1%	Accumulation times are: TSN mode: 48 seconds TSF mode: 24 seconds RTD mode: 4 seconds MSB 0000-1111 = 0 Counts Magnitude Mantissa	B
W14-f2-b0 -f6	Shielded Telescope Channel 4	S23B	48DS3	8	N/A	96	48	Shielded Telescope, Chan. 4	Counts	$2^{19}-1$	0	±3.1%	Accumulation times are TSN mode 48 seconds TSF mode 24 seconds RTD mode 4 seconds MSB 0000-1111 = 0 Counts Magnitude Mantissa	B

TABLE 2

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN. CODE	SAMPLE INTERVAL				MEASUREMENT DESCRIPTION	UNITS	MAX. VALUE	MIN. VALUE	ACCURACY	COMMENTS	
				RTD	MRO	TSN	TSF							
W14-f3-b0 -f7	Open Telescope Channel 3	S20B	48DS1	8	N/A	96	48	Open Telescope, Chan. 3	Counts	$2^{19}-1$	0	±3.1%	Accumulation Times are: TSN mode: 48 seconds TSF mode: 24 seconds RTD mode: 4 seconds MSB 0000-1111 = 0 Counts (Magnitude, Mantissa)	B
W14-f4-b0 -f8	Open Telescope Channel 4	S22B	48DS3	8	N/A	96	48	Open Telescope, Chan. 4	Counts	$2^{19}-1$	0	±3.1%	Accumulation Times are: TSN mode: 48 seconds TSF mode: 24 seconds RTD mode: 4 seconds MSB 0000-1111 = 0 Counts (Magnitude, Mantissa)	B
W15-f0-b0	C2 Detector Count	S07B	24DS4	2	N/A	24	12	C2 Detector Count	Counts	$2^{19}-1$	0	±3.1%	Accumulation Times are: TSN mode: 4 x sector period TSF mode: 2 x sector period RTD mode: 2 seconds MSB 0000-1111 = 0 Counts (Magnitude, Mantissa)	B
W16-f1-b0 -f2 -f5 -f6	Open Telescope Channels 1-4	S16B	4DS1	25	N/A	4	2	Open Telescope, Chan. 1-4	Counts	$2^{19}-1$	0	±3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts (Magnitude, Mantissa)	B

NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE [ ] PRELIMINARY [X] FINAL	PAGE 5 OF 9 DATE 7/27/71

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NAS9-10800	NA	1	NC

EXPERIMENT NUMBER	SPECIFICATION NUMBER, TITLE AND DATE
S164, S173, S174	16763-40B; P&F Subsatellite Measurement List

APPROVAL AUTHORITY	FILE OPPOSITE SPECIFICATION
MSC TWX #BC341/T184-71/L90 of 7/27	PAGE NO. 14

SPECIFICATION CHANGE

Page 14

1) Measurement No. C03B: Change comment to read:

"Deviation from center frequency is nominally 1KHz/count. See Calibration Report for each subsatellite for exact telemetry calibration range."

2) Measurement No. D12B: Change comment to read:

"See Calibration Report for each subsatellite for exact nominal value."

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TABLE 2

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO	CHAN. CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	Max. VALUE	MIN. VALUE	ACCURACY	COMMENTS
W16-f3-b0 -f4 -f7 -f8	Shielded Telescope Channels 1-4	S17B	4DS1	25	N/A	4	2	Shielded Telescope, Chan. 1-4	Counts	$2^{19}-1$	0	±3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Magnitude Mantissa
W17-f0-b0	Receiver Loop Stress	C03B	2A1	2	2	N/A	N/A	Indicates deviation of locked frequency from center freq.	Hz	+150Hz	150Hz	±2%	Center Frequency - 2.5V (binary counts = 128) Deviation from C.F. - 50 KHz per volt nominal (1 KHz per bit)
W18-f0-b0	2.56V Calibration Voltage	D12B	2A2	2	2	N/A	N/A	Analog voltage quantitatively indicating performance of the analog-to-digital converter (ADC)	Volts	2.570	2.550	±1%	
W19-f0-b1 -b2 -b3 -b4 -b5 -b6 -b7 -b8	Receiver Sig. Present UV Protection IN/OUT	C02B E08B	2DP5-1 2DP5-2	2 2	2 2	N/A N/A	N/A N/A	Indicates lock-up of receiver Command Verification	[illegible]	[illegible]	0 0	N/A N/A	0 - Rcvr not locked, 1 - Recvr locked 0 - UVP in, 1 - UVP out

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NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL		PAGE 6 OF 9 DATE 7/27/71
CONTRACT NUMBER NAS9-10800	ECP NO. NA	SCN NO. 1	REVISION NC
EXPERIMENT NUMBER S164, S173, S174	SPECIFICATION NUMBER, TITLE AND DATE 16763-40B; P&F Subsatellite Measurement List		
APPROVAL AUTHORITY MSC TWX #BC341/T184-71/L90 of 7/27	FILE OPPOSITE SPECIFICATION PAGE NO. 15		

SPECIFICATION CHANGE
Page 15

1) Measurement No S02D: Change comment to read:

$$T_m = \frac{(\text{binary count})}{32} + 0.0156$$

2) Measurement No. S03R; Change comment to read:

"In RTD mode only. Same as W6-f0-b0. See Calibration Report for each subsatellite for exact telemetry calibration range."

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TABLE 2

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN CODE	SAMPLE INTERVAL				MEASUREMENT DESCRIPTION	UNITS	MAX. VALUE	MIN. VALUE	ACCURACY	COMMENTS
				RTD	MRO	TSN	TSF						
W20-f0-b1 -b2 -b3 -b4 -b5 -b6 -b7 -b8	Spare		2DP6-1	2	2	N/A	N/A						
W21-f0-b0	C5 Detector Sector III Count	S12B	24DS7	2	N/A	24	12	C5 Detector. Sector III counts	Counts	$2^{19}-1$	0	±3 1%	Accumulation time TSN mode 0.5 sector period TSF mode 0.25 sector period RTD mode 50 seconds Sector III is -90° to -135° and +90° to +135° of B field vector MSB 0000-1111 = 0 Counts Magnitude — Mantissa
W22-f0-b0	Magn Time Delay (T_M) (in MRO mode only)	S02D	24DS5	N/A	N/A	24	12	Time delay of magnetometer zero crossing pulse reference to frame start	31 2 ms	8 sec	0 sec	±15.6ms	Tm = (0.0312) x (binary count)+.0155 In TSN or TSF modes only.
W22-f0-b0	Magnetometer Transverse Out (B_T) in RTD mode only	S03R	24A1	2	N/A	N/A	N/A	Transverse Magnetometer output, dual range, 0-50γ and 0-200γ range bit is W10-f3-b0.	Gamma	+200	-200	± 1%	In RTD mode only Same as W6-f0-b0.

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TABLE 2 PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS NO	CHAN CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN VALUE	ACCURACY	COMMENTS
W23-f0-b0	C3 Detector Count	S08B	24DS6	2	N/A	24	12	C3 Accumulated Count	Counts	2^{19} 1	0	± 3.1%	Accumulation Time: TSN mode: 4 x sector period TSF mode: 2 x sector period RTD mode: 2 seconds MSB 0000-1111 = 0 Counts Magnitude Mantissa
W24-f1-b0 -f2 -f5 -f6	Open Telescope Channels 1-4	S16B	4DS1	25	N/A	4	2	Open Telescope, Chan 1-4	Counts	$2^{19}-1$	0	± 3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Mantissa Magnitude
W24-f3-b0 -f4 -f7 -f8	Shielded Telescope Channels 1-4	S17B	4DS1	.25	N/A	4	2	Shielded Telescope, Chan 1-4	Counts	$2^{19}-1$	0	± 3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Mantissa Magnitude
W25-f0-b0	C1 Detector Count	S06B	12DS1	1	N/A	12	6	C1 Accumulated Counts	Counts	$2^{19}-1$	0	± 3.1%	Accumulation Time: TSN mode: 2 x sector period TSF mode: 1 x sector period RTD mode: 1 second MSB 0000-1111 = 0 Counts Mantissa Magnitude

NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL	PAGE 7 OF 9 DATE 7/27/71

CONTRACT NUMBER	ECP NO.	SCN NO.	REVISION
NAS9-10800	NA	1	NC

EXPERIMENT NUMBER	SPECIFICATION NUMBER, TITLE AND DATE
S164, S173, S174	16763-40B; P&F Subsatellite Measurement List

APPROVAL AUTHORITY	FILE OPPOSITE SPECIFICATION
MSC TWX #BC341/T184-71/L90 of 7/27	PAGE NO. 17

SPECIFICATION CHANGE

Page 17

Measurement No. E02B: Change comments to read:

See Calibration Report for each S/S for exact TLM calibration range.

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TABLE 2. PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS NO	CHAN CODE	SAMPLE INTERVAL				MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN. VALUE	ACCURACY	COMMENTS
				RTD	MRO	TSN	TSF						
W26-f1-b0	Elapsed Time. Fine	D09B	192DS2	16	N/A	192	96	Binary count of 2^4 second intervals	2^4 sec	$2^4(2^8-1)$ Sec	0	0.05%	8 bit counter counts units of 16 second intervals, thus LSB changes state every 16 seconds.
W26-f2-b0	Spin Count	T02B	192DS4	16	N/A	192	96	Count of sun pulses and magnetometer pulses	revs	256	0		Non-resetting counter, counts sun pulses in sunlight and magnetometer pulses in eclipse. Sun presence logic level output selects magnetometer pulses in eclipse.
W26-f3-b0	Sector Period	T04B	192DS5	16	N/A	192	96	Period of Spin	sec.	8	0	±15.6ms	Measured spin period that is used in retaining and accumulation control. Updated every 8 frames. Period = (0312)(binary count)
W26-f4-b0	Solar Array Current	E02B	192A2	16	N/A	192	96	Output current of solar array	Amps	2.048	0	±2%	Scale Factor: 8 mA per bit

NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL	PAGE 8 OF 9 DATE 7/27/71

CONTRACT NUMBER	ECP NO.	SCN NO.	REVISION
NAS9-10800	NA	1	NC

EXPERIMENT NUMBER	SPECIFICATION NUMBER, TITLE AND DATE
S164, S173, S174	16763-40B; P&F Subsatellite Measurement List

APPROVAL AUTHORITY	FILE OPPOSITE SPECIFICATION PAGE NO. 18
MSC TWX #BC341/T184-71/L90 of 7/27	

SPECIFICATION CHANGE

Page 18

1) Measurement No. E04B Change comment to read:

"See Calibration Report for each S/S for exact TLM calibration range."

2) Measurement No. E06B Change comments to read:

"Scale Factor: 20 mV per bit. See Calibration Report for each S/S for exact nominal value".

3) Measurement No. S14B Change comments to read:

"Scale Factor: 20 mV per bit. See Calibration Report for each S/S for exact nominal value".

4) Measurement No. S30B Change comments to read:

"See Calibration Report for each S/S for exact TLM calibration range."

TABLE 2. PARTICLES AND FIELDS SUBSATELLITE
MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN CODE	SAMPLE INTERVAL				MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN VALUE	ACCURACY	COMMENTS
				RTD	MRO	TSN	TSF						
W26-f5-b0	Battery Current	E04B	192A4	16	N/A	192	96	Positive or negative battery current	Amps	+1 92	-1 92	2%	Scale Factor- 15 mA per bit
W26-f6-b0	Low Voltage Monitor	E06B	192A6	16	N/A	192	96	+5 Volt Monitor	Volts	5 12	0	2%	Scale Factor: 20 mV per bit
W26-f7-b0	Curved Plate Volt. Monitor	S14B	192A8	16	N/A	192	96	5.0 Volt Monitor proportional to HV	Volts	5 12	0	2%	Scale Factor: 20 mV per bit
W26-f8-b0	Shielded Telescope Temperature	S30B	192A10	16	N/A	192	96	Detector Temperature	°C	-40	+40	2%	See Calibration Report

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NAME AND ADDRESS TRW Systems One Space Park Redondo Beach, Calif. 90278	SPECIFICATION CHANGE NOTICE ☐ PRELIMINARY ☒ FINAL		PAGE 9 OF 9 DATE 7/27/71
CONTRACT NUMBER NAS9-10800	ECP NO. NA	SCN NO. 1	REVISION N C
EXPERIMENT NUMBER S164, S173, S174	SPECIFICATION NUMBER, TITLE AND DATE 16763-40B; P&F Subsatellite Measurement List		
APPROVAL AUTHORITY MSC TWX #BC341/T184-71/L90 of 7/27	FILE OPPOSITE SPECIFICATION PAGE NO. 19		

SPECIFICATION CHANGE

Page 19

1) Measurement No. T01B Change comment to read:

$$T_s = \frac{\text{Binary Counts}}{32} + .0156$$

TABLE 2. PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO.	CHAN. CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX. VALUE	MIN. VALUE	ACCURACY	COMMENTS
W27-f0-b0	Sun Pulse Delay	T01B	24DS8	2	N/A	24	2	Time delay of sun pulse from frame start	sec	8 sec	0	±15.6ms	T_s = (.0312) (binary count) + 0.0155
W28-f1-b0 -f2 -f5 -f6	Open Telescope Channels 1-4	S16B	4DS1	0.5	N/A	4	2	Open Telescope, Chan. 1-4	Counts	$2^{19}-1$	0	± 3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Magnitude Mantissa
W28-f3-b0 -f4 -f7 -f8	Shielded Telescope Channels 1-4	S17B	4DS1	0.5	N/A	4	2	Shielded Telescope, Chan. 1-4	Counts	$2^{19}-1$	0	± 3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Magnitude Mantissa
W29-f0-b0	C5 Detector Sector IV Count	S13B	24DS9	0.5	N/A	24	2	C5 Detector, Sector IV	Counts	$2^{19}-1$	0	± 3.1%	Accumulation time TSN mode 0.5 sector period TSF mode 0.25 sector period RTD mode 50 seconds Sector IV is +135° to -135° from B field vector MSB 0000-1111 = 0 Counts Magnitude Mantissa

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ORIGINATOR	DATE	TITLE	ENGINEERING SKETCH TRW SPACE TECHNOLOGY LABORATORIES
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TABLE 2 PARTICLES AND FIELDS SUBSATELLITE MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS. NO	CHAN CODE	SAMPLE INTERVAL RTD	MRO	TSN	TSF	MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN VALUE	ACCURACY	COMMENTS
W30-f1-b0 -f5	Shielded Telescope Channel 5	S25B	48DS2	8	N/A	96	48	Shielded Telescope Chan. 5	Counts	$2^{19}-1$	0	± 3.1%	Accumulation Time: TSN mode: 48 seconds TSF mode: 24 seconds RTD mode: 4 seconds MSB 0000-1111 = 0 Counts Magnitude Mantissa
W30-f2-b0 -f6	Shielded Telescope Channel 6	S27B	48DS4	8	N/A	96	48	Shielded Telescope, Chan 6	Counts	$2^{19}-1$	0	± 3.1%	Accumulation Time TSN mode 48 seconds TSF mode 24 seconds RTD mode 4 seconds MSB 0000-1111 = 0 Counts Magnitude Mantissa
W30-f3-b0 -f7	Open Telescope Channel 5	S24B	48DS2	8	N/A	96	48	Open Telescope, Chan. 5	Counts	$2^{19}-1$	0	± 3.1%	Accumulation Time: TSN mode: 48 seconds TSF mode 24 seconds RTD mode 4 seconds MSB 0000-1111 = 0 Counts Magnitude Mantissa
W30-f4-b0 -f8	Open Telescope Channel 6	S26B	48DS4	8	N/A	96	48	Open Telescope. Chan 6	Counts	$2^{19}-1$	0	± 3.1%	Accumulation Time: TSN mode: 48 seconds TSF mode: 24 seconds RTD mode: 4 seconds MSB 0000-1111 = 0 Counts Magnitude Mantissa

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TABLE 2 PARTICLES AND FIELDS SUBSATELLITE
MEASUREMENT LIST

FORMAT LOCATION	MEASUREMENT TITLE	MEAS NO	CHAN CODE	SAMPLE INTERVAL				MEASUREMENT DESCRIPTION	UNITS	MAX VALUE	MIN VALUE	ACCURACY	COMMENTS	
				RTD	MRO	TSN	TSF							
W31-f0-b0	C4 Detector Count	S09B	24DS10	2	N/A	24	12	C4 Detector Counts	Counts	$2^{19}-1$	0	± 3 1%	Accumulation Time: TSN mode: 4 x sector period TSF mode: 2 x sector period RTD mode: 2 seconds MSB 0000-1111 = 0 Counts Mantissa Magnitude	B
W32-f1-b0 -f2 -f5 -f6	Open Telescope Channels 1-4	S16B	4DS1	25	N/A	4	2	Open Telescope, Chan. 1-4	Counts	$2^{19}-1$	0	± 3.1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Mantissa Magnitude	B
W32-f3-b0 -f4 -f7 -f8	Shielded Telescope Channels 1-4	S17B	4DS1	25	N/A	4	2	Shielded Telescope, Chan. 1-4	Counts	$2^{19}-1$	0	± 3 1%	Accumulation time equals sample interval MSB 0000-1111 = 0 Counts Mantissa Magnitude	B

ORIGINATOR	DATE	TITLE	ENGINEERING SKETCH
			TRW SPACE TECHNOLOGY LABORATORIES
MJO			SK
			SHEET 16 OF 16

TABLE 3. SUBSATELLITE DOWNLINK DATA FORMAT (16 WORDS/SEC) (Page 1 of 2)

1 word = 8 bits, 1 frame = 32 words (2 secs), 1 data cycle = 8 frames (16 secs).

*Words 6 and 22 are 24A1 (S03R) in Real Time Mode ( ) = Stored Format Word No.

NO.	1	2	3	4	5(1)	6(2)	7(3)	8(4)	9(5)	10(6)	11(7)	12(8)	13(9)	14(10)	15(11)	16(1
1	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1* S01D	24A2 S04B	4DS1 S17B	12DS1 S06B	192DS1 D08B	24DS2 S19B	4DS1 S16B	24DS3 S11B	48DS1 S21B	24DS4 S07B	4DS1 S16B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 C08B	4DS1 S16B	12DS1 S06B	192DS2 D09B	24DS8 T01B	4DS1 S16B	24DS9 S13B	48DS2 S25B	24DS10 S09B	4DS1 S16B
2	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1 S01D	24A2 S04B	4DS1 S16B	12DS1 S06B	192DS3 T03B	24DS2 S19B	4DS1 S16B	24DS3 S11B	48DS3 S23B	24DS4 S07B	4DS1 S16B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 S08B	4DS1 S16B	12DS1 S06B	192DS4 T02B	24DS8 T01B	4DS1 S16B	24DS9 S13B	48DS4 S27B	24DS10 S09B	4DS1 S16B
3	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1 S01D	24A2 S04B	4DS1 S16B	12DS1 S06B	192DP1 Note 3	24DS2 S19B	4DS1 S17B	24DS3 S11B	48DS1 S20B	24DS4 S07B	4DS1 S17B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 S08B	4DS1 S17B	12DS7 S06B	192DS5 T04B	24DS3 T01B	4DS1 S17B	24DS9 S13B	48DS2 S24B	24DS10 S09B	4DS1 S17B
4	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1 S01D	24A2 S04B	4DS1 S17B	12DS1 S06B	192A1 S34B	24DS2 S19B	4DS1 S17B	24DS3 S11B	48DS3 S22B	24DS4 S07B	4DS1 S17B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 S08B	4DS1 S17B	12DS1 S06B	192A2 E02B	24DS3 T01B	4DS1 S17B	24DS9 S13B	48DS4 S26B	24DS10 S09B	4DS1 S17B
5	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1 S01D	24A2 S04B	4DS1 S17B	12DS1 S06B	192A3 E03B	24DS2 S19B	4DS1 S16B	24DS3 S11B	48DS1 S21B	24DS4 S07B	4DS1 S16B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 S08B	4DS1 S16B	12DS1 S06B	192A4 E04B	24DS8 T01B	4DS1 S16B	24DS9 S13B	48DS2 S25B	24DS10 S09B	4DS1 S16B
6	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1 S01D	24A2 S04B	4DS1 S16B	12DS1 S06B	192A5 S15B	24DS2 S18B	4DS1 S16B	24DS3 S11B	48DS3 S23B	24DS4 S07B	4DS1 S16B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 S08B	4DS1 S16B	12DS1 S06B	192A6 E06B	24DS8 T01B	4DS1 S16B	24DS9 S13B	48DS4 S27B	24DS10 S09B	4DS1 S16B
7	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1 S01D	24A2 S04B	4DS1 S16B	12DS1 S06B	192A7 E05B	24DS2 S18B	4DS1 S17B	24DS3 S11B	48DS1 S20B	24DS4 S07B	4DS1 S17B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 S08B	4DS1 S17B	12DS1 S06B	192A8 S14B	24DS3 T01B	4DS1 S17B	24DS9 S13B	48DS2 S24B	24DS10 S09B	4DS1 S17B
8	2DP1 D01B	2DP2 D02B	2DP3 Note 4	2DP4 Note 1	24DS1 S10B	24A1 S01D	24A2 S04B	4DS1 S17B	12DS1 S06B	192A9 S29B	24DS2 S19B	4DS1 S17B	24DS3 S11B	48DS3 S22B	24DS4 S07B	4DS1 S17B
	2A1 C03B	2A2 D12B	2DP5 Note 2	2DP6 Note 5	24DS7 S12B	24DS5 S02D	24DS6 S08B	4DS1 S17B	12DS1 S06B	192A10 S30B	24DS8 T01B	4DS1 S17B	24DS9 S13B	48DS4 S26B	24DS10 S09B	4DS1 S17B

TABLE 3. (Page 2 of 2)

Note 1

2DP4, 1	Command Val. Word	- C01B
2		
3		
4		
5	Subsatellite I.D.	- D04B
6	R/T or Dump Data Format	- D05B
7	Data Dump Auto or Manual	- D06B
8	Calib. ON/OFF	- D07B

Note 2

2DP5, 1	Rx Signal Present	- C02B
2	Undervolt. Bypass IN/OUT	- E08B
3	Spare	
4	Spare	
5	Spare	
6	Spare	
7	Spare	
8	Spare	

Note 3

192DP1, 1	Magnetometer R_t Range I.D.	- S05B
2	Telescope I.D.	- S28B
3	Magnetometer Rp Range	- S31B
4	Bit Rate	- D11B
5	Sun Sensor Polarity	- T05B
6	PHA Threshold	S32B
7	Spare	
8	Spare	

Note 4

2DP3, 1	Sync Word 3 - D03B	A
2		
3		
4		A
5	Frame Count - D10B	A
6		
7		
8		

Note 5

2DP6, 1	Spare
2	Spare
3	Spare
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare

A