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TENTH QUARTERLY PROGRESS REPORT
FOR THE
APPLICATIONS TECHNOLOGY SATELLITE
GRAVITY GRADIENT
STABILIZATION SYSTEM

1 NOVEMBER 1966 THROUGH 31 JANUARY 1967

CONTRACT NO. NAS 5-9042

FOR THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

Emphasis was directed toward implementing the handling of flight data in preparation for the launch of ATS-A. These efforts included interface meetings at NASA/Goddard to establish data formats and procedures for the Quick-Look system wherein on-line attitude computations will be done on the GE Desk Side Computer from near real-time attitude data. An area in the GE Space Technology Center has been designated as the "ATS Flight Analysis Room" and teletype facilities to and from Goddard, and to and from the GE Desk Side Computer facility, in nearby Penn Park, are being installed.

A schedule was established for publication of the five volume Orbit Test Plan which was originally outlined on pages 2-4 through 2-11 of the Seventh Quarterly Progress Report. This plan will serve the double purpose of providing NASA with a recommended plan for orbital operations, as well as a comprehensive summary of the software aspects of the ATS program.

The first flight unit Primary Boom Systems (S/N 101 and 102) were acceptance tested at GE and shipped to the vehicle contractor on 24 December 1966, thereby completing delivery of the ATS-A gravity gradient stabilization system.

Attempts to uncage the Flight Unit S/N 10 Primary Booms while in the thermal-vacuum test chamber at GE resulted in failure. A plan was carried out to conduct six thermal-vacuum uncaging tests to demonstrate a degree of confidence in the S/N 10 unit. However, retraction anomalies were apparent following exposure to three cycles of cold and hot temperatures and the unit was returned to deHavilland for analysis of these continuing difficulties.

Deployment malfunctions occurred during a series of engineering tests that involved the Prototype Damper Boom (S/N 11). Conclusions reached as a result of these tests included a revised rewind procedure.

Difficulties were experienced during initial functional testing of the Flight 2 CPD. Investigations revealed that an internal misalignment was the cause of the major part of the problem. The unit was disassembled, checked out and reassembled.

Flight Unit TV Camera (S/N 5109) remained as the only camera still to be accepted. Troubleshooting as a result of burn-in test failures revealed a bad vidicon socket and frayed wire in the camera unit. Repairs were undertaken.

The third Flight Unit Solar Aspect Sensor is undergoing acceptance testing.

Presentations of the ATS gravity gradient stabilization system were made to the NASA/LaGow committee members when they visited GE in November 1966, and again in January. The graphic material used in the lectures was printed in GE Document No. 66SD4495 and copies were presented to the members of the committee.

SECTION 1

INTRODUCTION

1.1 PURPOSE

This report documents the technical progress made during the period from 1 November 1966 to 31 January 1967 toward the design and development of Gravity Gradient Stabilization Systems for the Applications Technology Satellites.

1.2 PROGRAM CONTRACT SCOPE

Under Contract NAS 5-9042, the Spacecraft Department of the General Electric Company has been contracted to provide Gravity Gradient Stabilization Systems for three Applications Technology Satellites: one to be orbited at 6000 nautical miles (ATS-A), and two to be orbited at synchronous altitude (ATS-D and ATS-E). Each system will consist of primary booms, damper boom, damper, attitude sensors and the power conditioning unit. In addition to the flight systems, GE will provide a thermal model, a dynamic model, an engineering unit and two prototype units. GE will also supply two sets of aerospace ground equipment.

SECTION 2

SYSTEMS ANALYSIS AND INTEGRATION

2.1 EVENT SUMMARY

Events of significance to systems analysis and integration activities during the months covered by this reporting period are summarized as follows:

27 October	ATS Systems Memo No. 098 issued summarizing recommended installation geometry for Primary Boom system flight tapes; these recommendations were based on data obtained from initial straightness measurements of tapes prior to installation in the deployment units. Installation was specified so as to minimize errors due to non-straightness characteristics.
2-3 November	First NASA Design and Test Audit at GE; charts used in presentations were published as GE Document No. 66SD4495.
14 November	ATS Systems Memo No. 099 issued to update results of Memo No. 098; this was necessitated by replacement of one tape and receipt of new data for the replacement tape; based on the assumption that installation has no effect on initial straightness, the optimum installation geometry results in a 0.3 degree pitch bias and a 0.9 degree yaw bias.
14 November	PIR 41M1-318, "Effect of Hardware Tolerances on ATS-A and D" issued; this shows the effect on damping time of variations in damping coefficient, spring constant, damper moment of inertia, spacecraft moment of inertia and damping axis alignment.
15 November	Telemetry Calibration Book (Nominal Data), Document No. 66SD4525
16 November	ATS Systems Memo No. 100 entitled "ATS Quick-Look Data System" was issued describing, in principle, the physical system to be implemented for quick-look attitude determination.
17 November	Data System Interface meeting at NASA/GSFC; required modifications to SVS-7429 established -- these were subsequently documented in SVS-7429, Revision A. Modifications were primarily concerned with a definition of the GE-POLANG tape, the deletion of POLANG data from the RTDT and the specification of certain ATS-A Data Interface Requirements. Other results of the meeting were summarized in Systems Memo No. 101.

22 November	Direction received from NASA to proceed with the Data Merge Module which merges the GE-POLANG tape with the RTDT.
23 November	Revised system requirements for the ATS Data Simulation Program were documented in PIR 4A26-112.
28 November	"ATS Attitude and Boom Dynamics," PIR 4T45-23, published as "wrap-up" of boom dynamics computer studies.
30 November	List of gravity gradient command interlocks established; 32 commands will be interlocked from launch through orbit injection; in-orbit interlocks are reduced to 5. These are summarized in ATS Systems Memo No. 102.
5 December	Revision A, SVS-7429, "ATS Data Formats" issued through GE Print Control and Reproduction.
6 December	PIR 41M1-321, outlining corrections required in the NASA/GSFC copy of the ATS Math Model, were forwarded to GSFC.
9 December	Received sample Ephemeris Data Tape from R. Chaplick of NASA/GSFC for use in GE data system checkout.
12 December	"Compensation for Shortened Damper Booms and Increased Stiffness of Damper Spring" issued as PIR 41M1-336; this provides the backup analysis for the decision to add 0.4427 pounds (7.08 oz) to each damper boom tip mass.
14 December	GE participation in ATS review at Hughes Aircraft Corporation.
16 December	"Maximum Allowable Rate for ATS Vehicles" issued as PIR 41M1-342; this sets 5 times orbital rate as maximum allowable rate for prevention of damper boom "lockup."
18 December	"ATS Data System Checkout Plan" published to provide guidelines for the completion of GE software checkout.
18 December	"ATS Data Analysis Module (DAM) Fundamental Equations and General Description of the Computer Program" issued as PIR 4411-015.
19 December	"Data System Checkout; Simulation Orbit Definition - Phase I" issued as PIR 4A23-108. This defines the orbit conditions to be used in simulating steady-state flight attitude data.
21 December	"Analysis of GGTS Solar Aspect Sensor Anomaly" issued as PIR 4A23-103. This documents the analysis whereby a flight malfunction within the Adcole Solar Aspect Sensor was identified. On the basis of this analysis, ATS acceptance test requirements were modified to prevent the occurrence of similar anomalies on ATS.

21 December	"Analysis of Calibration Data for two ATS IR Earth Sensors" issued as PIR 4411-018. This summarizes an analysis of test data from Prototype 2 and Flight 1 units against theory. The data appears in good agreement with theory over the principal range of interest with deviations less than 0.5 degrees. Anomalistic behavior in the vicinity of -11 degrees was noted.
22 December	Mathematical Model User's Manual, Document No. 66SD4569
22 December	Steady-state performance estimates for ATS-D/E were revised in PIR 41M1-349. Worst-case error estimates (bias plus oscillations) are now stated as 5.4 degrees in pitch, 3.4 degrees in roll and 17.4 degrees in yaw.
23 December	Last of ATS-A flight hardware (Serial No. 101 and 102 Primary Boom systems) shipped to HAC.
28 December	Memo No. 4732-222 issued giving data on final configuration and straightness profiles of S/N 101 and 102 units shipped 23 December. This data confirms the invalidation of assumptions made in prior analyses (Systems Memos No. 098 and 099) that installation of tapes in erection units has no effect on initial straightness measurements. By comparison with previous data, in fact, the installation effects are seen to be of extreme significance. Subsequent analysis of the data in Memo No. 4732-222 indicates a 0.4 degree pitch bias, a 0.8 degree roll bias and a 3.1 degree yaw bias due to initial boom curvature. Solar pressure effects are increased by 0.3 degrees in pitch, 0.2 degrees in roll and 2.5 degrees in yaw due to this initial curvature.
3 January	Decision to convert the GE attitude determination programs back to IBM-7094 computers due to systems difficulties using the GE-635 computers; data system checkout delayed approximately two months (from 1 December 1966 to 1 February 1967).
5 January	Second interface meeting with NASA on orbital operations planning attended by Wolf Research and Development Corporation contractors for NASA's Satellite Schedule Program (SSP).
6 January	Received sample RTDT from P. McKowan for use in GE data system checkout.
9 January	Equations for correction of Quick-Look POLANG data, due to variations in antenna-mount systems, were received from NASA/GSFC. These will be incorporated in the next revision of the Data Formats Specifications.

11 January	"Progress Report on the ATS Quick-Look Math Model Program" issued as PIR 5540-45. This presents the basis for quick-look attitude determination using IR and SAS data only.
12 January	"ATS-A Orbit Operational Procedures (Preliminary)" issued for review by NASA/GSFC prior to publication of final version in Volume II of the Gravity Gradient Orbit Test Plan.
13 January	Model 28 TTY installed in GE flight analysis area for subsequent hookup with the GE/DSCS. This will ultimately provide GE's end of the Quick-Look attitude determination system.
15 January	GE/ATS flight analysis area established.
16 January	"Geophysical Ephemeris Calculations on the GE Desk Side Computer System at MSD" issued as TIS67SD207. This report summarizes a variety of orbit-related information programs which will find frequent application in ATS flight analysis activities.
17 January	"Results of Computer Runs Evaluating Failure Modes" issued as PIR 41M1-365; this corrects data presented in the 29th Monthly Progress Report. If one primary boom pair fails to deploy, the ultimate steady state errors should not exceed 7.1 degrees in pitch and yaw or 2.2 degrees in roll (ATS-A). If one damper boom fails to deploy, the ultimate errors should not exceed 3.0 degrees in pitch, 2.2 degrees in roll or 16.5 degrees in yaw.
17 January	An interface meeting with Westinghouse, to resolve Quick-Look and Class II teletype formats, was held at NASA/GSFC. A decision to transmit only every third frame of data will make the transmission of quick-look data more nearly a real-time operation; the balance of GE data will be available in real time via the class II message route.
18 January	"Capture Runs for ATS-D/E" issued as PIR 41M1-366. This study shows that capture can be achieved rather quickly on ATS-D/E if boom deployment is achieved within 50 degrees of the local vertical. For initial attitudes in excess of 50 degrees, however, tumbling for periods exceeding 400 hours is a natural consequence.
23-24 January	Second NASA Design and Test Audit at GE; charts used in first presentations on 2-3 November were updated and GE Document No. 66SD4495 was reissued.
31 January	"Equations for Determining Boom Deflection from ATS Camera Measurements" issued as PIR 4411-024A.

3 February	Conversion of ATS attitude determination programs to the IBM 7094 computer completed.
9 February	CCN negotiations at NASA/GSFC; quick-look system, additional quick-look programs and new NADT format established by official direction.
9 February	"Allowable Leakage Rates on the Inversion Thruster" published as PIR 41M1-378A. For thrusters with a nominal thrust level of 5.4×10^{-4} pounds and a moment arm of 29 inches on ATS-A, and 7.13 inches on ATS-D/E, the leakage rate for a one degree pitch error is 1.26 percent for ATS-A and 0.85 percent for ATS-D/E. Leakage at rates 20 times as great will induce tumbling.
9 February	"Nominal Hysteresis Contour for the Varying Torque Hysteresis Damper" published as PIR 41M1-380. This PIR reports on a review of prior studies of variable-torque hysteresis dampers and establishes a new contour for recommended use on ATS-D/E. Performance comparisons with the constant-torque hysteresis damper are made.
10 February	Data System Interface meeting at GE-- B. Trudell and R. Chaplick represented NASA in discussions of the GE-POLANG tape and definition of negotiated revisions to the NADT.
12 February	"Recommended ATS-A Orbit Operational Procedures" issued as Volume II of the Gravity Gradient Orbit Test Plan.
13 February	"Effect of Magnetic Dipole of Tip Masses on ATS-A Performance" published as PIR 41M1-385A in response to a NASA request. The 15 pole-cm magnetic dipoles are estimated to produce 0.004 degrees roll error and 0.05 degrees yaw error. The effect on damping is considered even more negligible.
14-15 February	ATS-A Experimenter's Meeting at NASA/GSFC. Significant items of interest are summarized in ATS Systems Memo No. 107.
16 February	"Passive Hysteresis Damper Null Offset," describing the behavior of the hysteresis damper at small angular offsets from null, issued as PIR 41M1-387.
20 February	"Effect of Twist on Straightness Profiles of Molybdenum GG Booms of ATS Configuration" issued as PIR 41M2-122. This demonstrates the extreme sensitivity of straightness profile data to the method used to orient the seam of the overlapped rod configuration and leads to the conclusion that the methods used to obtain the Memo No. 4732-222 data probably produce worst case results on deflection magnitude.
23 February	Model 28 TTY interface with the GE-DSCS completed.

SECTION 3

BOOM SUBSYSTEMS

3.1 KEY EVENTS

1 November 1966	Flight unit No. 1B (S/N 101) Primary Boom acceptance test cycle started at GE.
5 November 1966	Flight unit No. 1A (S/N 10) Primary Boom acceptance test cycle started at GE.
7 November 1966	Prototype Unit No. 1 (S/N 100) Primary Boom returned to deHavilland for failure analysis and subsequent retrofit to ATS-D/E configuration.
6 December 1966	Flight Unit No. 1A (S/N 10) Primary Boom returned to deHavilland for failure analysis and subsequent retrofit to ATS-D/E configuration.
14 December 1966	Hot/cold test track tests completed on Prototype No. 1 (S/N 11) Damper Boom at GE.
15 December 1966	Flight Unit No. 1A (S/N 102) Primary Boom received from deHavilland.
16 December 1966	Flight Unit No. 1A replacement (S/N 102) Primary Boom acceptance test cycle started at GE.
24 December 1966	Flight Units No. 1A replacement (S/N 102) and No. 1B (S/N 101) Primary Booms shipped to HAC.
21 January 1967	Flight I backup (S/N103) Primary Boom received from deHavilland.
24 January 1967	Acceptance test cycle started at deHavilland on Flight Unit No. 2 (S/N 101) Damper Boom.

3.2 UNIT DESIGNATION

The designations and use of the Primary and Damper Boom Systems are listed in Table 3-1.

Table 3-1. Boom System Identification

Designation		Serial No.	Use
Engineering Units			
T-1A	Primary Boom	S/N 2	
T-1B	Primary Boom	S/N 3	
T-1	Damper Boom	S/N 2	
Prototype Units			
P-1	Primary Boom	S/N 100	Component Qualification
P-2A	Primary Boom	S/N 11	System Qualification
P-2B	Primary Boom	S/N 12	System Qualification
P-1	Damper Boom	S/N 11	Component Qualification
P-2	Damper Boom	S/N 12	System Qualification
Flight Units			
F-1A	Primary Boom	S/N 102	Flight Unit, ATS-A
F-1B	Primary Boom	S/N 101	Flight Unit, ATS-A
F-1(BU)	Primary Boom	S/N 103	Flight Unit, ATS-A
F-2A	Primary Boom	S/N 104	Flight Unit, ATS-D/E
F-2B	Primary Boom	S/N 105	Flight Unit, ATS-D/E
F-3A	Primary Boom	S/N 10	Flight Unit, ATS-D/E
F-3B	Primary Boom	S/N 103	Flight Unit, ATS-D/E
F-1	Damper Boom	S/N 100	Flight Unit, ATS-A
F-2	Damper Boom	S/N 101	Flight Unit, ATS-D/E
F-3	Damper Boom	S/N 102	Flight Unit, ATS-D/E

3.3 PRIMARY BOOMS

3.3.1 ENGINEERING UNITS

3.3.1.1 Engineering Unit T-1B (S/N 3)

Primary Boom S/N 3 is presently undergoing retrofit to the ATS-D/E configuration tip masses for preliminary vibration tests prior to receipt of ATS-D/E flight hardware from deHavilland. In conjunction with the heavier tip masses (8.0 pounds as compared to 2.5 pounds) of the

ATS-D/E configuration, a spring plate reinforcement is being incorporated into the S/N 3 unit. Basis for incorporation of this reinforcement was obtained from a structural analysis conducted by GE on the adequacy of the present spring plate configuration for the ATS-D/E tip mass requirements. A review of the vibration records obtained during T-1A engineering testing indicated that the maximum response of the ATS-A tip mass was 50 g's along the critical axis. There can be no guarantee that the same response will be obtained when testing the ATS-D/E configuration, but a deviation of at least 25 percent should be expected. Based on this assumption, the results of a conservative analysis indicate that the current plate will have excessively high deflections in the area where the attachment of the 0.005-inch retaining spring is made. These deflections will cause an indeterminate nonuniform stress to be introduced which may be high enough to precipitate failure at the 0.03-inch bend radius of the spring. If a reasonably stiff spring plate is provided, the stresses calculated for the spring are 66,500 psi tensile and 22,000 psi bending which are acceptable for the material being used (410 SS). Along with the ATS-D/E changes being incorporated into the S/N 3 unit, Delrin standoff rings are also being mounted on the erection units. These Delrin standoff rings will be incorporated into Flight 2 and 3 Primary Booms. The polycarbonate standoff rings presently installed in the Flight I (ATS-A) Primary Booms experienced some crazing at the polycarbonate housing mounting holes during the final testing of the Flight I units at GE, and the decision was made to select another material for Flights 2 and 3 which would not exhibit this peculiarity. A preliminary qualification level vibration of T-1B with one Delrin housing installed showed no significant degradation of the housing.

3.3.1.2 Engineering Unit T-1A (S/N 2)

All planned tests involving the T-1A primary boom have been completed, and the unit is retained by deHavilland awaiting disposition from NASA/GSFC.

3.3.2 PROTOTYPE UNITS

3.3.2.1 Prototype Unit P-1 (S/N 100)

At the completion of the planned environmental portion of the component qualification program involving the S/N 100 primary boom, two anomalies were evident: (1) the sealed enclosure that is maintained at a pressure of 7.5 psi was found to be leaking; and (2) the boom deployment motor stalled during retraction on the test track. A plan was implemented to troubleshoot both problems at GE prior to returning the unit to deHavilland for complete failure analysis (see Failure Analysis 264-E-30).

3.3.2.1.1 Enclosure Leak

The S/N 100 unit was utilized as an evaluation vehicle for exploratory deployment tests prior to efforts to pinpoint the leak location. A review of the qualification test data revealed that the leak was first evident in the thermal/vacuum cycle, although it was not discovered until the unit had soaked at ambient pressure and temperature for several days. The unit was pressurized with helium and sniff tests revealed that the leak was near the hermetically sealed connector that penetrates the pressure wall behind the wire duct. The connector is brazed to the wall of the enclosure and guaranteed by the manufacturer to be leakproof. The unit was subsequently returned to deHavilland with instructions to repair the leak during the retrofit to ATS-D/E.

3.3.2.1.2 Retraction Anomaly

Troubleshooting of the anomaly at GE revealed that the upper bearing on the sealed drive eccentric input shaft was approaching the point of seizure. The retraction anomaly on the S/N 100 unit is currently under investigation and analysis at deHavilland concurrent with a somewhat similar retraction anomaly investigation on the S/N 10 primary boom. Preliminary results of these analyses are summarized in Section 3.3.4.1. Upon completion of this investigation, the S/N 100 unit will be fully inspected, rebuilt to the ATS-D/E configuration and resubmitted to the qualification test program.

3.3.2.2 <u>Prototype Units P-2A (S/N 11) and P-2B (S/N 12)</u>

The P-2A and P-2B Primary Boom units are designated as the system qualification units. They are at HAC for evaluation with the ATS spacecraft. They have been subjected to functional tests while mounted in the spacecraft; vibration, thermal/vacuum and acceleration tests. A status of these units is presented in Section 6.

3.3.3 FLIGHT UNITS

Both F-1A (S/N 10) and F-1B (S/N 101) units were delivered to GE with the enclosure covers unwelded after rework at deHavilland and at GE, and were subjected to a vibration test and short functional test prior to welding the covers in position. The subsequent F-1A replacement (S/N 102) was delivered in the same condition. However, the prewelding vibration test was eliminated due to a pressing delivery schedule.

Justification for this test elimination was that no prewelding problems in the transmission unit were encountered as a result of vibration on previous units submitted to this manufacturing sequence at GE. All three units were subsequently subjected to the acceptance test procedure in accordance with the applicable GE standing instruction. The test cycle to which these units were committed included the following:

a. Visual mechanical inspection

b. Circuit isolation and DC resistance

c. Insulation resistance

d. Leak test

e. Short extension and retraction

f. Short scissor test

g. Thermal/vacuum uncagings

h. Circuit isolation and DC resistance

i. Insulation resistance

j. Electrical isolation (S/N 102 only)

k. Leak test

l. Short scissor test

m. Full extension and retraction

n. Straightness and alignment

3.3.3.1 Flight Unit F-1A (S/N 10)

The S/N 10 Primary Boom encountered unsuccessful uncaging attempts during the initial thermal/vacuum tests at GE in the above test cycle after being reworked at deHavilland for the retraction anomaly outlined in Failure Analysis 256-E-27. The highlights of this anomaly are presented on page 3-11 of the Ninth Quarterly Report and essentially were attributed to a misalignment and cocking of the uppermost bearing on the sealed drive eccentric input shaft.

The first attempt at uncaging in cold thermal/vacuum was unsuccessful due to improper installation of the test cable. Failure during the second attempt at uncaging in cold thermal/vacuum resulted in only one tip mass becoming uncaged on command. Subsequent investigation revealed several tip mass discrepancies contributing to the failure. Corrective action consisted of deepening the slot in the latching cable locking sleeve, realigning the spigot and shaft to achieve looseness relative to each other, loosening the boom mounting screws, and lubricating the tip mass sliding surfaces with molykote.

A plan was formulated to conduct six thermal/vacuum uncaging tests to demonstrate a degree of confidence in the S/N 10 unit; three tests were conducted at cold temperature and three at hot temperature and all tests were successful. During subsequent deployment tests, S/N 10 again experienced a retraction anomaly (Reference Failure Analysis 269-E-33). Investigation by deHavilland at GE revealed a loose conical housing on the sealed drive binding against an adjacent gear in the extension drive train. Rework at GE by deHavilland to correct this situation improved the performance but retraction on the test track was still unsatisfactory. This unit was returned to deHavilland where it is currently undergoing extensive investigation and analysis concurrent with a somewhat similar retraction anomaly investigation on the S/N 100 Primary Boom. This unit has been replaced on Flight 1; S/N 102 is now designated as F-1A. S/N 10 eventually will be fitted with ATS-D/E tip masses and will be designated as F-3A. Preliminary details of the deHavilland failure analyses on S/N 10 and S/N 100 are presented in Memos 4732-228 and 4732-229. Correlation of the findings of these two investigations is also presented in Memo 4732-228 and essentially indicates that both units contain lower sealed drive bearings which have been excessively loaded during testing. The S/N 10 unit lower bearing overload appears to be a combination of operation with the previously cocked upper bearing and loose conical housing, and an interference of the polycarbofil gear with the polycarbonate housing experienced while attempting to deploy at minimum scissor angle. The S/N 100 unit lower bearing overload appears to be a combination of an interference of the polycarbofil gear with the polycarbonate housing, experienced while attempting to deploy at minimum scissor angle, and is also due to excessive loads applied during engineering type dynamic uncaging and unlatching force tests conducted after completion of the thermal/vacuum tests of the qualification program.

3.3.3.2 Flight Unit F-1B (S/N 101)

Environmental testing was successfully completed and flight elements were installed and tested prior to encountering the thermal/vacuum uncaging problems on the S/N 10 unit. Shipment was delayed pending resolution of the S/N 10 unit uncaging problems. Subsequent loss of the S/N 10 unit due to its return to deHavilland necessitated removal of the flight elements and installation of work elements to evaluate tip mass modifications deemed necessary to preclude future uncaging difficulties in thermal/vacuum as encountered on S/N 10. A series of 100 uncagings after incorporation of these tip mass modifications resulted in reduction of the caging voltage requirement from 26 vdc to 18 vdc to insure proper uncagings upon command. The flight elements were reinstalled and retested prior to shipment to the S/N 101 unit to HAC on 24 December 1966. Since completion of the environmental testing at GE, this unit has undergone 20 full deployments on both the test track and water tank. These tests demonstrated with a degree of confidence that this unit is not experiencing either retraction anomaly encountered on the S/N 10 and S/N 100 units.

3.3.3.3 Flight Unit F-1A Replacement (S/N 102)

Environmental testing on the S/N 102 unit was successfully completed. Flight elements were installed and completely tested prior to shipment to HAC on 24 December 1966. The tip mass modifications deemed necessary to preclude future uncaging difficulties in thermal/vacuum as encountered on S/N 10, were incorporated immediately after electrical checkout upon receipt of the unit from deHavilland on 15 December 1966. Since these modifications were installed, 20 successful uncagings have been performed and 10 full deployments have been conducted on both the test track and water tank. These tests demonstrate with a degree of confidence that this unit is not experiencing the uncaging and retraction anomalous conditions which beset the S/N 10 and S/N 100 units.

3.3.3.4 Flight Units F-2A (S/N 104) and F-2B (S/N 105)

These flight primary booms are in the manufacturing cycle at deHavilland. Upon successful completion of the ATP, these units will be placed in bonded storage at GE for later delivery.

3.3.3.5 Flight Unit F-3B (S/N 103)

This unit is presently undergoing welding of the enclosure cover at GE after having been received from deHavilland on 21 January with ATS-A tip masses installed. Upon successful completion of the ATP, this unit will be placed in bonded storage at GE as a backup unit for Flight 1. After Flight 1, this unit will be returned to deHavilland for retrofit to the ATS-D/E configuration.

3.4 DAMPER BOOM

3.4.1 ENGINEERING UNIT T-1 (S/N 2)

All planned tests involving the T-1 damper boom have been completed, and the unit is retained by GE awaiting disposition from NASA/GSFC.

3.4.2 PROTOTYPE UNITS

3.4.2.1 Prototype Unit P-2 (S/N 12)

The P-2 damper boom is designated as the system qualification unit. The unit is at HAC for evaluation with the ATS spacecraft. It has been subjected to vibration, thermal/vacuum, and acceleration tests while mounted in the spacecraft. A status of this unit is presented in Section 6.

3.4.2.2 Prototype Unit P-1 (S/N 11)

Deployment malfunctions occurred during a series of engineering tests of the Prototype Damper Boom (S/N 11). These tests followed completion of the formal qualification program, and were performed to provide backup information. The deployment tests were preceded by a qualification flight level random vibration test performed to determine the effect of possible tape looseness on the drum under simulated test launch conditions.

Deployment tests were performed at ambient, hot (87.8°C), and cold conditions. The first two cold tests were performed at -59°C. The third cold test was performed at -47.8°C following revision of temperature requirements. Manual release was used for the ambient test; squib fire release (flight configuration) was used for both hot and cold tests which were performed in an enclosure.

3.4.2.2.1 Test No. 1 History

Deployment at ambient was successfully performed on 12 November 1966. As a result of the preceding random vibrations, Element No. 2 was very loose on the drum while Element No. 1 was tight. Initial difficulty in deployment of Element No. 1 was resolved when misalignment of the ball lock piston was corrected. Both elements subsequently deployed satisfactorily.

3.4.2.2.2 Test No. 2 History

The hot deployment test was performed on 23 November 1966. Element No. 2 deployed satisfactorily; Element No. 1 deployed approximately 16 feet and then stopped. If was found that the trolleys had been interchanged through operator error, resulting in misalignment of the respective oscillation dampers. In addition, the No. 1 rewind gear had unscrewed two turns during deployment, causing binding of the rewind shaft bearing. The oscillation dampers were removed. Binding of the bearing was relieved by tightening the rewind gear and loosening the side support plate. Both elements then deployed satisfactorily.

3.4.2.2.3 Tests No. 3 and 4 History

Cold deployment tests were performed on 1 December and 7 December 1966. On the first test, a heavy layer of frost formed on the unit. On the second test, a vinyl bag was placed around the chamber and dry nitrogen gas was passed through the enclosure to remove the moisture. However, a light layer of frost formed on the unit. On both tests, the elements deployed a few inches and stopped. The test equipment was readjusted but full deployment could be attained only with manual assistance. On both tests, a configuration with one rewind gear and one straight standoff on each trolley was used. The rewind gear shaft threads into the end of the drum shaft and rotates with it. The straight standoff is a rigid support bolted to the side of the tip mass and aligned with the bore of the drum shaft bearing by means of a mating pilot diameter. Both are part of the test equipment; they support the tip mass at bearings in the trolley side plate and allow it to tilt slightly during deployment. Between the tests, the unit was disassembled and the brakes and brake linings were inspected and cleaned. A small amount of black debris was removed. A small tear was also found in Element No. 1.

3.4.2.2.4 Test No. 5 History

A third cold deployment test was performed on 14 December 1966. The test trolley configuration was modified to place two straight standoffs on the No. 2 trolley. Both rewind gears were placed on the No. 1 trolley. The purpose of the test was to verify that the test equipment rewind gears were the cause of the deployment malfunctions. Deployment of Element No. 2 (supported on straight standoffs) was satisfactory.

3.4.2.2.5 Analysis

The initial deployment difficulty on the ambient test was caused by malfunction of the manual release mechanism. The ball lock piston was used without the spring and housing attached, permitting misalignment of the piston. This prevented normal manual release. Manual operation of the ball lock piston was repeated, resulting in successful deployment.

On deployment, the tip masses tend to assume a tipped position. The oscillation dampers are positioned differently on the two trolleys to match the normal orientation of the tip masses. Interchanging the trolleys at the start of the hot test forced the tip masses into a position which caused binding.

Binding of the drums may also be caused by the rewind gear and bearing. This occurs if the rewind shaft is not aligned with the drum axis, or if the rewind shaft bearing (located in the side plate) is not aligned with the drum bearings.

Disassembly and cleaning of the brake area after the first cold test showed that only a small amount of wear products had accumulated from brake operations. This is normal; cleaning had no apparent effect on deployment.

Preparation for the cold tests included vacuum drying the unit. The heavy coating of frost formed on the unit on the first test restricted deployment to two inches. The drying procedure was improved on the second test by enclosure of the test setup with a vinyl cover and purging with dry nitrogen, but this was still not completely effective. Castor oil used in the oscillation dampers congealed at low temperature and its use was discontinued after the first cold test.

On the third cold test all frost was eliminated by prolonged vacuum drying, protection from moisture during handling, and careful purging of the test enclosure. The test setup was significantly changed by removing both rewind gears from the No. 2 trolley, and also by the use of two straight standoffs to support the tip mass. This eliminated binding due to misalignment of the rewind gear shaft and bearing. Satisfactory deployment under this condition was demonstrated.

The tapes were found to be damaged, probably from handling and prolonged use. When deployed, a section of Element No. 1 did not close completely due to ripple, edge wrinkles, and possible fatigue. A small tear existed near the tip mass. Element No. 2 was wrinkled approximately 6 inches from the center body.

The four drum bearings were tested on a "smootherator". There was no evidence of excessive damage or contamination. The condition of the bearings was as expected from normal operation.

3.4.2.2.6 Conclusions

Looseness of tape on the drum did not cause deployment difficulty at ambient. The initial difficulty was due to operator error in misalignment of the ball lock piston.

Hot deployment was considered to be successful. The hangup of Element No. 1 was due to binding of the rewind gear, which was a test equipment malfunction.

It is essential to eliminate moisture and frost from the unit and test enclosure by following correct drying, pruging, and handling procedures as provided in TR 11258 and TR 11267.

On any additional testing, the method of attachment of the unit to both test trolleys should be modified by replacing the rewind gear shaft by rigid standoffs. Test Report 11280 was issued to provide parts. The oscillation dampers should be removed and counterweights used for cold test. Cold deployment was satisfactory under these conditions. The wear product accumulation in the brake area was apparently a result of normal operation and did not contribute to deployment failure.

As a secondary factor, wrinkling and damage to the tapes may have contributed to deployment difficulty.

3.4.2.3 <u>Flight Unit F-1 (S/N 100)</u>

The Flight 1 unit is presently mounted on the Flight 1 CPD within the spacecraft at HAC and is undergoing spacecraft acceptance testing.

3.4.2.4 <u>Flight Units F-2 (S/N 101) and F-3 (S/N 102)</u>

Flight 2 Damper Boom is presently undergoing ATP at deHavilland and Flight 3 Damper Boom is in the manufacturing cycle at deHavilland. Upon successful completion of the ATP, these units will be placed in bonded storage at GE for later delivery.

SECTION 4

COMBINATION PASSIVE DAMPER

4.1 STATUS OF HARDWARE

a. Flight No. 1. Modification kit for adding additional mass to the damper boom tip weights was completed and shipped to HAC. Additional weight is 7.07 ounces per tip weight.

b. Flight No. 2. Unit is being reassembled following readjustment of torsional restraint magnet flux densities.

c. Flight No. 3. Unit is in final assembly.

4.2 REPORTS

Engineering Report (PIR 41M2-097) has been completed. The report details the development of the CPD, including a summary of engineering testing and the effect on the design.

4.3 TESTING AND TEST RESULTS

4.3.1 FLIGHT NO. 2

Difficulties were experienced during the initial functional testing of the CPD. The problem areas were in limited rotational travel of the Passive Hysteresis Damper and high torsional restraint values for the Eddy Current Damper. Investigation into the problems revealed that an internal misalignment was the probable cause of the PHD problem and that improper inprocess magnet flux density adjustment (flux was too high) caused the ECD problem. Investigation of these problems eventually necessitated a major disassembly of the CPD. The unit is now being reassembled.

SECTION 5

ATTITUDE SENSOR SUBSYSTEM

5.1 TV CAMERA SUBSYSTEM

5.1.1 ENGINEERING UNITS

The specification and drawings of the TVCS were revised and reissued to reflect the latest configuration. The engineering report was written and issued. The life testing on Engineering Units 5101 and 5102 was discontinued. The video for Engineering Unit Serial No. 5101 degraded to the point where it was useless and readjustment of the electronics did not help to provide a useful video. The unit had approximately 200 hours of operating time prior to being placed on life test and it had accumulated 1573.5 hours before the video first degraded. It was then readjusted and it ran for an additional 936 hours before the test was halted. The unit was then used for a series of special dipole tests and placed in storage. The power to the camera was applied (and removed) approximately 200 times during the testing of the unit.

Serial No. 5102 video degraded and the life test was halted after a total of 2646 hours of life test time. This was the second failure during the life test. The camera video was lost after 386.7 hours when the video output transistor shorted. The component was replaced and the unit operated an additional 2260 hours before the video degraded: power was applied (and removed) about 500 times on this unit. The unit is presently in storage.

Engineering Unit Serial No. 5103 is being maintained by engineering as an aid in trouble-shooting potential problems which may occur on the flight cameras and to verify the storage time limits set on flight cameras between applications of power to the units.

Engineering has directed Quality Control to apply power to the flight cameras, being stored for Flights No. 2 and 3, at 50-to 60-day intervals. This will prevent the vidicons from becoming too gaseous, and provide testing the shutter mechanism. A test report has been added to the applicable standing instruction to provide the testing details.

5.1.2 COMPONENT QUALIFICATION UNIT

TVCS Serial No. 5104 has successfully passed the qualification test and no further testing is being done on this unit. The Quality Control report has been issued on the test results and the TVCS is considered qualified.

5.1.3 FLIGHT UNITS

Two units (Serial No. 5110 and 5107) were shipped to HAC on 29 October 1966 for use on the first flight spacecraft. Serial No. 5107 had two shorted telemetry outputs. The unit was taken to Lear-Siegler and reparied, tested, and found satisfactory. Both units had the control unit compression pads changed at HAC by GE personnel. The change was required because the black sponge rubber contained an excessive amount of sulfur. The new material is a polyurethane sponge. Both units satisfactorily passed the post rework testing.

TVCS No. 5108 successfully passed the acceptance testing at GE and is presently in storage. All design changes were incorporated into this unit prior to the start of the final acceptance test.

TVCS No. 5109 failed in the burn-in test. The unit was returned to Lear-Siegler and trouble-shooting revealed a bad vidicon socket and a frayed wire in the camera. The unit was returned to GE and the burn-in test was completed with two additional failures: the resistor in the temperature telemetry circuit of the camera failed; and the sun sensor for the sun shutter mechanism degraded in sensitivity. The resistor and sun sensor mechanism were replaced and testing was resumed. The repaired items successfully passed testing, however the video signal was not present. Troubleshooting and repair is presently being accomplished. It appears that the first stage of video amplification is out--transistor Q101. Upon repair of this problem, the TVCS will resume functional testing and will be placed in storage.

5.2 SOLAR ASPECT SENSOR

5.2.1 EQUIPMENT STATUS

5.2.1.1 Flight 2 System (F0-5)

At the start of this reporting period, the Flight 2 SAS was undergoing acceptance tests at GE. Apparent anomalies in the operation of the detectors were traced to "walking" of the arc in the solar simulator xenon lamp. The lamp was replaced, and the acceptance tests proceeded without incident; testing was completed during the last week of November. For the first time, the acceptance tests included checks of system operation with pairs of detectors illuminated. The purpose of this test is to assure that there has been no electronic failure which would cause improper switching of detector identification and sun angle output signals. This type anomaly occurred on the Gravity Gradient Test Satellite (GGTS), and was investigated as described on Page 5-5 of the Ninth Quarterly Progress Report. The equipment set-up for this test is shown in Figure 5-1. The test requires that, as long as the system identifies the detector on the rotary table as "most illuminated", there be no change in the angular readout at nominal sun angles of 30 and 60 degrees. The type anomaly seen on GGTS is detectable by this method. While a given detector is on the rotary table, each of the other four detectors is illuminated in turn at an intensity below one solar constant, and the required performance verified.

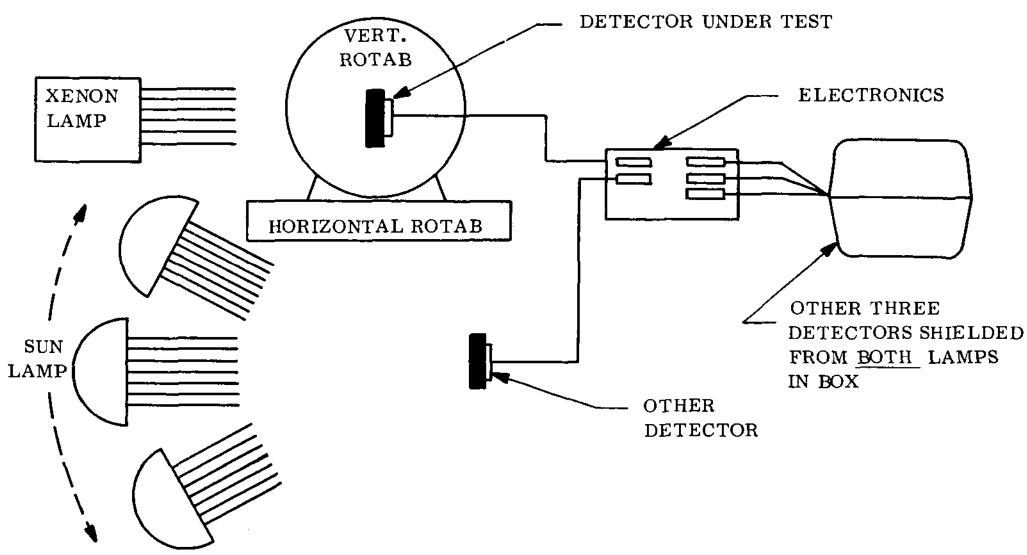

Figure 5-1. SAS Detector Identification Test Setup

The process is repeated as each of the five detectors undergoes complete functional test on the rotary table, thus assuring that all possible combinations of two illuminated detectors are checked.

The Flight 2 SAS has been placed in bonded stock. The long term storage requirements have been determined through contacts with the vendor, and the unit will be packaged accordingly in the near future.

5.2.1.2 Flight 3 System (F0-3)

The Flight 3 SAS was delivered to GE during the first week in January, and acceptance testing began the following week. During the first functional test, it was noted that a voltage generated within the electronics unit was not within specified limits, although system operation was otherwise normal. After a discussion with the vendor, a decision was made to return the system to the vendor (Adcole) for re-test and evaluation. At the same time, the vendor has been directed to interchange the electronics unit case of the Flight 3 system with that of the PO-3 prototype (which is also being provided to them) since a small crack was detected in the Flight 3 case. A date for re-delivery of the Flight 3 SAS will be scheduled.

Upon completion of the final acceptance test, this system will also be packaged for long term storage and placed in bonded stock.

5.2.2 DESIGN EVALUATION

Evaluation of the SAS for use on the ATS is complete and no further activity is anticipated in this area.

5.3 POWER CONTROL UNIT

The first flight unit PCU was shipped to HAC in October, and the remaining two flight units were successfully acceptance tested. The units were assigned to bonded storage at GE where they will be inspected periodically to ensure their flight worthiness.

SECTION 6

GROUND TESTING

6.1 ENGINEERING EVALUATION TESTS

During the past quarter, component engineering testing was limited to the areas described below:

6.1.1 PRIMARY BOOMS

Tests involving the Primary Boom Engineering Units have been completed.

6.1.2 DAMPER BOOM

Tests using the Damper Boom Engineering Unit have been completed.

6.1.3 TV CAMERA

The life testing on the Engineering Unit cameras (S/N 5101 and 5102) was discontinued and no plans exist for resuming these tests. Camera No. 5101 accumulated more than 1570 hours, and Camera No. 5102 accumulated almost 2650 hours of operation before the video of both systems degraded. These tests were begun in the Spring of 1966.

6.1.4 POWER CONTROL UNIT

Tests involving the PCU Engineering Unit have been completed.

6.1.5 SOLAR ASPECT SENSOR

All scheduled testing with the use of the Engineering Unit SAS has been completed.

6.1.6 COMBINATION PASSIVE DAMPER

Testing involving the Engineering Unit CPD has been completed.

6.2 COMPONENT QUALIFICATION

Test instructions have been completed for qualification and acceptance testing of the ATS components. Table 6-1 summarizes the test procedure activity during the past quarter.

Table 6-1. Qualification Test Instructions*

Component	Document Available	ITPB Review	NASA Approval
Solar Aspect Sensor	1/19/66	2/15/66	4/20/66
TV Camera	2/3/66	3/16/66	4/20/66
Combination Passive Damper	2/25/66	3/24/66	4/20/66
Power Control Unit	2/7/66	2/25/66	4/20/66
Damper Boom	2/14/66	3/29/66	4/20/66
Primary Boom	7/25/66	8/1/66	9/2/66
*Also applicable to flight acceptance test instructions			

The component qualification hardware program is summarized in Table 6-2.

Table 6-2. Qualification Program Summary

Component	Qualification Status	Remarks
PCU	Test Completed	Test Report No. 4315-QC-003 issued 7/14/66
Damper Boom	Test Completed	Test Report in process
CPD	Test Completed	Test Report issued 1/16/67
SAS	Test Completed	Test Report 4315-QC-007 issued 8/31/66
TV Camera	Test Completed	Test Report No. 4315-QC-021 issued 1/13/67
Primary Booms	Tests in Process	See Section 3 for problem discussion.

6.3 SYSTEM QUALIFICATION

The low temperature thermal-vacuum test on the system qualification ATS vehicle was completed on 1 November. The thermal-vacuum test was in a hold status pending further direction from NASA. The hold permitted the flight unit TV camera system in the gravity gradient attitude sensing system and the flight unit CPD to be checked with the EPC.

The system test on the Y2 qualification spacecraft was resumed on 9 November, and the hot temperature-vacuum test was completed. After the chamber was vented, the live squibs on the Primary Boom B package were fired and a successful boom actuation was performed, which included boom extension, retraction and scissoring.

Pump-down of the chamber was started on 13 November as a preparation for the solar vacuum test. However, the mechanical test equipment that rotates the spacecraft in the chamber broke down during the Phase I condition of the test (i.e., where the spacecraft is maintained at 0 degrees tilt relative to the sun). The test was discontinued after unsuccessful attempts to correct the mechanical problem.

During the short form test of 15 November, two problems occurred:

a. Forty percent of the video picture from Flight A Camera 2 was lost during transmission. As displayed on the scope, the video signal showed the vertical sync pulse had a period of 11 milliseconds; the correct period should be 17 milliseconds.

b. IR sensors 1 and 2 failed to produce a satisfactory video signal. The 7-pulse 5 kHz burst, which serves as a sync pulse for the video signal, appeared as a single pulse of approximately 1.5 milliseconds. The sync pulses did repeat with the proper 400 millisecond period.

The temperature of these units was measured during these tests and it was found that the TV cameras were between 30 to 46°F and the IR sensors were 20 to 40°F. The spacecraft was removed from the chamber and the tests were repeated at ambient conditions, but the problems with the TV camera and IR sensors could not be repeated; all units were successfully tested.

The system solar vacuum test of the qualification spacecraft was restarted on 17 November. A short form test was conducted with the following results.

a. Primary Booms A and B were successful including extension, retraction, and scissoring of each boom plus simultaneous operation of both booms.

b. Good telemetry was received from the damper, SAS, and damper boom.

c. TV video signal from the repeater was poor; however, a hard wire line from the camera displayed on the scope was good. The problem might have been due to the directional characteristics of the repeater antenna that was used in the test.

d. The IR sensor still exhibited the intermittent loss of the 5-kHz bursts on the sync pulses.

The system solar vacuum test was completed on 25 November, and a short form test was successfully completed two days later.

Mechanical check of the prototype spacecraft alignment after system vibration and solar vacuum testing was completed in December.

It was decided to cage the booms on the spacecraft at -18 volts instead of the original requirement of -30 unregulated volts. HAC confirmed that -18 volts can be furnished to the boom package during the caging operation. An input was furnished to the Hughes Aircraft Company for inclusion in the flight test plan pertaining to the -18 volt caging requirement.

The NASA Review Committee sessions on the Y2 spacecraft were completed on 20 December 1966 at Hughes Aircraft Company.

The pre-acceleration system functional test at Sandia was completed on 14 January for the prototype spacecraft. During this checkout, one of the mirrors on the earth sensor was found to be inoperable. All other gravity gradient hardware was successfully tested. A decision was made to accelerate the spacecraft without removing the fautly earth sensor. NASA concurred with this decision.

The spin tests were completed at Sandia on 16 January. Post-acceleration functional tests were completed on 17 January with the following results. All gravity gradient components were successfully operated with the exception of one of the earth sensors. This earth sensor

X-axis mirror still was inoperable as previously found during the pre-acceleration tests. A check of the "g" switches that were mounted in the trailer during the trip from HAC to Sandia revealed the 2g switch was activated and the 5g switch was not activated. A failure analysis will be conducted on the faulty earth sensor to localize the exact problem.

Plans have been formulated to perform live squib firings at HAC on the system prototype spacecraft at the completion of the qualification testing. The damper will have live squibs installed and then fired. The damper boom circuitry has live squibs fired into a expended piston assembly thereby permitting the damper boom to be returned to GE in a caged position where a functional test will be performed.

The system qualification spacecraft (Y2) was returned to HAC after undergoing acceleration tests at Sandia. One of the earth sensors (SN 001) was removed from the spacecraft on 24 January. This unit was hand carried by Mr. Austin of NASA to ATD for failure analysis of the inoperable mirror. Preliminary report from ATD on 25 January indicates a broken flexure pivot.

Live squibs were shipped to HAC to perform uncaging tests of the prototype damper and damper boom circuitry.

On 13 February 1967 live squib firings on the CPD and the Damper Boom were completed. All the tests on the Damper Boom and CPD went perfectly. Both squibs fired on the first command in each instance. The Angle Indicator in the CPD was tested and performed exactly as required. At the completion of the tests, the Damper Boom was secured and the CPD was manually caged in preparation for the shipment to GE for detailed testing.

6.4 FLIGHT ACCEPTANCE AND AGE

6.4.1 STATUS

All flight acceptance test instructions have been approved by NASA/GSFC. The document number (Standing Instructions) and NASA approval dates are:

Unit	SI	NASA Approval Date
Primary Boom	237,037	9/2/66
Damper Boom	*DHC-SP-ST.110M	4/20/66
CPD	237,016	4/20/66
TV Camera	237,013	4/20/66
SAS	237,012	4/20/66
PCU	237,015	4/20/66

*deHavilland document

During November 1966, the Flight No. 2 TV Camera Subsystem was checked with the EPC (Experimenter's Console) and a short was found in the electronics package. The unit was sent to Lear-Siegler for repairs and returned to HAC after correcting the problem. The flight TV cameras were successfully checked with the EPC on 29 December 1966.

Both flight Primary Booms were successfully checked out at HAC on 28 December 1966 using the EPC. During checkout, a test problem occurred; subsequent troubleshooting revealed the problem was in the HAC console.

The initial system functional test of ATS-A flight hardware on the spacecraft was completed on 11 January, with the exception of SAS detectors 1 and 5. These detectors were not checked at this time because the solar pressure ring had not been installed. All of the gravity gradient components were successfully operated including Earth Sensor No. 2. Earth Sensor No. 2 had previously exhibited an intermittent condition during the EPC checkout.

Copies of GE revisions to the system Flight Test Plan were transmitted to NASA. GE field test personnel integrated these revisions into the HAC formal document. These revisions pertained to the caging and uncaging of the Primary Booms, and the firing of inert squibs at AMR.

NASA directed that the alignment of the gravity gradient sensors be performed prior to system vibration of the flight spacecraft. The alignment was completed on 20 January with a GE test engineer in attendance.

The system vibration tests of the flight spacecraft was started on 21 January and completed on 24 January. A post-vibration functional test was made of all gravity gradient hardware except the Primary Booms on 24 January. The Primary Booms were successfully checked on 25 January. NASA directed that the Primary Booms be uncaged and the tip masses removed for the duration of the solar vacuum testing.

The Flight No. 2 spacecraft system solar vacuum testing was started on 27 January 1967. Three short form tests were successfully completed during the solar vacuum tests including operation of the Primary Booms. Minor problem areas of interest to GE that occurred during solar vacuum testing included:

a. Intermittent troubles with the HAC Payload Power Switches

b. Intermittent bad data from the EME (Environmental Measurements Experiment) package when monitoring boom capacitance

c. Difficulty in turning off the subliming solid thrusters during the high power phase of the test.

The F-2 system solar vacuum testing was completed on 7 February 1967. The extra two days of test were necessary to evaluate the fix made to one of the flight subliming solid thrusters.

A post-environmental long form test was completed on 3 February with all gravity gradient components operating successfully. The only items that still have to be tested are the SAS detectors D1 and D5. These units could not be tested at this time as the solar pressure rings had been removed.

The flight Primary Booms were successfully caged after testing in preparation for the mass properties test and subsequent shipment to Goddard.

SECTION 7

QUALITY CONTROL

7.1 BOOM SYSTEM

Cold weld testing of the boom element was completed. It was concluded, as a result of these tests, that cold weld will not occur on the Damper Boom during normal orbital operating conditions.

Acceptance testing of the first two flight unit Primary Boom packages (S/N 101 and S/N 102) was completed at GE on 24 December, and the units were delivered to HAC for installation in the medium altitude flight spacecraft.

Quality Control Engineering Test Report 4315-QC-229 pertaining to the acceptance test of Flight No. 1 Damper Boom was issued during the period.

Hot and cold deployment tests were conducted on qualification Damper Boom S/N 11. Several problems attributable to test equipment and test methods were encountered during the early portions of the test. Failure Analysis Report 279-E-38 pertaining to these difficulties was issued; this is a continuing report with further actions still required.

Primary Boom S/N 103 was received from deHavilland. During initial testing, a serious leak was discovered in the transmission area. The unit was returned to deHavilland for failure analysis and rework.

During this reporting period, failure analysis activity on the boom system continued. Product Assurance representatives participated in failure analysis investigations at deHavilland, Fischer Bearing, and Split Ball Bearing relative to apparent bearing failures on S/N 10 and 100 Primary Booms. The following Failure Analysis Reports (F.A.R.) were issued:

F.A.R. 205-E-10 pertains to the failure of the damper boom linear actuator housing; this failure analysis was completed.

Supplement No. 1 to F.A.R. 228-E-17 pertaining to the Prototype (S/N 11) Damper Boom; the report is open pending completion of recommended corrective action.

Supplement No. 1 to F.A.R. 212-E-11 pertaining to recommended corrective action for Primary Boom S/N 11; the report was completed.

Supplement No. 1 to F.A.R. 225-E-10 pertaining to corrective action on the qualification Primary Boom unit (S/N 100); the report is complete.

Supplement No. 1 to F.A.R. 254-E-27 pertaining to several failures to Flight Unit Primary Boom S/N 10; the report is complete.

F.A.R. 264-F-30 pertaining to leak and motor stalling during retraction of qual unit S/N 100; the F.A.R. established two corrective action items to be completed between GE and deHavilland.

F.A.R 266-E-31 pertaining to backwinding problem on S/N 101; the backwind was apparently caused by the omission of tip springs which allowed the boom mass, riding on a free-wheeling trolley, to impact against the stopped boom element, thereby causing a loop within the housing. The test procedure (Standing Instruction 237036) was revised to emphasize the assembly of the tip mass springs. This report is now complete.

F.A.R. No. 268-E-32 pertaining to a boom scissor test failure on S/N 10; this problem was due to misalignment of the minus angle (11 degrees) mechanical stop as a result of misinterpretation of scissor angle requirements. The mechanical stops were properly adjusted and the GE specification was corrected to resolve the problem.

F.A.R. 269-E-33 pertaining to the bearing failures and transmission alignment of Flight Unit Primary Boom S/N 10; the analysis is continuing and the report is still open. Supplement No. 1 to this report was also issued. Bearing investigations are continuing and the report is still incomplete.

F.A.R. 277-E-37 pertaining to uncaging anomalies of Primary Boom Flight Unit S/N 10 during thermal-vacuum testing. The report is complete.

As a result of bearing and transmission failures that occurred in the Primary Boom Flight Unit S/N 10, several in-process tests were introduced during the build-up procedure of the Primary Booms. In addition, all inspection procedures applicable to the build-up of the Primary Booms are being revised at deHavilland with GE Product Assurance representatives participating in the revisions.

7.2 COMBINATION PASSIVE DAMPER

Failure Analysis Supplement No. 1 to 237-E-20 pertaining to corrective action on the excessive hi-pot application to the CPD Flight No. 1 was issued.

Machining of detail parts and subassembly testing for the Flight No. 3 CPD was completed during the period.

Failure Analysis Supplement to report 257-E-28 in reference to magnetic screws and variations in eddy current damping was issued. This report details a series of six corrective action items taken to prevent a recurrence of the anomalies.

The revised CPD standing instruction (SI 237016) was issued during the reporting period.

Acceptance testing of the Flight No. 2 CPD was started during December. Problems developed due to high torsional restraint values, and it was necessary to disassemble the units and retest the torsional restraint magnets and magnet pattern.

Supplement No. 2 to Failure Analysis Report 271-E-34 pertaining to the high torsional restraint of the Eddy Current Damper and limited rotational travel of the Passive Hysteresis Damper was issued. This report will continue with further action to be accomplished.

Product Assurance Process Control Engineering participated in corrective action on the cleanliness of the CPD assembly and test effort. Because of the nature of the CPD, continuous monitoring of the assembly areas is required to assure freedom from contamination.

The QC engineering qualification test report on the Combination Passive Damper was issued during this period.

Further testing of flight Combination Passive Dampers has been delayed pending the incorporation of a variable torque damper into the component.

7.3 TELEVISION CAMERA SYSTEM

Acceptance tests of Flight Units (S/N 5107 and 5110) were completed. The units were subjected to a compatability test at GE, then shipped to the spacecraft contractor. Camera S/N 5107 sustained a pinched wire during rework at GE. The faulty wire was discovered at HAC and the camera was returned to the vendor for repair. Failure Analysis Report 276-E-36 pertaining to this difficulty was issued; the report is considered complete.

Acceptance Test Reports 4315-QC-231 (S/N 5110) and 4315-QC-232 (S/N 5107) were issued by QC engineering.

Testing of Camera S/N 5104 was completed early in November. A broken wire was discovered to the shutter motor. Repairs were made and a retest was successful. Failure Analysis Report 275-E-35 - Rev A pertaining to the broken wire was issued; this report is now completed. A Quality Control engineering test report relative to the qualification tests of S/N 5104 was issued.

Acceptance testing of Flight Unit Camera S/N 5108 was completed. In addition, an operational test was conducted on the unit. This operational test will be conducted approximately every 60 days beginning with the completion of acceptance testing, on each of the Flight TV camera systems in bonded stock. The tests will be conducted to spot check electronic and electromechanical parts and to check for possible gaseous vidicons during storage.

The S/N 5109 camera system was subjected to burn-in tests at GE. During these tests, the video signal dropped to 0.78 volt peak-to-peak, and the transistor temperature was indicated to be 200°F. The unit was reworked at GE by an LSI representative, but further testing revealed that the camera had a faulty sun shutter. A trip was made to Wollensak to witness replacement of the photo sensor in the sun shutter. The unit was returned to GE and acceptance testing was resumed. The unit successfully passed the sun shutter test, however, the video was lost during the initial turn-on of the camera in functional test. Troubleshooting revealed two transistors in the video amplifier to be shorted (collector to base). The transistors were replaced and the unit was again placed in the acceptance test cycle.

7.4 SOLAR ASPECT SENSOR

Acceptance testing of the Flight No. 2 Solar Aspect Sensor was completed during November. A trip was made to Adcole by Product Assurance personnel to witness the testing of the Flight Unit 3 SAS. This unit was accepted and delivered to GE during the last week of December. During the acceptance test cycle, it was noted that small cracks had developed on the outer case of the SAS electronics package and out of specification readings were found in a detector. The unit was returned to Adcole for rework.

7.5 POWER CONTROL UNIT

Acceptance testing of the Flight No, 3 Power Control Unit was completed, and QC Engineering Test Report 4315-QC-020, which pertains to the acceptance tests results of Flight No. 3, was issued.

7.6 SYSTEMS TEST

During this period, Product Assurance personnel participated in systems test activity at Hughes Aircraft Company. Prototype Vehicle (Y2) had experienced practically all qualification tests with no failures of any GE components. The GE components for Flight No. 1 vehicle were installed and alignment of the vehicle was completed; the flight unit is undergoing acceptance tests with a GE systems test representative in attendance.

7.7 GENERAL

The NASA Quality and Reliability Manager for ATS activities visited GE to review quality systems incorporated at GE and deHavilland.

Product Assurance quarterly audit report for the fourth quarter 1966 was issued. A qualification status report for all ATS components was issued in January. Since all components except the Primary Booms have completed qualification testing, this report will be discontinued and information pertaining to the qualification status of the Primary Booms will be incorporated into the Quality Control section of the monthly ATS progress report.

SECTION 8

MATERIALS AND PROCESSES

8.1 BOOM SYSTEM

The solar reflectance values for a section of boom material checked after qualification thermal-vacuum was within specification values.

	REFLECTANCE
Before Thermal-Vacuum	0.879
After Thermal-Vacuum	0.868

The solar reflectance values for a section of boom material after qualification humidity testing were within specification values.

BEFORE HUMIDITY	AFTER HUMIDITY
0.880	0.875
0.894	0.879

The solar reflectance values of material taken from the opposite ends of the 153-foot S/N 366-1 tape were within specification.

INBOARD END	OUTBOARD END
0.909	0.902
0.909	0.901

A fix for cracked polycarbonate ring standoffs consisting of filling the cracks with Eastman 910 and overcoating with Epon 815 was evaluated. Test items were successfully vibration and humidity tested.

New ring standoffs fabricated from a 20 percent glass reinforced Delrin, 570XNC-000, have been fabricated and are being tested as a substitute in future units.

Two sealed drive units were successfully X-rayed showing the proper positioning of set screws.

8.2 COMBINATION PASSIVE DAMPER

Seventeen lamps from Chicago Miniature Lamp, Incorporated, used for the Angle Indicator were examined after qualification vibration per drawing No. PR47C207314. A magnification of 80X was used for visual examination, and the noise for each filament was determined using a Quan-Tech resistor noise test set. These lamps had been evaluated using the same procedure before testing. All the lamps were visually unchanged by the vibration testing. The pre- and post-test noise indexes (db) were essentially unchanged as shown below.

UNIT NO.	PRE-VIBRATION	POST-VIBRATION
15	-25.1	-25.1
	-25.1	-----
10	-25.1	-25.1
	-25.1	-25.1
18	-26.45	-25.1
	-26.45	-25.1
33	-25.1	-25.1
	-25.1	-25.1
34	-24.3	-25.1
	-25.1	-25.1
1	-25.1	-25.1
	-25.1	-25.1
35	-19.2	-19.4
	-25.35	-25.1
26	-25.1	-25.1
	-25.1	-----
46	-25.1	-25.1
	-26.45	-----
25	-25.1	-25.1
	-25.35	-25.1
24	-25.35	-25.1
	-23.1	-23.8

UNIT NO.	PRE-VIBRATION	POST-VIBRATION
2	-26.45	-25.1
	-26.45	-25.1
37	-26.45	-25.1
	-26.45	-25.1
7	-25.1	-25.1
	-25.1	-25.1
6	-25.1	-25.1
	-25.1	-25.1
29	-26.45	-25.1
	-25.1	-25.1
9	-25.1	-25.1
	-25.1	-25.1

The missing post-vibration values are due to a lead being broken by mishandling. This was not caused by vibration.

Sixteen of the same type lamps were examined (as received) by the same methods. Two of these had lead wires broken at a point where they entered the glass envelope. The rest were visually satisfactory and the noise indexes were between -24.0 and -26.3, which is satisfactory.

Seventeen parts from CPD Prototype No. 1 were examined by X-ray. No cracks or other defects were found. The same parts with the exception of the encoder disc were also examined using dye penetrant (Zyglo); again, no defects were found.

SECTION 9

MANUFACTURING

Technical support was provided by the Manufacturing operation during assembly and test of the ATS gravity gradient stabilization system. The manufacturing status of the systems is summarized as follows:

a. Prototype 1

Fabrication of all units comprising the Prototype 1 system is completed. The Primary Boom unit was returned to deHavilland for conversion to the ATS-D/E Configuration.

b. Prototype 2

Fabrication of all components is complete.

c. Flight Units

1. Flight 1 - Shipment of Flight 1 hardware to HAC was completed on 24 December 1966.

2. Flight 2 - Fabrication of Flight 2 hardware is complete.

3. Flight 3 - The CPD is in final assembly; the Primary Boom fabrication is in a hold status.

d. AGE

Fabrication of all AGE has been completed.

e. Test Equipment

Fabrication of all test equipment is complete.

f. Bonded Storage

Plans are being formulated for inventory disposition of the ATS flight equipment in bonded storage at GE.

SECTION 10

NEW TECHNOLOGIES

There are no new technologies to report for the quarter. Efforts to monitor the analytical and developmental areas will continue, and resulting new technologies will be reported in future reports.

SECTION 11

GLOSSARY

The following is a list of abbreviations and definitions for terms used throughout this report:

ADTF	Advanced Damping Test Fixture (used for CPD testing)
ATS-A	Medium Altitude Gravity Gradient Experiment (6000-nautical mile orbit flight)
ATS-D/E	Synchronous Altitude Gravity Gradient Experiment (24-hour orbit flight)
CPD	Combination Passive Damper
Crab Angle	Out-of-orbit angle flight caused by changes in X-rod angle
DME	Dynamic Mission Equivalent (Accelerated Functional Program)
GE-MSD	General Electric Company Missile and Space Division
GGS/ATS	Gravity Gradient System/Applications Technology Satellite
HAC	Hughes Aircraft Company
ITPB	Integrated Test Program Board
Local Vertical	Imaginary line extending from the satellite center of mass to the center of mass of the earth
LOFF	Low Order Force Fixture (used for CPD testing)
MTBF	Mean Time Before Failure
MTTF	Mean Time to Failure
PCU	Power Control Unit
PIR	Program Information Request/Release, GE documentation
SAS	Solar Aspect Sensor
Scissoring	Changing the angle included between the primary booms in a manner that maintains a symmetrical configuration about the satellite yaw axis
STEM	Storable Tubular Extendable Member
Stiction Torque	That amount of torque required to overcome the initial effects of friction
SVA Fixture	Shock and Vibration Attachment Fixture
Thermal Twang	Sudden thermal bending which the booms experience in passing from a region of total eclipse into a region of continuous sunlight or vice versa
TR	Torsional restraint
TVCS	TV Camera Subsystem