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31 March 1965
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RADAR

PROGRAM [redacted]

# VEHICLE 2355 SYSTEM REPORT (U)

## VOLUME II – ENGINEERING

Quill





LOCKHEED MISSILES & SPACE COMPANY

AC-04306
Volume II
31 March 1965

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VEHICLE 2355 SYSTEM REPORT (U)
Volume II - Summary

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FOREWORD

This report covers the span of time from the inception of the first satellite borne radar system through the final evaluation of the on orbit performance of the first flight. An objective review is attempted, of the complete scope of activities associated with bringing a new system into being and of the system performance during an essentially nominal and troublefree mission.

From this review, it is hoped that the systems management and program control parameters which were found to be effective may be properly recognized and thereby enhance the organization and conduct of similar future activities.

The system definition and resulting configuration is reviewed in retrospect, together with the problems associated with this Program development and testing.

The engineering management concept and the test philosophy which were applied are outlined and restated, with the objectives of first recording these, and then attempting to objectively analyze them for areas susceptible to improvement. The Air Force - LMSC - Associate Contractor team is defined, as it existed during the development, testing and operation of Vehicle 2355.

The system performance from launch through recovery and thence to battery depletion is evaluated from the primary aspect of payload operation.

System performance is compared against predictions, and the performance accomplishments and achievements are enumerated.

The report is therefore, in addition to a flight report, a total summary of the composite effort associated with the preparation and operation of this system. From the system evaluation certain conclusions and recommendations are formulated which are intended to be useful for later work on similar systems.

Through the medium of the detailed information contained in this report, it is intended to properly acknowledge the efforts of all those who were instrumental in managing and conducting a program which produced a completely successful mission with the first flight of a new payload vehicle system.

PART II

TABLE OF CONTENTS

PART II (Cont.)

TABLE OF CONTENTS

## Report Numbering and Organization

The complete 2355 System Report is contained in three volumes.

Volume I - (PART I) - Summary

Volume II - (PART II) - Engineering

Volume III - (PART III) - Flight Performance

The report paragraph numbering is in accordance with the following convention:

First number indicates volume number

Second number indicates main paragraph number

Third number indicates a subparagraph

Fourth number indicates a further subdivision of a subparagraph

Figures are numbered consecutively within main paragraphs.

<u>Reports By Participating Contractors</u>

The complete system description and performance evaluation is contained in reports issued by the three contractors. These are listed here for reference by the reader:

Lockheed Missiles and Space Company:

Title: 2355 System Report, dated 31 March 1965.

Volume I - Summary

Volume II - Engineering

Volume III - Flight Performance

Goodyear Aerospace Corporation:

Title: Program Report, KP-II Orbital Doppler Radar, Thor/Agena Satellite Program, dated 1 March 1965.

[redacted]

Title: [redacted]

## 2.1 Satellite System Engineering

The subsystems of the satellite vehicle which required engineering development, study or program peculiar applications are discussed in this section. Included also are sections on radar antenna development, thermodynamics and a thorough review of the work which was directed toward control of high voltage breakdown in a vacuum. A brief discussion of vacuum measurements is included due to the early considerations of the possibilities of high voltage breakdowns on orbit and a requirement to measure pressures in the payload vehicle.

The thermodynamic work which was done on this payload vehicle; accommodating the energy dissipated by the payload and during a time period when battery temperatures were under critical review; yielded a new level of quality in on-orbit thermal control. All engineering efforts which are reviewed in this section resulted in the complete and correct operation of the total satellite vehicle through the prescribed mission, setting an enviable standard of excellence in the first flight of a new payload system. This mission was conducted to a duration which exceeded predictions without a failure of any type aboard the satellite vehicle.

### 2.1.1 Structural Subsystem

#### 2.1.1.1 Requirements and Design Concepts

The first definition of the philosophy to be followed in engineering of the spaceframe indicated certain major areas where the design approach would be nearly unique for Vehicle 2355. The primary task was to install in a space vehicle, equipment normally associated with conventional aircraft, and to achieve orbit of this vehicle in such a manner that the equipment could operate normally in the acquisition and storage of data. Additionally, Subsystem "A" was to provide the mounting and ejection mechanisms for the capsule which would eventually return the stored data to the ground.

The initial approach envisioned hard-mounting of payload items in structure which was to be as light as possible consistent with the requirements dictated by predicted ascent loads and heating. This resulted in the design and/or installation of seven items tailored to the payloads and to the mission: (See Figure 2.1.1.1)

- Recovery Capsule
- Conical Payload Rack
- Cylindrical Payload Rack
- Ejectable Fairing for the C&C Antenna
- Guidance Auxiliary Rack
- Ejectable Fairing for the Radar Antenna
- Lifeboat Equipment

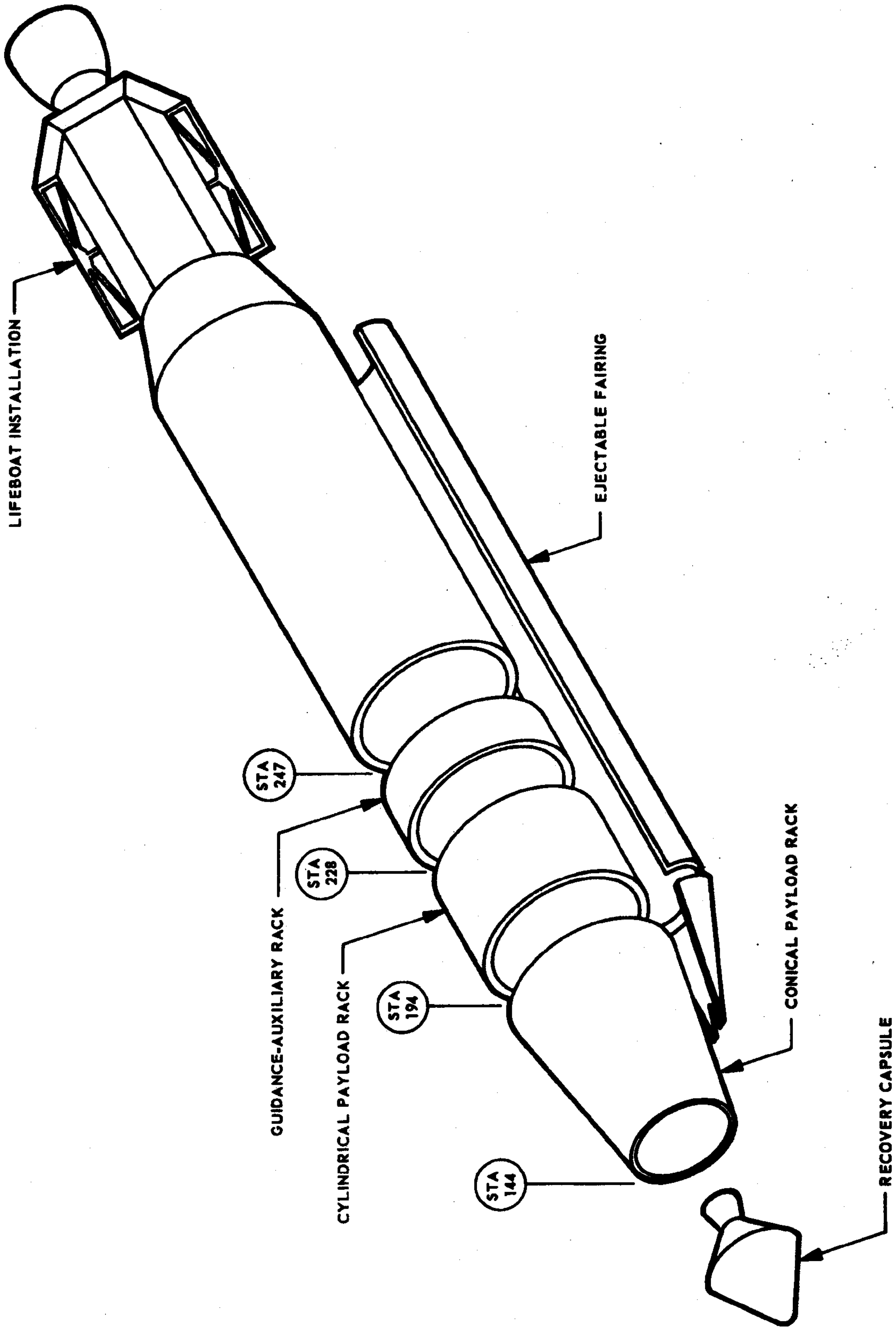



Figure 2.1.1.1 - Major SS/A Components

2.1.1.2 Configuration - Basic Concepts

Recovery Capsule. This capsule in its entirety was available as GFE. It housed the storage container for the raw data film and served as the nose cone during ascent. Since this recovery capsule had been used in other applications, its characteristics were known quantities requiring only incorporation into the 2355 System. A program peculiar installation had been made to accommodate the film takeup mechanism.

Conical Payload Rack. This structure was located just aft of the recoverable capsule and included mounting provisions for the capsule. The structure was a straightforward design comprising seven rings and a magnesium skin riveted together in the form of a truncated cone. The space inside this rack was allocated to Payload Box #7. Radiation protection for the raw data film feeding from Box #7 to the recoverable capsule was provided in the form of a thermal-tape-covered shield standing off from the inside of the forward portion of the rack. (See Figure 2.1.1.2).

Cylindrical Payload Rack. The third structure item was designed to mount to the forward face of the Guidance Auxiliary Rack, to provide mounting for the Conical Payload Rack, and to accommodate Payload Boxes 1, 2, 3, 4, 5, and 6. The structure comprised three rings, eight longerons, two torque boxes, eight doors, and eight access holes.

The floors of the two torque boxes, on which the payload boxes

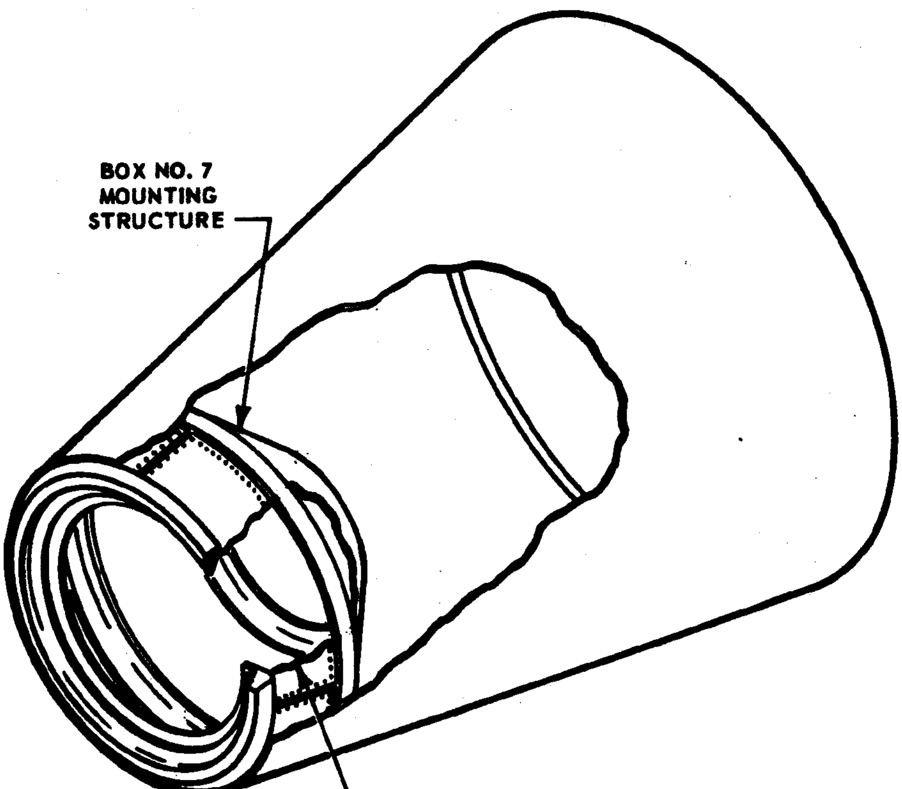



Figure 2.1.1.2-Cone and Thermal Shield

mounted, were located longitudinally between two longerons and over a third, with a web running from this middle longeron to the middle of the floor base. The magnesium skin connecting the three longerons completed each torque box. To offer access to the payload mounting devices, four access holes were located in suitable positions in the magnesium skin.

The remaining space was enclosed by four doors on each side of the rack providing access to all payloads mounted in the rack. (See Figure 2.1.1.3)

Ejectable Fairing for the C&C Antenna. The original design concept called for the Type 7 C&C Antenna to be mounted on the surface of the skin covering the Cylindrical Payload Rack. Protection for the antenna in this location would have been provided by a fairing mounted over it, secured to the outside of the vehicle by tension bolts and pinpuller assemblies. At a suitable time this fairing would have been ejected, permitting proper operation of the antenna.

The launch configuration of Vehicle 2355 did not carry the ejectable fairing. Reasons for this decision are covered in the Design Development section of this report.

Guidance Auxiliary Rack. The Guidance Auxiliary Rack structure comprised two rings, eight longerons, two floors for mounting guidance components, a web joining these floors, and a skin in

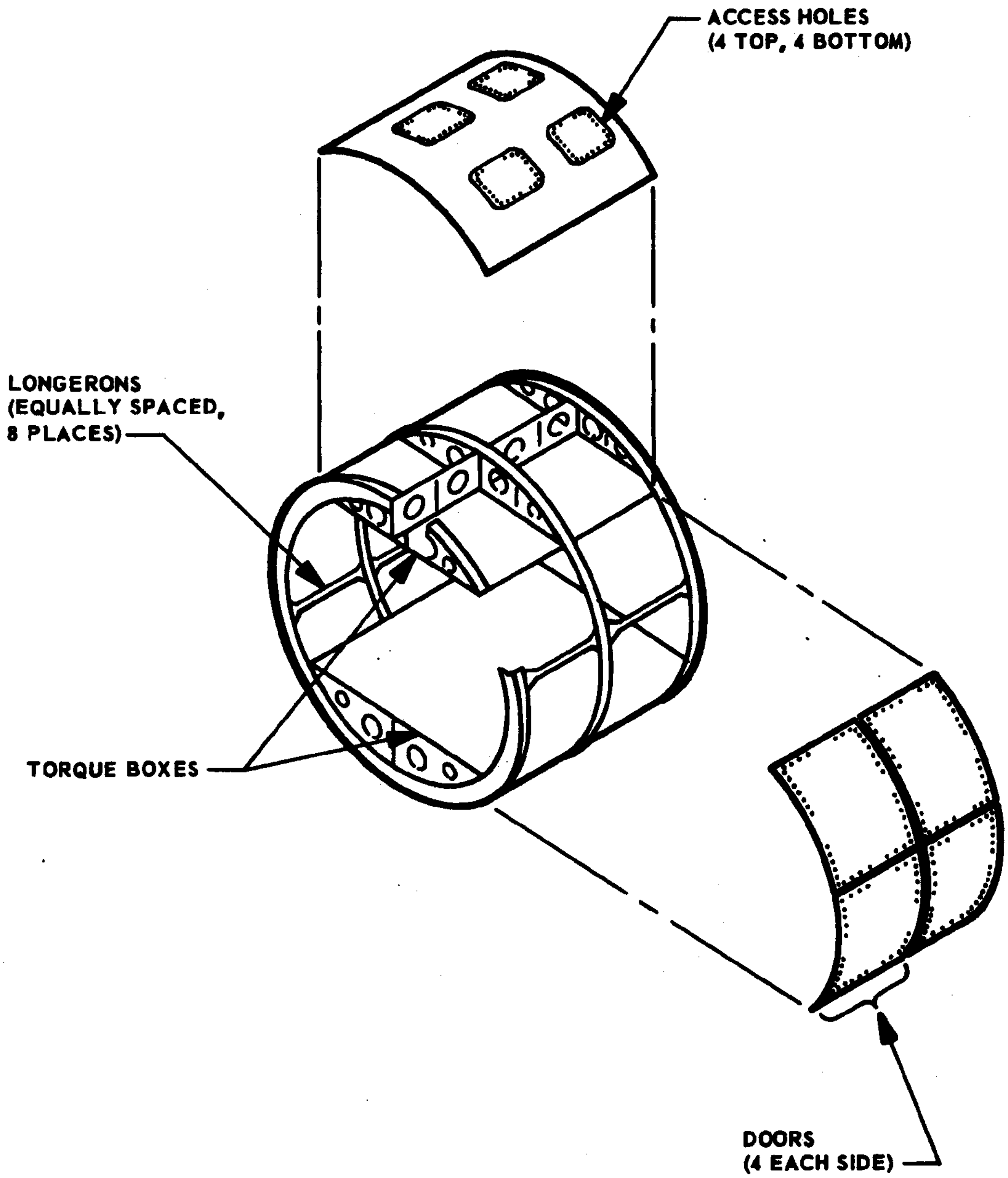



**Figure 2.1.1.3 Cylindrical Payload Rack**

the form of removable doors which permitted access to all equipment located in the rack. As in the equipment rack, the floors joined two longerons located ninety degrees apart with an additional web running from the center of the floor to the central longeron.

The floors extended from station 247 forward to approximately station 231, leaving a three-inch space aft of the ring at station 228 for the wave guide installation in the forward portion of the rack. (See Figure 2.1.1.4)

<u>Ejectable Fairing for the Radar Antenna.</u> This fairing comprised a 27-inch wide channel, six inches deep, approximately 226 inches long. It was mounted longitudinally on the skin of the vehicle in the +Y+Z quadrant, and provided aerodynamic and thermodynamic protection for the radar antenna during ascent.

The ejectable portion of the fairing, 187 inches long extending from the forward edge of the cylindrical rack aft to station 381, was secured to the vehicle by longitudinal forward-facing retainer pins (five on each side of the fairing). These pins fitted into matching sockets secured to the vehicle, thereby providing radial and transverse stability for the fairing. Longitudinal stability was provided by a tongue extending forward from the face of the ejectable portion of the fairing into the fixed portion where it was secured by a pinpuller assembly.

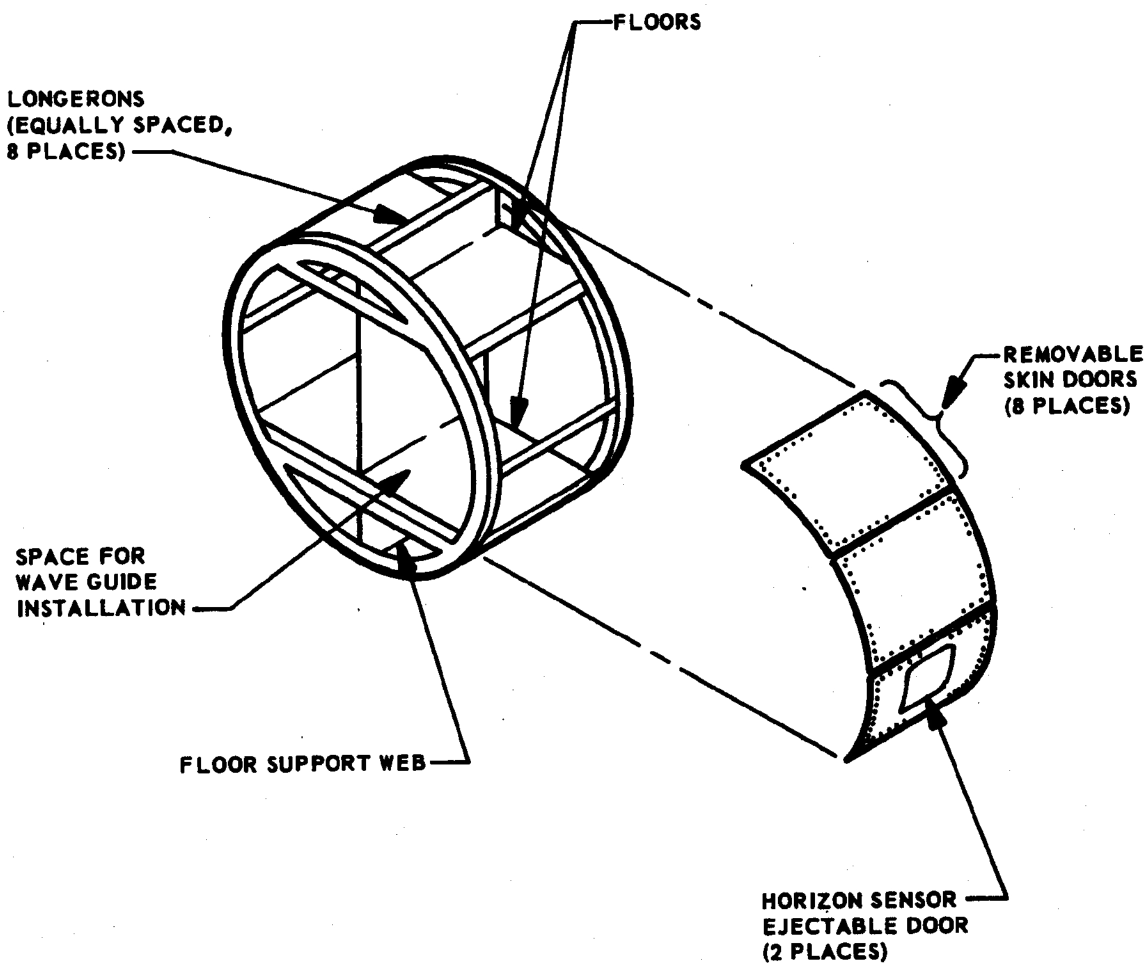



Figure 2.1.1.4 Guidance Auxiliary Rack

Lifeboat Equipment. This equipment was installed on the aft structure of the SS-01A. Since installation and functioning of the equipment had been developed and proven by other programs, a nearly identical installation was utilized for the 2355 vehicle.

2.1.1.3 Equipment Installations -- Basic Concepts

Recovery Capsule. As with the Lifeboat equipment, the capsule itself, together with its attachment and separation mechanisms, had been utilized and proven by other programs. Rather than embark on a development program, the already-proven design was utilized for 2355.

Payload Units - Excepting the Recorder. These payload units were contained in the cylindrical rack. All equipment was secured to the floors of the torque boxes through hard mounting points. Traditional hardware (clips, angles, brackets, etc.) was utilized to take advantage of the structural stiffness of the rack and to carry the predicted loads back through the secondary structure into the primary structure.

Film Recorder. This unit had to be mounted in the conical rack in a manner which would permit feeding of the raw data film forward into the storage container housed in the recovery capsule. The unit was L-shaped with its base pointing forward. The mounting structure employed for the front end of this box was a truncated cone with the small diameter facing aft. The large diameter was secured to the conical rack ring at station 152.

The base of the L-shaped recorder was secured to the mounting structure with three uniball bearing assemblies.

The original concept for the mounting of this unit called for the aft end of the payload to be secured by a device which would restrain it during ascent. After the vehicle had attained orbit, this device was to release the aft end of the box from all restraint.

The design specified four legs extending inboard from the ring at station 194 toward the aft end of the payload. These legs terminated in a plate directly behind the payload. This plate was then secured to the payload with a pin which could be withdrawn upon receipt of the proper signal. In this way the payload was to be rigidly supported during launch and ascent, and free of restraint at the aft end during orbital operations. (See Figure 2.1.1.5.)

<u>C&C Antenna Fairing Ejection Mechanism</u>. The fairing covering the C&C antenna was to be secured to the outer skin of the vehicle by two tension bolts in pinpuller assemblies, one located at the aft end of the fairing, and one located at the forward end. To provide for longitudinal and transverse shear, pins mounted to the rack protruded through holes in the fairing.

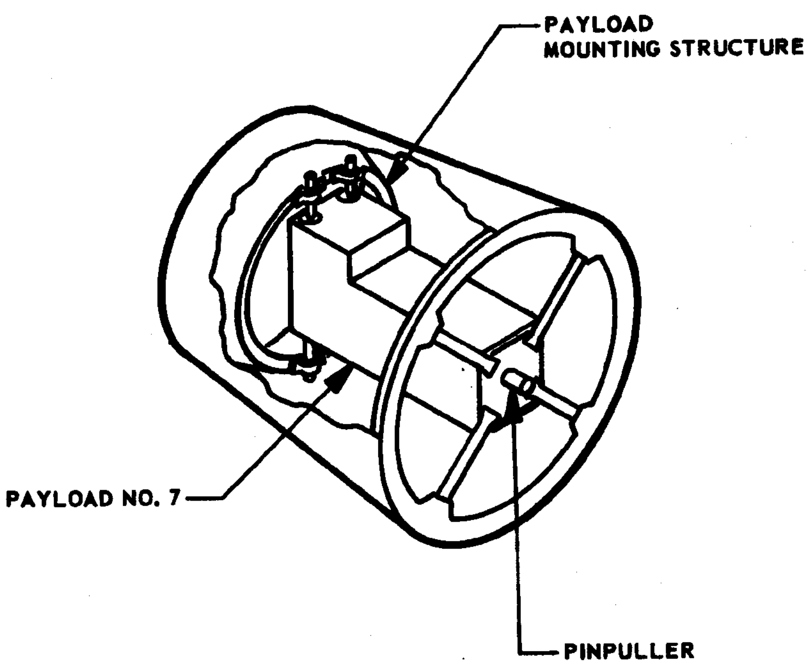



Figure 2.1.1.5 Box #7 Installation

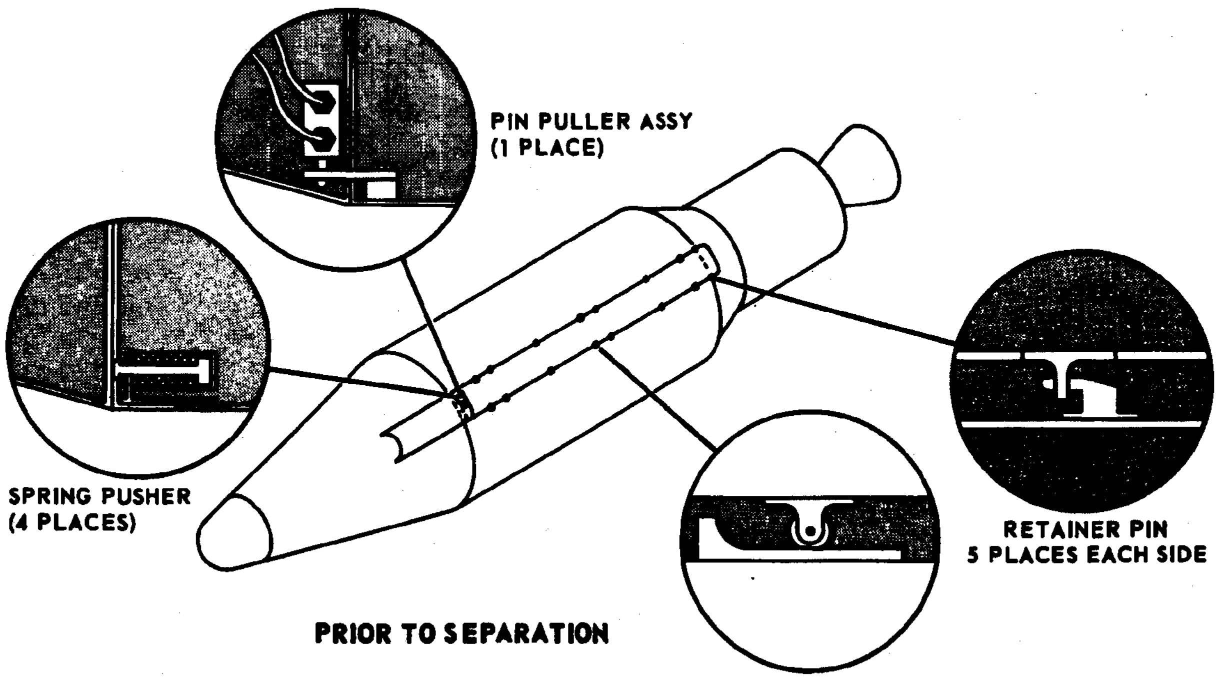
Motive force for ejection of the fairing was provided by two compression spring assemblies between the vehicle skin and the fairing. One spring was located approximately ten inches aft of the leading edge of the fairing, and the other incorporated the aft pinpuller bolt.

Upon receipt of the proper signal the pinpullers would have retracted and the fairing would have been jettisoned, exposing the C&C antenna.

Vehicle Fairing Ejection Mechanism. Upon receipt of the command to eject this fairing, the pinpuller retracted. This permitted four compression spring assemblies mounted between the ejectable and fixed portions of the fairing to thrust the ejectable portion aft. As soon as the retaining pin cleared their sockets a radial thrust vector was imparted to the fairing by six ramps (three on each side of the fairing) riding on six needle-bearing rollers attached to the vehicle. The resultant separation was in a +X-Y direction with the fairing remaining essentially parallel to the vehicle (See Figure 2.1.1.6)

2.1.1.4 Design Development

Following the original concepts discussed above, design proceeded in a normal manner. Despite the fact that some of these concepts were relatively new, structures and equipment installation engineering was normal in relation to state-of-the-art techniques. Problems with



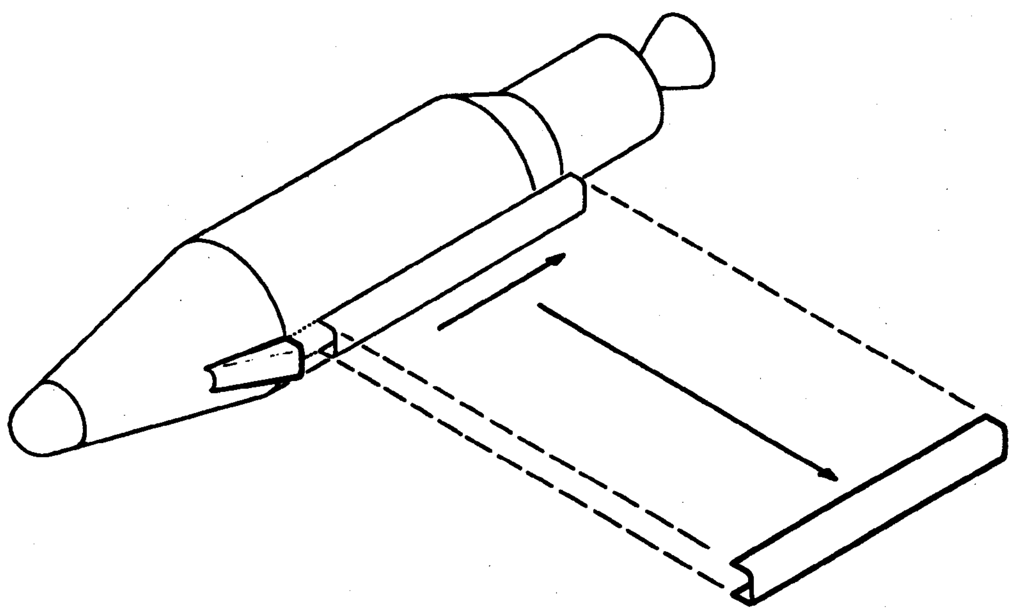




Figure 2.1.1.6 Vehicle Fairing Separation

components or changes to original design occurred in the following areas:

- Payload Mounting Vibration Difficulties
- Corona in the Transmitter/Modulator
- Wave Guide Heating (Ground Conditioning)
- Thermodynamic Requirements Changes
- Film Recorder Mounting
- Installation of Pressure Transducers
- C&C Antenna Change--Ejectable Fairing Deletion

Payload Mounting Vibration Difficulties. In accordance with the initial design approach the cylindrical rack was tailored to mount the payload boxes and to provide access to them in such a manner that the structure would be the lightest possible consistent with stress requirements. Upon completion, this design was passed to Manufacturing for fabrication and a copy of the engineering documentation was furnished to Goodyear Aerospace Corporation.

Goodyear, however, in conducting confidence tests on payload components discovered that the hard mountings originally planned could result in degradation of payload performance, particularly in light of the stringent vibration requirements called out in LMSC Spec 6117, Revision "D". Goodyear, in order to increase the confidence level in payload survival, dictated that shock mounts be utilized to isolate the critical items from vibration. The vibration isolation mounts were installed on the payloads by

Goodyear and these payloads furnished to LMSC for proper mounting in the rack.

The precision tailoring of the original design precluded the use of these mounts on a simple substitution basis. As a consequence, the cylindrical rack went through a redesign which saw a complete redistribution of equipment in the rack, and suitable modifications made to the secondary structure to provide the required structural stiffness.

Subsequent testing of the redesigned rack with the payloads restrained in the new shock mounts showed that the required confidence level had been attained.

Corona in the Transmitter/Modulator. Concurrent with the vibration difficulties outlined above, an unrelated problem was discovered in the transmitter. During testing by Goodyear a corona effect was observed inside the unit. Various possibilities for correction were considered; and, Goodyear's proposed solution of encapsulating the transmitter in a pressure vessel was started as an alternative to potting. This pressure vessel in turn was to be mounted in the cylindrical rack.

The eventual solution to the corona problem proved to lie in the potting techniques for components in the transmitter rather than in pressurization of the complete unit. This entailed only removal of the pressure vessel in the final installation since the mounting provisions remained the same.

Wave Guide Heating (Ground Conditioning). A modification to the original design arose in connection with the wave guide installation. A Program Office directive was received which required the addition of a device for heating the wave guide during the pre-launch phase of operation.

This requirement was fulfilled by laying heater strips on the wave guide, wrapping these strips to the guide with insulation, and providing power to the heater strips from the electrical umbilical which was disconnected at launch. The wave guide heating facilitated the outgassing of the wave guide during ascent, since the wave guide was warmed at liftoff.

Thermodynamic Requirements Changes. As the design progressed and the thermodynamic characteristics of the vehicle could be more accurately predicted, changes were initiated to assure the correct thermal environment for all components.

In response to these developing requirements Subsystem "A" revised the mounting of Payload Unit #1 (battery) by changing the insulating strips which were located between the mounting pads and the battery itself. Additionally, a radiation shield was installed over the battery; however, as thermodynamic analysis continued, it was determined that this shield should be deleted from Vehicle 2355.

Film Recorder Mounting. As outlined above, it was planned that this unit would be hard-mounted at the forward end and secured by a pinpuller to spider-legs at the aft end, the plan being to release this pinpuller after orbit injection to permit the aft end of the recorder to be unrestricted. Subsequent analysis, however, indicated that the firing of the pinpuller with its attendant shock was more likely to result in recorder malfunction than would the slight torsion effect resulting from expansion of the unequal spider-legs. As a consequence, the final design called for hard-mounting both forward and aft ends of the recorder.

Installation of Pressure Transducers. At the direction of the Program Office, vacuum measuring instruments were installed in the cylindrical and conical racks. A total of five were installed, one transducer located on the recorder, one on the transmitter, one between the transmitter and the RF-IF, in the high power wave guide, one on a structural ring at the -Y axis, and one on the same ring at the +Y axis.

Installation of the transducers was in accordance with current state-of-the-art techniques, and was problem free.

C&C Antenna Change--Ejectable Fairing Deletion. The ejectable fairing to cover the C&C Antenna was designed as outlined above. However, difficulties were arising in connection with the pattern of the Type 7 Antenna which had been planned for installation on Vehicle 2355. These difficulties were such that a substitution of antennas was required. The Type 4 C&C Antenna was selected and was installed.

Since the Type 4 Antenna is flush-mounted with the skin of the vehicle, the requirement for ejection of a fairing was obviated.

## 2.1.1.5 Structural Qualification

### General

The size, weight and mounting provisions of the Goodyear payload components required the qualification of the payload vehicle structure for this application. In addition, the large structure which housed the radar antenna involved qualification of that item inasmuch as it was a new design. Table I lists the tests which were performed on SS/A hardware to demonstrate qualification for flight on Vehicle 2355. All testing was performed by Lockheed Satellite System Test Services with the exception of the Guidance Auxiliary Rack Vibration Test, Test Assignment No. 19-363, which was performed by Polaris Test Services (Lockheed Missiles Systems Division).

Two sets of test hardware were fabricated to accommodate the short test span, and also to provide hardware for testing in the Temperature-Altitude Simulation Chamber (TASC). Hardware was fabricated to non-released sketch type drawings due to the compressed schedule. Sketch numbers (SK) are referred to in the detailed test reports.

The following is a list which correlates SK numbers with the part numbers of the flight hardware:

| Part | Released Number | Sketch Number |
|---|---|---|
| Struct. Assy., Conical Aux. Rack | 1359864-501 | DN 618631-501 |
| Struct. Assy., Cylindrical Aux. Rack | 1359839-501 | SK 715631-501 |
| Struct. Assy., Aux. Rack, Guidance | 1359821-501 | SK 1001050-501 |

TABLE 1

| Test Condition | Job Request No. | Test Assignment Number | Test Hardware | Part Number | Structure Specimen Del. | Structure Test Comp. | Total Cost M/H |
|---|---|---|---|---|---|---|---|
| Static load test to simulate ascent loads on primary structure. Separation test of horizon sensor door. | A631226 | 5938 | Struct Assy Conical Rk.<br>Struct Assy Cylindrical Rk.<br>Struct Assy Guidance Rk. | 1359864-501<br>1359839-501<br>1359821-501 | 2/14/64 | 4/10 | [redacted] |
| Vibration test to simulate dynamic loads on equipment mounting structure. | A631210-01 | 5930 | Struct Assy Conical Rk. with a dynamic model of the payload recorder installed.<br><br>Struct Assy Cylindrical Rk. with dynamic models of all equipment installed. | 1359864-501 | 1/17/64 | 2/3/64 | [redacted] |
| Vibration test to simulate dynamic loads on equipment mounting structure. | A630816-04 | 19363 | Structure Assy guidance Rk., with dynamic models of pay-load packages installed. | 1359821-501 | 1/8/65 | 2/10/64 | [redacted] |

TABLE I (Cont.)

| Test Condition | Job Request No. | Test Assignment Number | Test Hardware | Part Number | Structure Specimen Del. | Structure Test Comp. | Total Cost M/H |
|---|---|---|---|---|---|---|---|
| Static load test on payload packages to simulate combined acceleration/ vibration loads on equipment mounting structure. | A640521 | 1082 | Struct Assy Cylindrical Rk. with dynamic models of payload packages installed. | 1354839-501 | 7/21/64 | 8/7/64 | [redacted] |
| Static load test on payload Box #7 to simulate combined acceleration/ vibration loads on equipment mounting structure. | A640428-3 | 1048 | Struct Assy Conical Aux Rk. with a dyhamic model of payload recorder intalled. | 1359839-501 | 8/3/64 | 8/6/64 | [redacted] |
| Pressure test to simulate ascent burst & collapse pressures on the payload fairing. | A631219-01 | 5937 | Struct Assy fairing mounted on a simulated vehicle. | | 1/6/65 | 2/14/64 | [redacted] |

TABLE I (Cont.)

| Test Condition | Job Request No. | Test Assignment Number | Test Hardware | Part Number | Structure Specimen Del. | Structure Test Comp. | Total Cost M/H |
|---|---|---|---|---|---|---|---|
| Thermal/ separation test to simulate ascent heating and demonstrate separation of payload fairing. | A631118 | 5906 | Struct Assy fairing mounted on a simulated vehicle. | | 1/28/64 | 2/5/64 | [redacted] |

All Test Hardware was structurally identical to the Flight Hardware.

**Test Descriptions and Results**

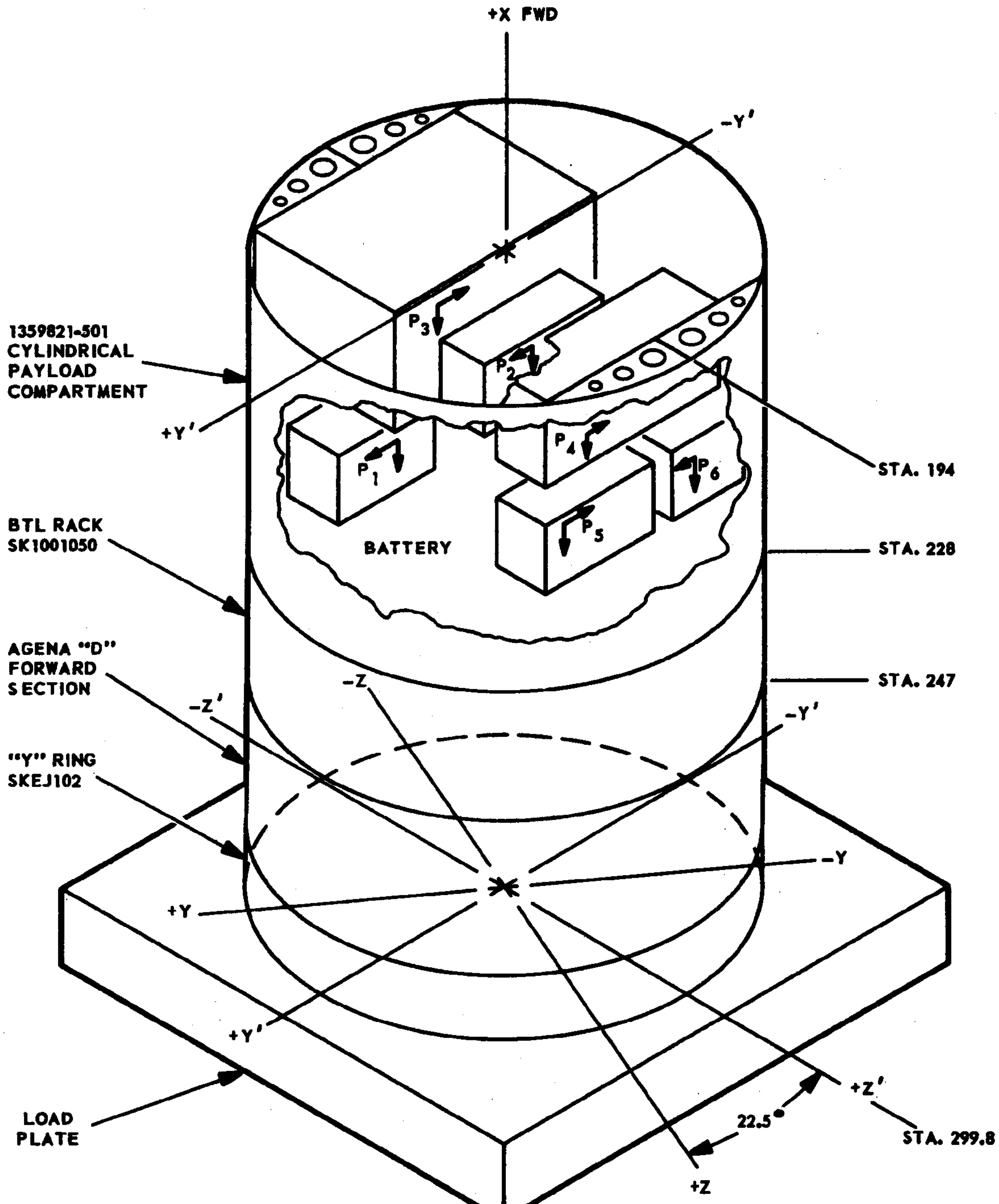
**Static Load Test on Conical, Cylindrical, and Guidance Racks (TA 5938).**

The test was divided into four parts as follows:

PART I: The Cylindrical Payload Rack was subjected to a collapse pressure test. This was accomplished by sealing and evaluating the entire rack to an ultimate differential pressure of 1.44 PSI. No failure was observed.

PART II: The Conical Rack, Cylindrical Rack, Guidance Rack, and an Agena D Fwd. Rack were assembled in flight configuration as shown in Fig. 2.1.1.7 (I). Hydraulic jacks exerted load P1 through P6, Fig. 2.1.1.7 (I). All loads were applied simultaneously in 20% increments to 100% design limit load (DLL), and then in 5% increments to 125% DLL. Load values are listed under Test IIA in Fig. 2.1.1.7 (II). No failure was observed.

PART III: The specimen setup was identical to that in Part II except the specimen was rotated 112.5 degrees counter clockwise (CCW)--looking aft--with respect to the bending loads P1-P3. Loads were applied in the same manner as in Part II. Load values are listed in Fig. 2.1.1.7 (II) under Test IIB. No failure was observed. After completion of this test, one Horizon Sensor Door was successfully jettisoned.




NOTES:

1. $P_1V$, $P_2V$, $P_3V$, $P_4V$, $P_5V$, AND $P_6V$ LOADS ARE IN $Y'$ DIRECTION.
2. $P_1X$, $P_2X$, $P_3X$, $P_4X$, $P_5X$, AND $P_6X$ LOADS ARE IN AXIAL DIRECTION.

Figure 2.1.1.7(I) - Equipment Mounting