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HISTORY OF ATLAS ABLE-5A

FLORIDA OPERATIONS

October 1960

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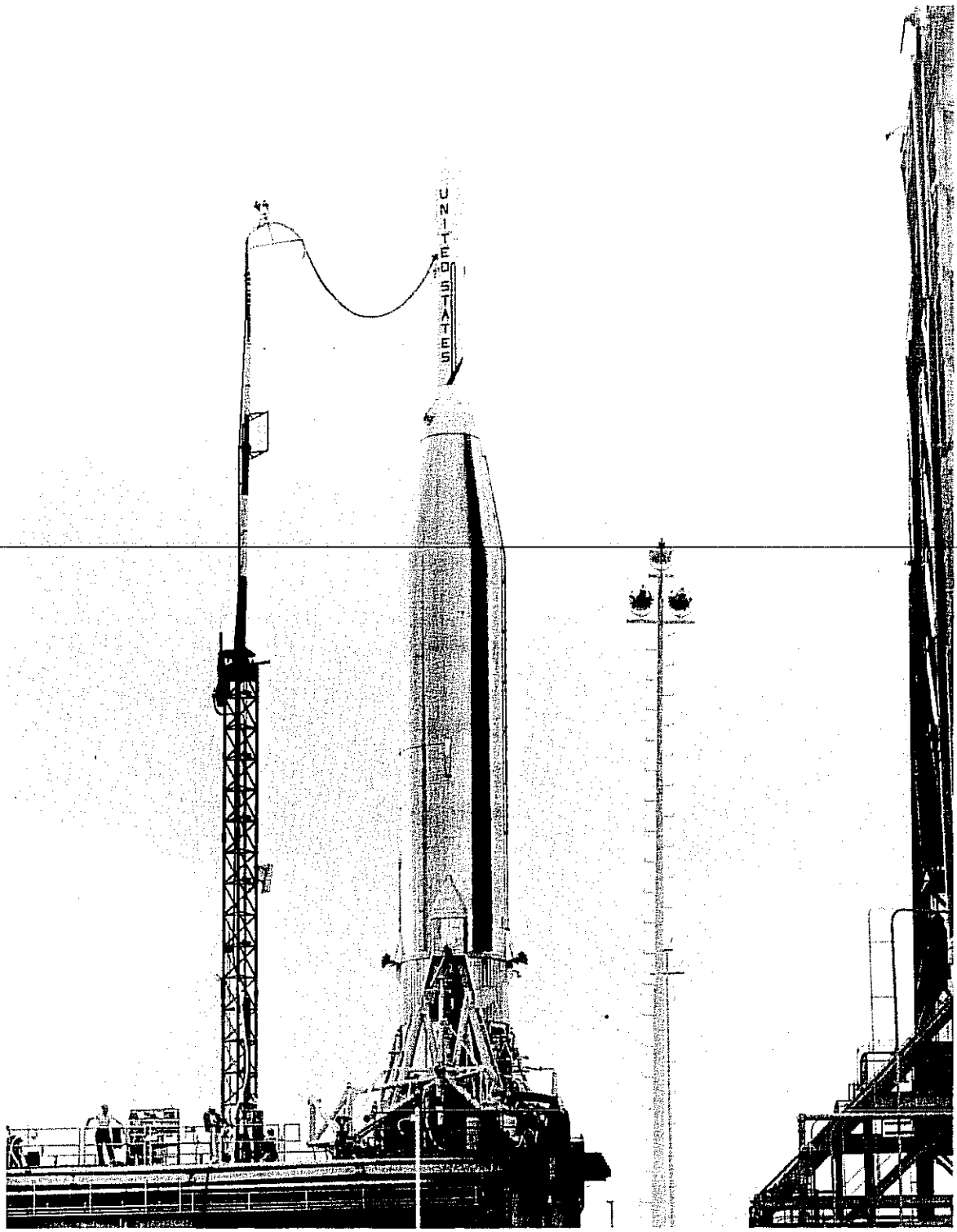

Atlas Able-5A Vehicle

INTRODUCTION

This publication is issued as a journal of the events, tests, preparations, and procedures undertaken at the Atlantic Missile Range, Cape Canaveral, to conduct the flight of the Atlas Able-5A vehicle

The principal objectives of the mission were to 1) launch an instrumented probe beyond the immediate gravitational field of Earth, 2) guide this spacecraft along a trajectory that would enable it to reach the Moon and describe the tightest circumlunar orbit consistent with a high degree of mission probability, 3) acquire scientific data concerning the environment and characteristics of the Moon, 4) demonstrate the capability of ground tracking stations to receive telemetered data from the vicinity of the Moon, and 5) verify the capability of the Atlas missile to boost the Able-5A stages to the altitude and velocity required to achieve the preceding four objectives The 387-pound spacecraft was to be the most highly instrumented probe yet launched by the United States.

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ILLUSTRATIONS

1 September

The delivery of the Able second stage and the new checkout van No. 4 to the Atlantic Missile Range and the arrival there of a sufficient number of engineers and technicians from STL-LA made possible the beginning of scheduled Hangar AA assembly and testing activities.

The PSA 5-1 second stage receiving inspection was completed during the morning as prescribed in Procedure A/5-201.

The checkout van was validated in accordance with Procedure A/5-221 launch control and instrumentation sections. This procedure was designed to insure the compatibility of the van electrical equipment with the Stage II equipment. The test was conducted by connecting to the van test umbilical and test instrumentation cables and exercising certain controls in the van to simulate flight sequences.

The second stage engineering inspection was completed pursuant to Procedure A/5-201. Sixteen minor "squawks" were noted; these represented minor items such as loose clips, screw, glyptal application, and other hardware fixes capable of immediate correction. The S/N 3 relay junction box was removed from the second stage for the purpose of completing adjustments. The mechanical timers on the switches were reset to arm at 140 seconds. The nose fairing time delay relay was readjusted from 25 to 35 seconds.

At the outlying site of the Ground Guidance System (GGS), formerly Advanced Guidance Studies (AGS), certain repairs and calibrations were completed on the transmitter and receiver units.

Autopilot and subsystem telemetry checks were begun in accordance with Procedures A/5-223 and A/5-227. It was decided that certain minor adjustments would be required before completion of the test.

2 September

The autopilot and telemetry subsystem checks begun on 1 September were completed satisfactorily.

When the Able-5 stage guidance GGS compatibility checks were conducted in accordance with Procedure A/5-5264A later in the day, unsatisfactory performance of the Stage II guidance transponder system was noted. GGS interrogations were received at a good level in the hangar, but GGS did not receive the reply signals on approximately 378 mc. This test was designed to set up the second stage into flight configuration and exercise the guidance transponder system through a sequence of commands. As an attempt at a fix, the transponder units were removed from the stage.

Spare units were installed and operation proved satisfactory. (See Table 1.) A second spare guidance transponder system was shipped from STL-LA.

Convair installed Atlas 80D on the launch pad of Complex 12 during the early afternoon. (See Figure 1.)

The I/II transition section was installed on the Atlas booster late in the evening. Exactly 192 screws--precisely the number required-- had been sent by STL-LA. Two were stripped during installation after an additional two had been found unsuitable prior to installation. Additional screws from LA were awaited to complete securing of the section.

During the late afternoon, the Stage II hangar transducer calibration was completed satisfactorily as prescribed in Procedure AFTP-10-101a-316; both Aerojet-General and STL personnel participated. The helium regulator valve flow test was performed later in accordance with Procedure AFTP-10-101a-310. The regulator was set to flow at 341 psig.

Figure 1. Installation of Atlas 80D on Pad 12. Note how Launcher Mechanism Tilts to Mate with Atlas Handling Trailer.

Table 1. Guidance Transponder Replacements.

UNIT	REMOVED	INSTALLED
Amplifier and Power Supply	S/N B-6	S/N B-3
Final Amplifier	S/N B-3	S/N B-3
VHF Diplexer (4 x 4)	S/N 11	S/N B-3
Guidance Receiver	S/N P-45	S/N 2

3 to 5 September

No work was scheduled over the Labor Day weekend at Complex 12 or Hangar AA.

6 September

Preparations were begun early in the morning for the second stage flight systems test (FST). The test setups were completed pursuant to STL Procedure A/5-205 and Aerojet-General Procedure AFTP-10-101a-333.

The second stage flight systems test was begun at 0930 hours in accordance with Procedure A/5-200A. The FST was designed to demonstrate flight readiness of the stage electrical, electronic, and propulsion systems. This was accomplished by exercising the stage through a complete sequence of events from T-3 minutes through liftoff, umbilical removal, and through various events up to +413 seconds (6 minutes, 53 seconds) of simulated flight.

The first run of the FST was, in general, performed successfully. A time count was missed because of generator noise. A re-run of the FST was decided upon for this reason, and because of failure to demonstrate autopilot uncaging and to show gyro reference polarity for missile motion. Action of the aft fan microswitch was not indicated on the APT van telemetry tape; this switch action provides the d-c level blip strip events.

The re-run of the FST was begun at 1136 hours and completed successfully.

During the afternoon a Flight Acceptance Compatibility Test (FACT) review was held at the Complex 12 blockhouse. Two particularly vital discrepancies were noted. The first concerned installation of a propellant depletion disabling relay in the propellant system sequencing circuits. The second discrepancy concerned installation of a 35-millisecond delay feature in the GE-Burroughs Mod III system. Every assurance was given by Convair that the installations and checkout of the relay and delay package could be completed within two days.

During the Atlas blowdown test, the lox tank regulator failed to open. The regulator was replaced, but the test was not re-run; it was scheduled for the following day, 7 September.

The second spare guidance transponder system arrived at the hangar from STL-LA. Functional bench tests were conducted on the units in the laboratory to qualify the system for flight operation.

7 September

Aerojet-General personnel conducted the Stage II leak test during the morning in accordance with Procedures AFTP-10-101a-308 and A/5-266. Integrity of all tanks and plumbing was verified.

The checkout van No. 4 and certain large test equipment items were moved to Complex 12 in preparation for the launch facility validation scheduled for 8 September.

The first missile operations system (MOPS) exercise was started for the purpose of checking communications between various STL vernier control loop (VCL) stations at Complex 12, the checkout van No. 4, Able payload telemetry (APT) van, Able communications (ACOM), and two of the hangar laboratories. The test was cancelled early in the proceedings because of incorrect loop hookups at Complex 12

The No. 1 flight payload S/N 3 arrived at the hangar from STL-LA. A receiving inspection, conducted pursuant to Procedure A/5-109, revealed no damage or loss of calibration in transit. A payload propulsion system leak check was completed later in accordance with Procedure A/5-164.

The hangar installation of explosive (primacord) ordnance in the second stage was completed as prescribed in Procedure AFTP-10-101a-329.

A "Condition IV" hurricane alert was posted early in the afternoon for the east Florida coastal region. Puerto Rico had been hit. Hurricane "Donna" had claimed 116 lives there. Although the course of the tropical storm could not be predicted accurately at the time, heavy weather was imminent in the Cape area within 72 hours. Preliminary discussions were held concerning measures to be taken for security of the missiles and equipment should hurricane "Donna" veer up the east coast to make a direct approach.

The Atlas blowdown test was re-run successfully. Later, a leak developed in the propellant utilization (PU) manometer. Spurious booster jettisoning signals were traced to a faulty autopilot (A/P) programmer, the unit was replaced in the Atlas B-1 pod.

8 September

Activities in three different areas were begun early in the morning in an effort to accomplish as many tasks as possible before being interrupted by the imminent bad weather.

The Complex 12 electrical facility validation test was completed successfully in accordance with Procedure A/5-15, except for meter calibrations. It was decided to calibrate meters two days prior to mounting the payload on the vehicle. At the completion of the test, the checkout van No 4 was returned to the hangar for sheltering.

At the hangar, meanwhile, final Stage II weight determination was made pursuant to Procedure A/5-262. The stage weight was determined to be approximately 791 pounds, less heat generator assembly (HGA), fuel, and oxidizer. After weighing, the command receiver S/N 25 was removed from the stage for plug-in checks. The stage was then secured in the "transtainer" trailer and covered.

The live ABL X248-A9 Stage III (S/N SV-133) was inspected in the ordnance area then transported to the Spin Building 56 in the ABMA area in preparation for the forthcoming fit checks. These tasks were performed in accordance with Procedure A/5-362.

A payload propulsion system preflight check was performed with several deviations from Procedure A/5-164. A full-procedure test was scheduled for some time prior to launch.

A joint STL-BMD-Convair meeting was held late in the afternoon to review the latest weather information. Three of the AMR downrange stations had been damaged. This would scrub several scheduled R and D launches, but would not affect Able operations. Downrange tracking was desirable but not specifically required. Hurricane preparations were to be instituted at both the Cape and Patrick AFB. The procedures involved a series of precautionary steps contained in "Hurricane Plan 1960." This document specified four sets of conditions and the measures to be taken under each:

Condition IV (Storm Warning) - Hurricane (75 mph) winds within 72 hours.

Condition III (Hurricane Alert) - Hurricane winds within 48 hours All protective measures to be undertaken

Condition II (Hurricane Warning) - Hurricane winds within 24 hours. All protective measures to be completed.

Condition I (Final Hurricane Warning) - Hurricane winds within 12 hours. This condition to remain in effect until an "All Clear" notice after passage of the storm.

Preparations at the hangar would concern securing all windows, doors, and air conditioning openings. Equipment and files would be elevated a minimum of four feet above the floors All antennas would be dismantled from the hangar roof and the instrument vans.

A GGS tracking exercise was held during the evening. A parallel payload r-f system test was conducted with only partial success.

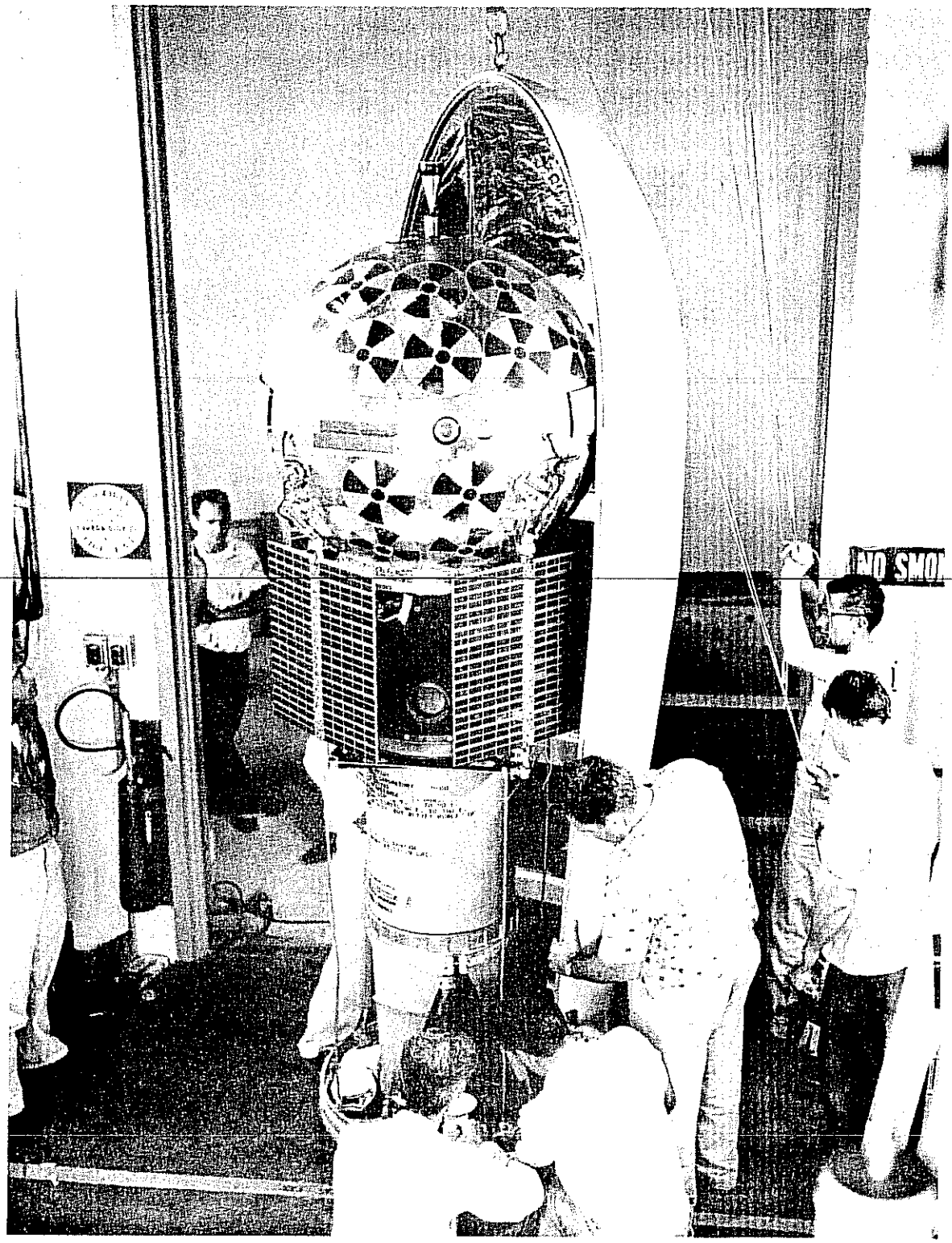

Figure 2. Fit Check and Alignment of Upper Able Stages and Nose Fairing.

9 September

Preparations were begun for the first AMR payload integrated systems test (IST) during the early morning. Test setups were completed pursuant to Procedure A/5-110. The IST was performed in accordance with Procedure A/5-113D during the morning. The test was generally successful, but, inasmuch as the test was begun with the batteries in a partially discharged condition, many of the system voltage measurements were low. Certain portions of the test were re-run with satisfactory results.

Command receiver checks were made for the purpose of measuring transmitter power output and modulation index. The modulation index on the coherent transmitter was 1.35 radians. The nominal index should have indicated 1.5 radians.

The payload was then prepared for removal to the ABMA area. This involved securing the payload in its handling dolly, installation of the cover and shipping band, and use of the fork lift and hangar hoist to place the payload in its trailer.

During checks at Complex 12, the autopilot programmer, installed 7 September as a replacement, was found to be resetting prematurely at 15 seconds. The cause was determined to be improper shielding and lack of ground connection.

The Stage III receiving inspection was conducted in the ordnance area pursuant to Procedure A/5-362. The flight and backup third stages were found to be in good condition.

Fit checks were conducted during the afternoon at Spin Building 56. A fit was made with the payload and dummy solar paddles on the live Stage III, then the live paddles were installed. The top retainer washer for the III/IV separation spring was determined to be too close to the payload aft antenna. The flux gate probe also interfered with one paddle holddown bracket. The bracket was reversed to provide sufficient clearance.

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At a later point in the proceedings when the Hydro-Set was suspended from the crane hook, the crane was tranversed accidentally and the edge of the Hydro-Set struck the payload sharply between axes III and IV. This accident was due entirely to overcrowded conditions and lack of adequate visibility within the bunker rather than personnel error. A dent approximately 1.5 inches long was made in the cover quarter panel, with a similar dent in the payload sill. All ordnance area fit checks were completed, but several deviations were made from the procedures; working time was running out. The fits included nose fairing location and alignment and adjustments of II/III turnbuckles, struts (fans), and blast bands.

A countdown review was also held during the afternoon at the blockhouse. Later, a general meeting was called at the hangar to discuss hurricane preparations. Although "Donna" was still 150 miles southeast of Miami Beach, that city and Miami proper were already being [illegible] by gusts as high as 65 mph, the hurricane had taken a more northerly tack towards the central Keys.

Two general courses of action were discussed. Plan "A" was the safest and simplest, but would necessitate expensive rescheduling of the entire operation. This was simply to put the payload, second stage, vital test equipment, and sufficient personnel for watch-escort into a large USAF cargo plane and return to Los Angeles. A more attractive alternative to this was to fly to some point far enough inland to be safe, but close enough to the Cape for a quick return after the storm had passed. Plan "B" would concern storage of the payload, solar paddles, and critical test equipment on the upper deck of one of the Titan blockhouses. Damage to the IST equipment by flooding or debris would scrub the operations, without this equipment,* the payload could not be readied for flight. Under

*The IST equipment rack accompanied the payload at all times. It was used at STL-LA during assembly and calibrations. In Florida, it was used in the hangar payload lab and on the gantry for tests prior to launch; it was to be used during and after launch to monitor the payload in support of the Able payload telemetry (APT) van. The rack would be difficult to replace, at any price, because of the long delivery lead time. Even after delivery, the equipment would require at least two weeks of calibration to be made compatible with the payload.

Plan "B," the second stage would be stored in Convair Hangar J, and the remaining equipment and facilities in STL Hangar AA would be secured in accordance with the hurricane plan document instructions. Van No. 4 and the APT van would be sheltered in the hangar.

Execution of either plan would be determined by "Donna's" whims. Any movement approximating a direct hit on the Cape area, or even a near miss of the hurricane eye, could be expected to put AMR out of action for some time to come because of both winds and the predicted 15-foot tides. (The maximum elevation of any part of the Cape terrain was approximately 10 feet, with other parts as low as two feet above sea level.) This would, of course, necessitate rescheduling for October launch. The only remaining decision in this case would be that of waiting until a direct hit was reasonably certain--so as not to retreat prematurely--but moving promptly enough to permit escape before aircraft were grounded, then it would be too late to carry out Plan "A," and personnel would be hard pressed even to secure equipment as per Plan "B."

The alternate Plan "B" was based on the hope that the unpredictable storm would pass through the Florida straits and on into the Gulf of Mexico, instead of moving up the east coast. Movement along this course would, optimistically, result in only minor damage to Cape antennas and other equipment and would permit quick mopping-up and resumption of launch preparations.

Because of these weather uncertainties, only limited hangar activities were scheduled for Saturday, 10 September. Crewmen removed the I/II transition section from the Atlas and returned it to the hangar. Convair personnel then installed the standard R and D nose section on the Atlas in preparation for its removal from the pad, should this become necessary during the night or early in the morning. The Atlas handling trailer was placed in readiness on the ramp.

"DONNA"

10 September

At dawn, all the logistics of disaster went into effect. The strategic placement of men and materiel where they would serve best for community survival began at the Cape and everywhere else in south and central Florida.

During the night, seas bordering Patrick AFB, Cocoa Beach, and Cape Canaveral had been stirred by distant winds and tides into a boiling, angry mass of tumbling foam and spindrift. The local wind, strangely, amounted to little more than a warm, stiff breeze. Rain was only intermittent.

Early morning broadcasts from Miami, 200 miles south, told how "Donna" had smashed into the Central Keys during the night. There had been no word since. STL and Convair crewmen, racing out to the Cape to do what could be done while there was still time, listened apprehensively to car radios. Bulletin followed bulletin.

At 0615 hours, the deadly, 11-mile eye passed 68 miles south of Miami. But "Donna" was 225 miles in diameter, and winds in the city were a constant 70 miles per hour. Two hours later, gusts reached 97 miles per hour at the airport and remained at this level for another two hours.

In the meantime, crewmen arrived at Hangar AA to implement Plan "B." The second stage was towed to Convair Hangar J for storage. At the outlying GGS site, antennas and cables were dismantled from the receiver trailers, transmitter trailer, and the I and R van. At Complex 12, Convair crews removed Atlas 80D from the launcher and moved it to Hangar J for shelter. This task and the removal of three R and D Atlas' on adjacent complexes was complicated by the gradually increasing gusts and rain squalls.

Pan Am personnel moved a large USAF van into the hangar. The payload was loaded into the van, along with the solar paddles, IST equipment rack, and other vital electronic equipment. The van was chosen in favor of the Titan blockhouse considered earlier, the van deck was approximately 5 feet above the hangar floor, and it was felt that this elevation would keep the equipment out of the reach of anticipated tidal flooding. Water higher than this would also flood the blockhouse.

Radio reports warned that "Donna," developing a sudden affinity for land, had rounded the tip of Florida and veered northeast on a course that would sweep her straight up the middle of the state. All the large transport aircraft were being evacuated from Patrick AFB to San Salvador and other downrange islands.

In addition to anxiety about Cape installations, there was concern about the Polaris missile sub Patrick Henry and her tender. Both had put to sea hurriedly in attempt to flee the hurricane, but there was the probability that tides would shoal the narrow channel that led from Port Canaveral to the Atlantic. The ships would be unable to return to dock for days.

By 1100 hours, personnel began leaving the hangar. Within an hour, those left behind to secure the hangar were evacuating hurriedly while the Cape Road remained passable. There was at least one point where the waters of Canaveral Harbor could flood over the road to link up with the Banana River. The last group of evacuees arrived at the motel area of Cocoa Beach after a hazardous drive in blinding rain squalls and the ever-mounting winds that threatened constantly to sweep the cars off the rain-slicked highway. At 1230 hours, "Donna's" eye passed over Naples and headed for Ft. Myers.

For the next 18 hours, the Patrick AFB-Cocoa Beach-Cape Canaveral area was battered by the 80-85-mile winds along "Donna's" periphery. Few people slept during the night, either at home or in the many crowded emergency shelters. Those who retired in the attempt to sleep did so

fully clothed. Misfortune in the area added to the statistics of disaster. Fortunately, as the center of the storm passed, the winds reversed direction to blow off-shore and prevent tidal flooding.

11 September

Sunday, just after sunrise, "Donna" swept out to sea between Daytona Beach and Jacksonville. Beaten, frightened Florida welcomed the first sun in days. The winds diminished gradually as the morning wore on. Relief at the storm's passage was only temporary. There remained the sickening ordeal of searching, clean-up, and repairs.

All STL personnel weathered the blow, although one engineer's rented car was crushed under a falling motel wall and two other cars were damaged by flying debris.

At the Cape, wind and driven rain had put out of commission the Azusa Mark II tracking system. The synchronous timing system for range instrumentation was also badly damaged. There were many instances of flooding and nuisance damage. But the Cape fared better than anyone had expected. The wind shift had prevented flooding. No damage had been sustained by the Complex 12 gantry, pad facilities, or the blockhouse. Aside from a few leaks in the roof, Hangar AA was intact. The tides had not shoaled the Port Canaveral channel; the Patrick Henry could return in safety.

Convair crews reinstalled Atlas 80D on the launch pad. But because of delays in removal of the standard nose adapter and in putting the missile in pressurized condition, installation of the I/II transition by STL personnel would be delayed until evening.

Meanwhile, work resumed at the hangar in effort to regain schedule. The payload, solar paddles, and electronic equipment were unloaded from the borrowed USAF van and set up in the payload lab.

The modulation index of the coherent transmitter was reset to 1.5 radians. Measurements and records were made of the acquisition and command sensitivity of the command receiver. The payload dynamic balance was accomplished as prescribed in Procedure A/5-171. A 0.21-pound weight was added to compensate for the receiver change made at

STL-LA prior to shipment. Additional weight adjustments were postponed. The command circuitry checker was used to test paddle erection simulation

A retest of the yaw loop gains was conducted satisfactorily on the spare control system S/N 492 in accordance with Procedure A/5-227.

Early in the evening, word was received from Warner-Robbins AFB, Georgia, that the newly modified "wastebasket" structure had been unloaded there from a BMD aircraft enroute from STL-LA to the Cape. The plane had landed there because of bad weather, and equipment it was carrying had been unloaded. Two men left the hangar for an all-night drive to the Macon air base to pick up the structure and deliver it as soon as possible to the hangar for fit checks.

12 September

The second stage was towed from the hangar to Complex 12 pursuant to Procedure A/5-202 and prepared for mounting on the Atlas booster.

A Stage I/II interface check was begun early in the morning in accordance with Procedure A/5-10. The purpose of this check was to verify the Atlas/Stage II interstage start and destruct circuitry through connector J264, the electrical disconnect to Stage II.

At the procedure step where Convair transmitted the range safety destruct signal, only 13 volts were received at connector J264 instead of the correct 28 volts. In the course of troubleshooting, no voltage was received. Subsequently, no Convair SECO signal could be detected. A complete check revealed that the transition section wiring harness was sound; this isolated trouble to Convair signal generating equipment. Convair electrical people continued trouble analysis.

It was revealed later that a microswitch on the Atlas outer lox boil-off valve was defective. Replacement of this valve delayed until afternoon the installation of the second stage on the Atlas which had been planned for the morning. Installation was rescheduled for 1300 hours. The Complex 12 electrical facility validation was completed in compliance with Procedure A/5-15A.

At approximately 1330 hours, the second stage was installed on the Atlas in accordance with Procedure A/5-261. (See Figure 2.) The operation was conducted smoothly, using a Hydra-Set for final 6-inch lowering and guide pins in the four bolt holes to maintain stage alignment with the transition section. The installation was complete barely in time to secure the gantry curtains for protection against a driving rainstorm.

The storm and the inadequate protection supplied by a hastily erected tarpaulin over level 113 of the gantry interrupted progress of the facility compatibility and calibration test at 1715 hours. The test was rescheduled for 1900 hours.

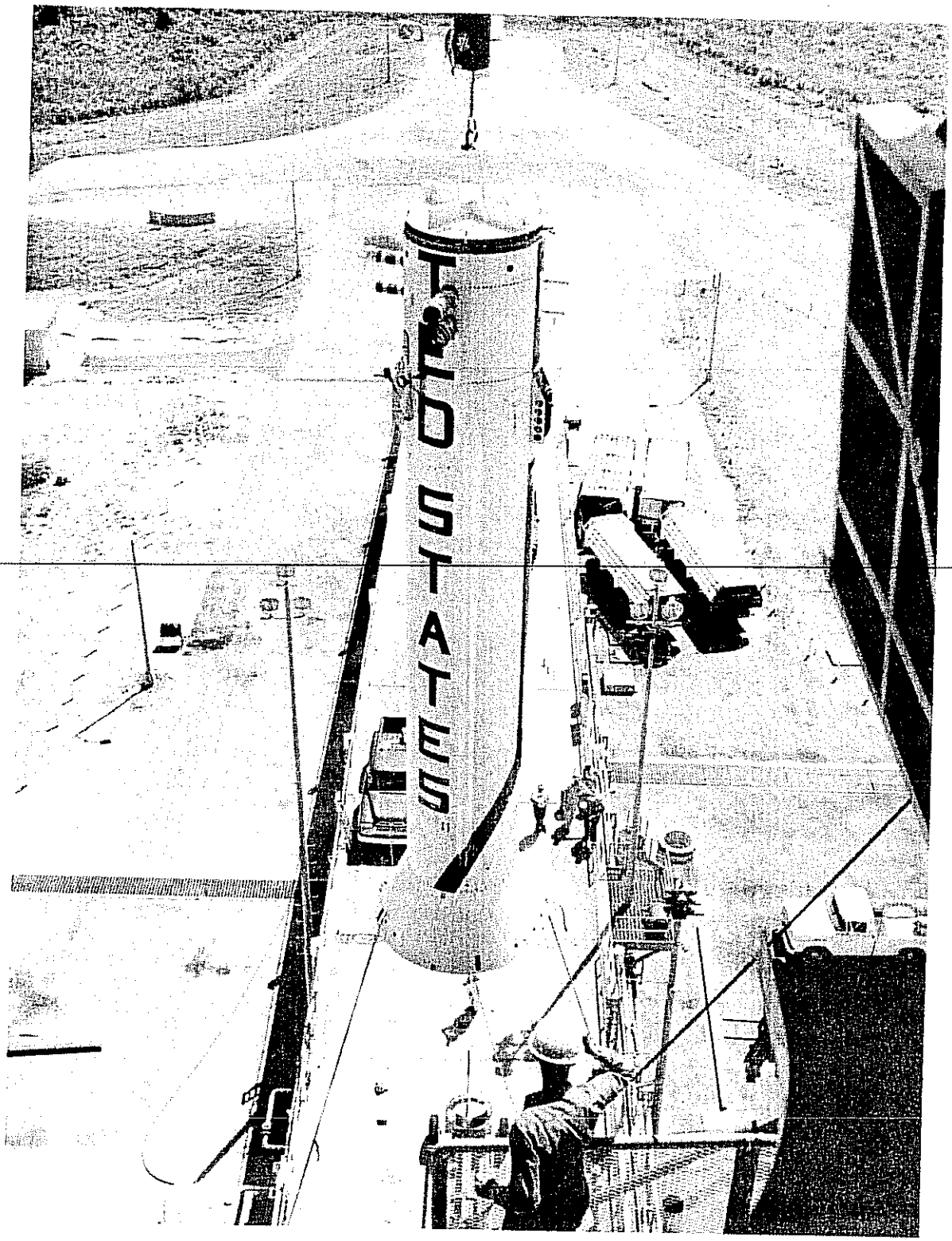


Figure 3. Hoisting PSA 5-1 Second Stage for Mating to Atlas Booster.

At the hangar, adjustments and fit checks were made with the wastebasket, payload, and inert dummy Stage III. Particular attention was devoted to the action and clearance of the "yo" ball de-spin device. This wastebasket had been modified by installation of the de-spin device and a shallow plastic shelf that would function to keep the blast band from tangling the "yo" ball and cable. The activator bracket for the III/IV separation microswitches was offset approximately 0.75 inch and failed to actuate the switches. The bracket was relocated. Wiring and application of epoxy to the wastebasket harness was completed

The five GGS antennas, removed Saturday for protection, were installed during the morning and realigned.

The facility compatibility and calibration test was resumed at approximately 2000 hours and continued late into the night, with equipment secured at midnight. The test was conducted as prescribed in Procedure A/5-12A, and calibrations, with exception of section 12 procedures, were completed successfully.

It was determined that the Atlas lox duct would have to be shortened approximately 2.5 inches; this would, in turn, require reworking of the "dustpan" fairing on the I/II transition section.

T-10 DAY

13 September

The dummy Stage III was installed on the second stage early in the morning. Installation and alignment with dummy interstage fans, separation bands, and dummy payload interstage were performed successfully as described in Procedures A/5-8, A/5-20, and A/5-362, except for ordnance and bonding provisions.

The payload was installed on its handling dolly and moved to Complex 12 for mounting on stand prior to the integrated systems test scheduled for 0930 hours. The gantry crane was found to be operating improperly. Support from Pan Am was required; installation of the payload was postponed until 1330 hours.

The flight wastebasket and payload were installed early in the afternoon. The Hydro-Set was used as insurance against further crane malfunction. When preparations had been completed, the integrated systems test was started in accordance with Procedure A/5-101.

At steps 37 through 43, the STL scintillation spectrometer experiment registered incorrect readings. Similar improper indications were obtained from the search coil magnetometer at steps 44 through 47, plus inability to repeat. At steps 48 and 49, the low-energy scintillometer exhibited a higher-than-normal count rate. The test was carried through the 102 steps to conclusion.

At the conclusion of the integrated systems test, an on-stand trouble analysis was conducted on components and component connections to the "Telebit" digital telemetry unit (DTU). The scintillometer was removed from the payload and returned to the hangar lab for further trouble shooting.

The remaining section 12 of the facility compatibility and calibration test was completed satisfactorily in accordance with Procedure A/5-12A.

The rapid data transmission scheme would make possible the transfer of tracking data from the Cape to the SpaN center in five minutes that, under the prior method, required 30 to 50 minutes. This scheme would make available in near real time the payload tracking data during the early minutes* of free flight Every range-rate (R) measurement, together with its time, would be made available to the LA IBM 7090 or 709 computers within five minutes of loss of GGS loss of lock on the payload coherent transmitter. The data would then be immediately available to SpaN center for orbit determination and the first vernier firing command. The sole human to act in the AMR transmission would be the engineer who carried the punched paper tape from the Burroughs computer van to the I and R van 300 yards distant.

Work proceeded on other payload components and subsystems through the night and into the early morning hours. The scintillometer was found to be defective, and it was suspected that a component of the DTU might also be faulty.

Recurrence of the spurious booster jettison signals, first encountered on 7 September, necessitated replacement of the second A/P programmer in the Atlas B-1 pod

*On prior Able launches, the data had been available only in a much abbreviated form, with a total of 20 range-rate measurements abstracted from a total of 600 to 1200 available. Moreover, this was possible only after a lengthy sequence involving the reading of data from Burroughs computer indicator lamps, voice transmission to SpaN center, transcription, retranscription, and key punching of IBM cards There was a resulting delay of 30 to 50 minutes from loss of lock to the time when the 20 range-rate points were available for computation.

T-9 DAY

14 September

Trouble analysis of payload subsystems and components continued into the early morning hours until 0300 hours. All items except the low-energy scintillometer performed satisfactorily in the hangar lab test setup.

A new scintillometer was installed in the payload later in the morning. System checks were performed subsequently, with satisfactory operation indicated.

Preparations were begun on 14 September for the first flight readiness demonstration (FRD). This overall test was designed to demonstrate the flight readiness of all vehicle airborne systems without mutual interference when the umbilical cables were connected to the vehicle. In addition, umbilical ejection was to be tested manually through activation on the 2-inch and 8-inch launcher liftoff switches. The test was also to have provided checkout of the autopilot-guidance loop; this consisted of the GE ground guidance complex and airborne systems, Mod III tracking radar, Burroughs computer, and the vehicle autopilot systems. Full range support was required, including GGS and range safety.

During the first 10 minutes of the test, Azusa operated non-coherent. At approximately 0900 hours, Convair informed STL that certain malfunctions were again evident in the Atlas A/P programmer and wiring; two shorts were also detected in the booster/sustainer umbilical cable. Convair then requested postponement of the test until 1300 hours so that trouble analysis and corrective action could be undertaken.

Preparations for the FRD test were resumed at approximately 1330 hours. The test was begun as prescribed in Procedures FTP-M-078 and A/5-116 when the T-70 minute countdown was initiated. Operations proceeded smoothly until the simulated T-0 liftoff phase was reached in

the count. At zero sequence 4, coincident with the first-motion signal to the sequencer, the Able umbilical was not pulled* as it should have been. (When ejected or pulled, this action releases the Atlas thrust chambers from the null position.)

At T+1 second, the Atlas 42-inch-rise umbilical was pulled properly. (When ejected or pulled this action releases the gyro to close the Atlas autopilot loop.) The Able umbilical, meanwhile, was permitted to remain connected until T+15 seconds, instead of being pulled immediately after T-0 at a point equivalent to 2-inch riseoff. Inasmuch as the Atlas is programmed to roll between T+2 and T+15 seconds, closing of the autopilot loop forced the engines to hunt from stop to stop, causing the whole vehicle to vibrate to a serious degree. Hydraulics were dropped to relieve the situation. It was noted that this condition would not normally occur during actual operation because of automatic sequencing.

At some time prior to the T+210 seconds--the sustainer engine cutoff (SECO) time--three Stage II propulsion system switches were actuated simultaneously and prematurely. This action caused a hang-up of the Ledex stepping relay in the electrical sequencing system, with no response in the propulsion system. Normally, during launch, the TPS, TVS_1, and TVS_2 switches would be actuated, respectively, in sequence.

The fan microswitch was inadvertently left in the open position through the first run, preventing Able payload telemetry (APT) from receiving strut release indications.

This portion of the FRD test was re-run twice. The first re-run was for the purpose of reproducing the malfunctions. When this was achieved and understood, the second re-run resulted in satisfactory electrical sequencing for the Stage II propulsion system.

*Umbilicals were unscrewed and pulled manually out of the vehicle connectors.

At the hangar, mechanical cleanup work was performed. This concerned touch-up painting and lettering of the nose fairing, fit checks, and machining of the transition section "dishpan" fairing. Installation of the dishpan over the shortened Atlas lox duct was scheduled for early evening.

As the payload systems had warmed up during FRD test operation--and due also to the ambient temperature increase at the top of the gantry--the original malfunctions recurred. The low-energy scintillometer exhibited a count rate higher than normal; both the scintillation spectrometer and search coil magnetometer indicated improper readings. Decision was made at this time to remove the DTU from the payload at the conclusion of the FRD test.

The payload crew worked through the night to perform high-temperature checks on DTU and its component connections. The suspect module (B-33) in the word-7 shifting accumulator proved to be heat-sensitive. This module was replaced. It was also determined that the apparent search coil magnetometer malfunction was actually a symptom of the DTU trouble. A slight light leak was detected in the STL scintillometer photomultiplier and sensor; the assembly was replaced, and a matched logic assembly was included in the replacement. Decision was made to reinstall the DTU in the payload for T-8 Day and T-7 Day operational tests and to remove the unit for environmental requalification on Saturday, 17 September.

GGS exercises were held throughout the day. A partial helicopter calibration test was conducted early in the day. The GGS portion of the FRD test was completed satisfactorily, except for evidence of some payload-guidance interference. Later in the evening, Mod I equation simulation and Mod I/DDE interconnection tests were completed successfully.

T-8 DAY

15 September

Fifteen spin rockets were checked in the ordnance area in accordance with Procedure A/5-21 and the Able-5 Ordnance Data Book specifications The flight Stage III S/N SV-133 was given an ordnance test. The igniter indicated 1.19 ohms, a reading well within specification.

During the morning, GGS also conducted a number of functional checks and inspections. These include a Mod I computer visual inspection, diagnostic marginal checks on the Mod I unit, installation of Able-5 trays followed by a sum check, a Mod I/DDE interconnection test, preliminary boresight tests, and a jeep polarity test. A helicopter calibration check was scrubbed because of the unavailability of a USAF helicopter.

The DTU was reinstalled in the payload on-stand in preparation for the scheduled guidance link loop test.

The guidance link loop test was begun late in the morning in accordance with Procedure A/5-225. A number of procedural errors made it necessary to postpone until afternoon completion of the test. The test was resumed at approximately 1330 hours and was completed smoothly with successful results.

Repairs were made on the Atlas during the afternoon. The vernier engine fuel line had been discovered to be badly chaffed. A leak had also been detected in the PU system bubbler system check valve. Atlas fueling was begun as soon as repairs had been completed.

T-7 DAY

16 September

A long-baseline flight test was conducted by GGS on Atlas 76D from launch at 0458 hours. A GGS transponder unit, identical to the unit used on Able-5 Stage II, was carried piggyback in the Avco nose cone and was tracked successfully to Earth horizon.

Crewmen reported to Complex 12 at 0530 hours for the scheduled final missile preparations for the flight readiness demonstration (FRD). Convair fuel topping on the Atlas, scheduled for completion at 0500 hours, had not yet begun. STL crews were delayed in access to the launch pad and blockhouse until approximately 0730 hours when correct fuel load was obtained on the second attempt by Convair.

Final missile preparations* were begun in accordance with Procedure A/5-3A. Several minor procedural errors occurred. Blast band cables P231, P232, and P233 were found to be too short; three adapter cables were fabricated quickly to enable proper connections. Preparations were, however, completed within the scheduled time of three hours and 45 minutes.

With preparations completed, the FRD mock countdown began at 1215 hours at the count of T-180 minutes. A half hour hold was called by Convair almost immediately because of faulty indications on both fuel valve indicators in the blockhouse. An additional half hour hold was called at 1245 hours to locate and repair the trouble. The FRD test was cancelled at 1330 hours, when it became apparent that the fuel indicator malfunctions could not be repaired promptly. The test was rescheduled for 0730 hours Saturday, 17 September.

*Live ordnance was used on a fit-check basis at all locations except the payload and flight Stage III; this was a departure from all former mock countdowns.

The nose fairing was left installed after permission from Range Safety was obtained for the live explosive actuators to remain in place. The Stage I/II blast band was removed to permit attachment of the Atlas stretch cables. Dry nitrogen was piped under moderate pressure into the fairing, and the access door and nitrogen hose were sealed with masking tape. Despite the sustained operation and high ambient temperature at the top of the gantry, the payload battery temperatures remained within a tolerable range.

Meetings were held to discuss schedule changes and to conduct a countdown critique. Payload DTU environmental checks and other component tests scheduled for Saturday, 17 September, were postponed until Sunday, 18 September.

Two GGS helicopter calibration exercises were held during the day.

Three prime power batteries for Stage II were acceptance tested pursuant to Procedure A/5-1011A. Each battery proved capable of supplying a minimum of 10 ampere hours, while being discharged at a rate of 30 to 40 amperes. Voltage during this period was 28 V (+3.0 - 1.0 V). Two flight batteries were to be used; one for general missile power and one for telemetry.

T-6 DAY

17 September

Crewmen reported to Complex 12 at 0730 hours for the re-run of final missile preparations for the flight readiness demonstration (FRD). Preparations were completed in accordance with Procedure A/5-3A in approximately three hours; the early completion was due to the fact that the nose fairing and related parts had been left installed for the prior FRD test. In order to expedite operations further, it was decided to revise slightly the final preparations procedure with a revision "B" for the actual countdown. Live ordnance was not used.

The FRD mock countdown began at 1100 hours at the count of T-180 minutes. The count proceeded smoothly through the early portions, with the gantry removal starting at T-130 minutes. The gantry was withdrawn from the pad, but tranverse had not yet started when Convair called a hold at T-83 minutes. An improper indication was observed on the blockhouse autopilot console. The hold, originally called for 15 minutes, was extended an additional 20 minutes.

During the hold period, certain payload checks were completed successfully. A short time later, a spurious signal was detected by APT, ARM, and APL. It was characterized as 56 kc above the Stage II guidance transponder nominal at -100 decibels. The signal was not troublesome to operations and was ignored; Pan Am radiation monitors investigated the source of the signal.

At T-82 minutes, GGS reported noise in the transponder beacon. None of the other loop stations noticed abnormal noise, however.

The blockhouse trouble was isolated to a wire in a connector or landline cable, and the countdown was resumed.

At T-49, or 1533 hours, a cloudburst occurred. This interfered only slightly with communications and telemetry, but caused some anxiety

about the payload and second stage because the vehicle was unprotected. The count was completed successfully through T-0 simulated liftoff and the subsequent events

Flight events were transmitted successfully to SpaN center by means of the rapid date scheme. Some confusion on the MOPS loop and lack of data from GGS and APT, which would not have occurred on a real launch, made necessary scheduling of a subsequent full-scale MOPS-SpaN drill prior to the launch.

Immediately following the conclusion of the FRD test, lox was discharged from the Atlas into the lox storage tanks. The gantry was moved back to the launch pad, enabling quick removal of the nose fairing in accordance with Procedure A/5-167. Atlas de-fueling interrupted removal proceedings when the area was declared "red" and the crew had to evacuate the complex for approximately half an hour. Removal of the payload, when resumed, was complicated by gusty winds and a light drizzle. Three tag lines were attached to the plastic covered payload to prevent swinging as the payload was lowered from gantry by the crane. The payload was returned to the hangar lab at approximately 2100 hours for inspection and removal of the DTU. The dummy Stage III was also de-mounted and returned to the hangar. Both the payload and the Stage II control compartment were found to be dry and undamaged by the severe storm.

The DTU was placed immediately in an electric oven at the hangar for a 6-hour high temperature soak at $110^{\circ}F$ in accordance with a portion of Procedure 8808. The payload crew worked late into the night to prepare for and start the final propulsion preflight checks; this procedure required approximately 14 hours to complete.

T-5 DAY

18 September

The DTU was removed from the oven early in the morning. It was checked and found to have passed satisfactorily the high temperature test.

The propulsion system preflight checks were completed later in the morning as prescribed in Procedure A/5-164; the leak check, oxidizer leak inspection, and regulator operational checks were all satisfactory.

The payload engine squib resistance checks were conducted in accordance with Procedure A/5-177. All resistances were within specification.

The DTU was taken to Radiation Inc., Melbourne, for a reacceptance vibration test. The unit passed successfully the required cycle of vibration tests on the shake table. The DTU was returned to the hangar and immediately reinstalled in the payload by approximately 1830 hours.

At the Complex 12 blockhouse, Convair replaced the plug-half of the faulty landline connector; two of the pins were found to have been badly corroded. Electrical checks determined that the connector was sound. This would be corroberated during the final FACT test scheduled for Monday, 19 September. The programmer was also rechecked and found to be operating satisfactorily.

General payload testing, calibration of the experiments, and receiver sensitivity checks were conducted late into the night.

T-4 DAY

19 September

The calibration of payload experiments was continued, starting early in the morning. A small light leak was detected in the Goddard scintillometer experiment. A spare unit was installed. This unit failed to qualify because of abnormal power consumption on the 10-volt line. (Normal current drain is 2 mils; the spare scintillometer was found to be pulling 4 mils.) The original logic was reinstalled. The spare photomultiplier was repaired with aluminum potting compound and installed in the payload to operate with the original logic. A careful calibration was required to match the photomultiplier with the logic.

An umbilical squib ejection test was held during the afternoon in accordance with Procedure A/5-295. This test was designed to insure proper explosive ejection of the umbilical plug from the Stage II missile connector. (On prior Able launches, the ejection had been accomplished with the use of an electrical solenoid device. The explosive squib was considered more forceful and required less power.) Initial tests failed to achieve ejection. After some delay in obtaining a fresh batch of explosive squibs from the ordnance area, the test was resumed and successful ejections were obtained.

Late in the afternoon, Stage II guidance checks were made with GGS. Clean transponder signals were obtained by GGS throughout the test, in contrast to the ragged signals received during the last FRD test.

The final Convair FACT test scheduled originally for the late morning, had been postponed until evening. Interference was detected between the Atlas vernier engine conduit and the lox line. This test was run and then repeated because of problems with the landlines.

The flight wastebasket was balanced dynamically in the spin fixture. The Stage III/IV separation microswitch adjustment was made after the balancing was completed.

A weather facilities briefing was held at Patrick AFB. The weather minimums agreed upon imposed no serious constraints upon launch so long as the weather remained normal.

A payload preliminary weight check was made during the evening. The payload, as weighed, was determined to be 220.8 pounds, less solar paddles, paddle arms, fuel, and small hardware items.

A final payload review was conducted during the late evening hours pursuant to Procedure A/5-160.

GGS conducted a long baseline jet tracking calibration test during the evening, with first point achieved at approximately 2030 hours.

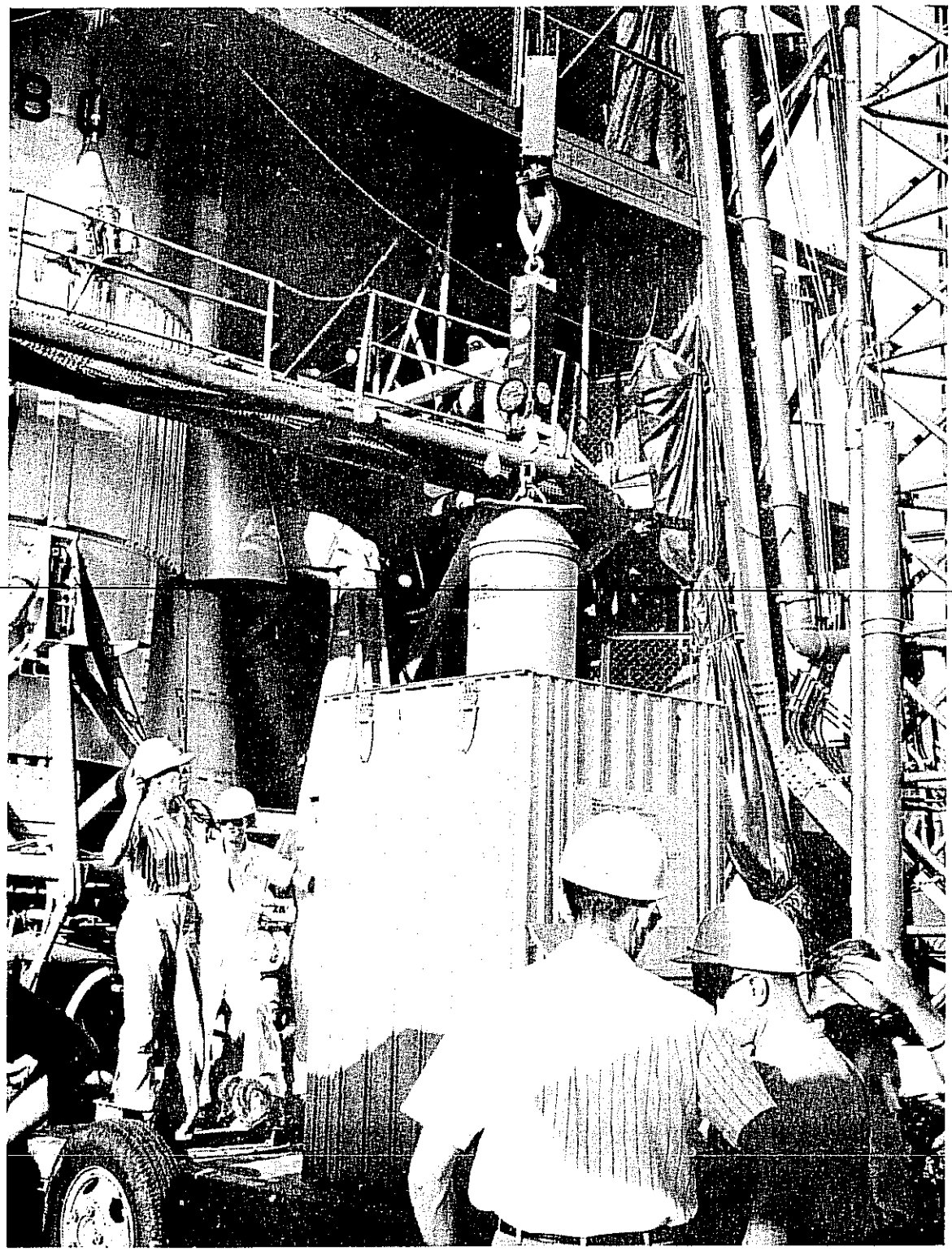


Figure 4. Live Third Stage is Hoisted from Shockproof, Sealed Container.

T-3 DAY

20 September

A payload integrated systems test was held during the morning and completed successfully as detailed in Procedure A/5-113D. The repaired scintillometer components functioned perfectly.

Payload propellant servicing was completed at Complex 12. This operation entailed filling of the hydrazine reservoir and lines. A total of 138.0 pounds of fuel was loaded into the payload reservoir.

An Atlas review was held at 1400 hours with STL, Convair, BMD, and NASA representatives present. During the FACT test Monday, Atlas telemetry problems had developed in addition to earlier troubles. It had been determined that the recurring troubles were due to the omission of a cable in the airborne electrical harness. This was a design error not detectable through normal factory or AMR tests; a special test and recheck of the cabling diagram were required to make the discovery. A blocking diode was also found to be missing from the vernier tank pressurization lead. The review was considered favorably, in view of the definite identification of the troubles and the assurance on the part of Convair people that the shortcomings could be remedied. Installation of the live Stage III on the vehicle was authorized. (See figure 4.)

Installation and alignment of the live Stage III, originally scheduled for the morning hours but postponed because of uncertainties with the Atlas booster, were begun at 1600 hours in accordance with Procedure A/5-8. A new alignment gear P/N 08T588 was used, in addition to the normal sine plate and T-bar, for aligning the third stage and III/IV interstage. The bonding procedure, section D, was postponed until Wednesday, 21 September.

Aerojet-General personnel installed the heat generator assembly (HGA) in the second stage.

T-3 DAY

21 September

Final payload preparations were completed as prescribed in Procedure A/5-110 prior to moving the payload to Complex 12. The payload was set up in a tent-covered fueling area for propellant servicing. The aft engine plug and desiccant were removed from the unit. Fueling was conducted in accordance with Procedure A/5-162 and completed by 1200 hours.

On the gantry, alignment and bonding of the small III/IV interstage structure to the third stage was completed pursuant to Procedure A/5-8D.

Sluggish crane traverse operation and inability of the crane to hoist sufficiently high above gantry level 113 complicated installation of the payload on the vehicle. After considerable delay, the payload was aligned and secured as prescribed in Procedure A/5-167A. The propulsion system was then pressurized in accordance with Procedure A/5-163 and set up to stabilize overnight.

At a lower level on the gantry, a re-run of the Stage II on-stand control system test was performed during the afternoon as prescribed in Procedure A/5-223. The test was completed satisfactorily.

At the hangar, meanwhile, the solar paddle erection springs were checked for correct tension in accordance with Procedure A/5-6, section 1.

The FACT test was re-run during the afternoon. Numerous holds were called during the test for various reasons, but persisting A/P programmer troubles were mainly responsible. The test was continued into the evening. Activities were postponed later by a Titan static firing on an adjacent complex. After the Titan operation, Convair trouble analysis was resumed. The source of the continuing programmer troubles was finally isolated to the electrical harness and pinpointed to the diode installations.

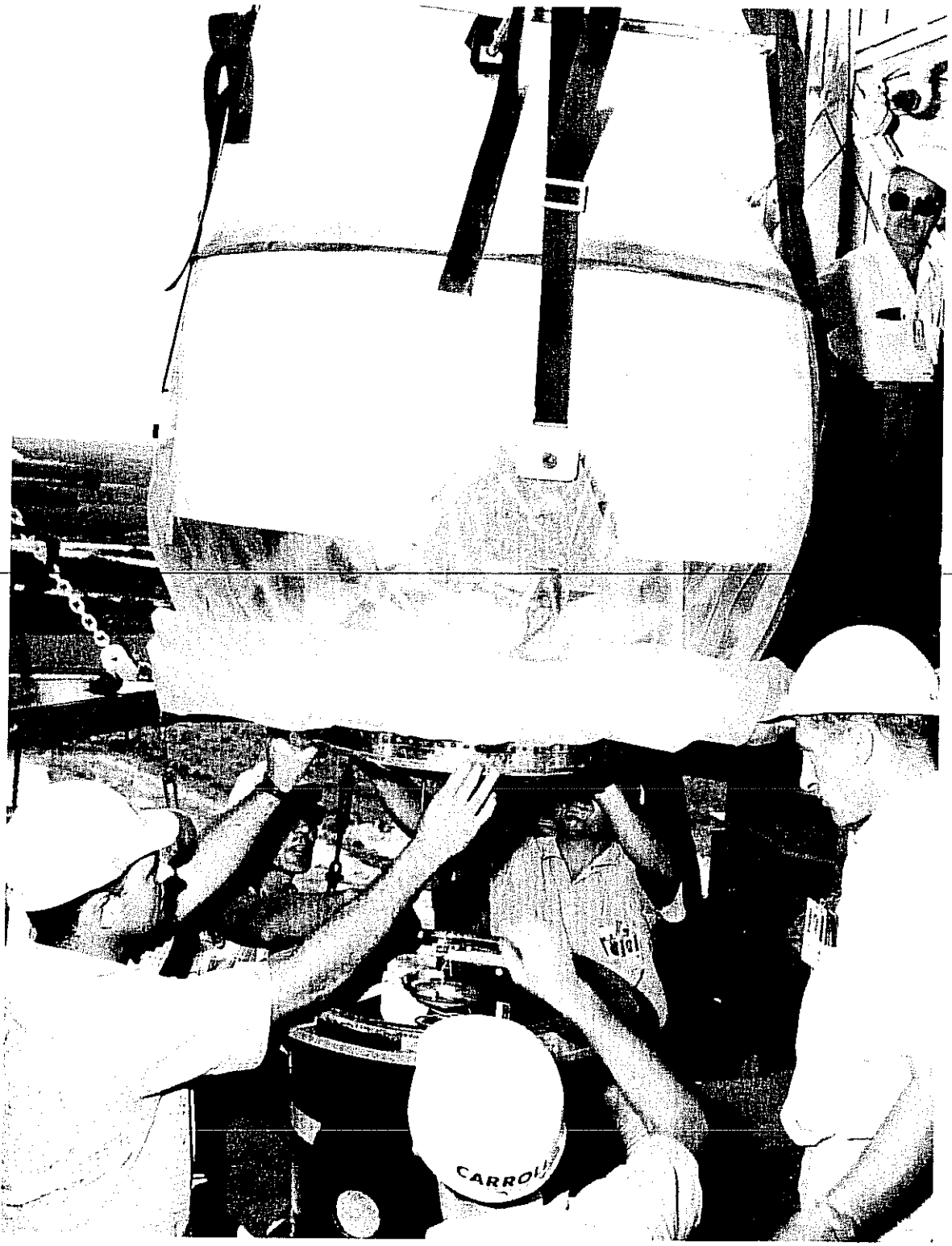


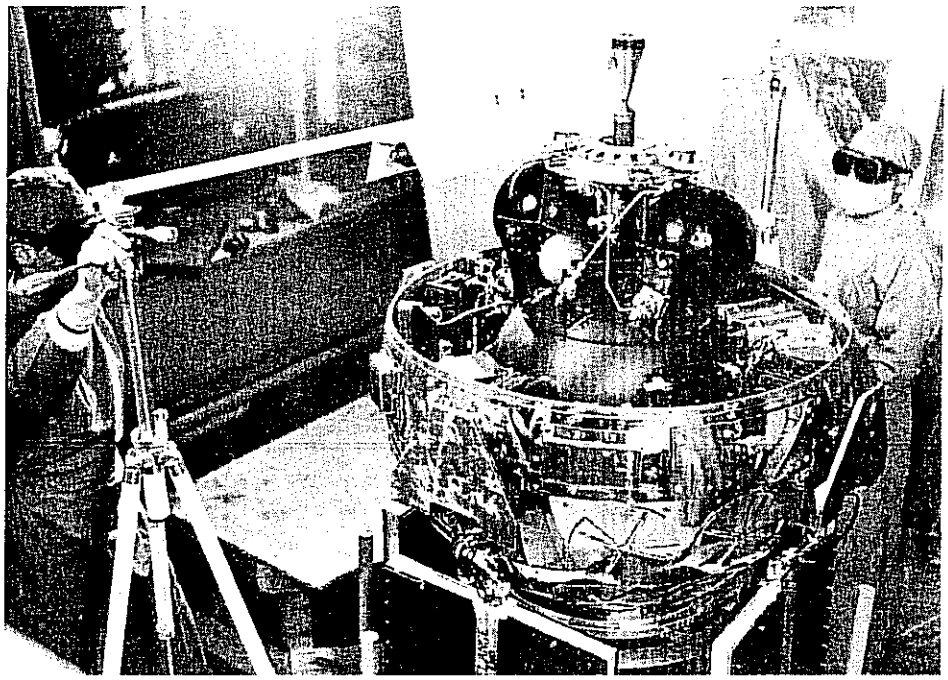
Figure 5. Installation of Payload on III/IV Interstage "Wastebasket" Structure.

In the D-series Atlas, the autopilot programmer had been triggered inadvertently on several occasions by external transients. Blocking diodes had been installed in the harness for protection of the programmer. Each of the diodes had two solid leads which were spliced into the harness leads. It had been discovered that flexing of the harness caused some of the diode leads to break at the splice points As a fix, a protective sleeve was installed around each diode and its splices to keep the connections rigid. To add further rigidity, each of the diodes was anchored to the missile structure. As additional insurance, parallel redundant programmer circuits were installed in the harness.

At 1730 hours, a special "missile secure" task was conducted at the gantry. This concerned mainly the securing of coverings for weather protection.

After completion of the repairs, the FACT test was resumed and completed satisfactorily just after 2300 hours.

NOTE: Two T-3 Days are listed, not because of schedule slippage but so that the usual precount T-2 Day checks could be accomplished within 48 hours of T-0 launch time.



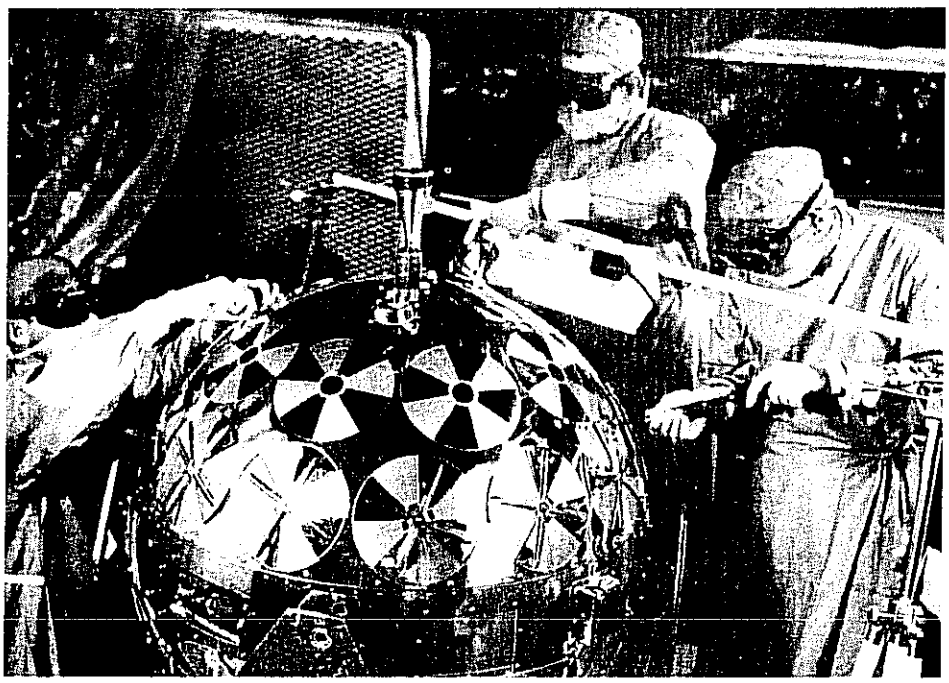


Figure 6. Crewmen in Surgical Dress Decontaminate Payload with Powerful Ultraviolet Lamps while Completing Final Assembly.

T-2 DAY

22 September

A payload pressurization check was performed early in the morning in accordance with Procedure A/5-163. Pressure had stabilized overnight to a satisfactory level in the propulsion system.

The four solar paddles were installed on the payload in compliance with Procedure A/5-165. Following the installation, a solar cell electrical check was performed on a single-module basis as specified in Procedure A/5-126.

Preparations were made for an on-stand integrated systems test. The IST was begun at 1400 hours and completed by 1630 hours as prescribed in Procedure A/5-101. GGS cooperated in the test.

This was followed immediately by biological decontamination and button-up of the payload. Two germicidal ultraviolet lamps were used by the crew in full surgical dress (Figure 6) to sterilize the interior and exterior of the payload and its attaching parts. This technique, which was conducted in compliance with Procedure A/5-169A, was designed to insure sterile condition of payload in the event of accidental impact on the Moon.

The "missile secure" procedure was completed by 1900 hours.

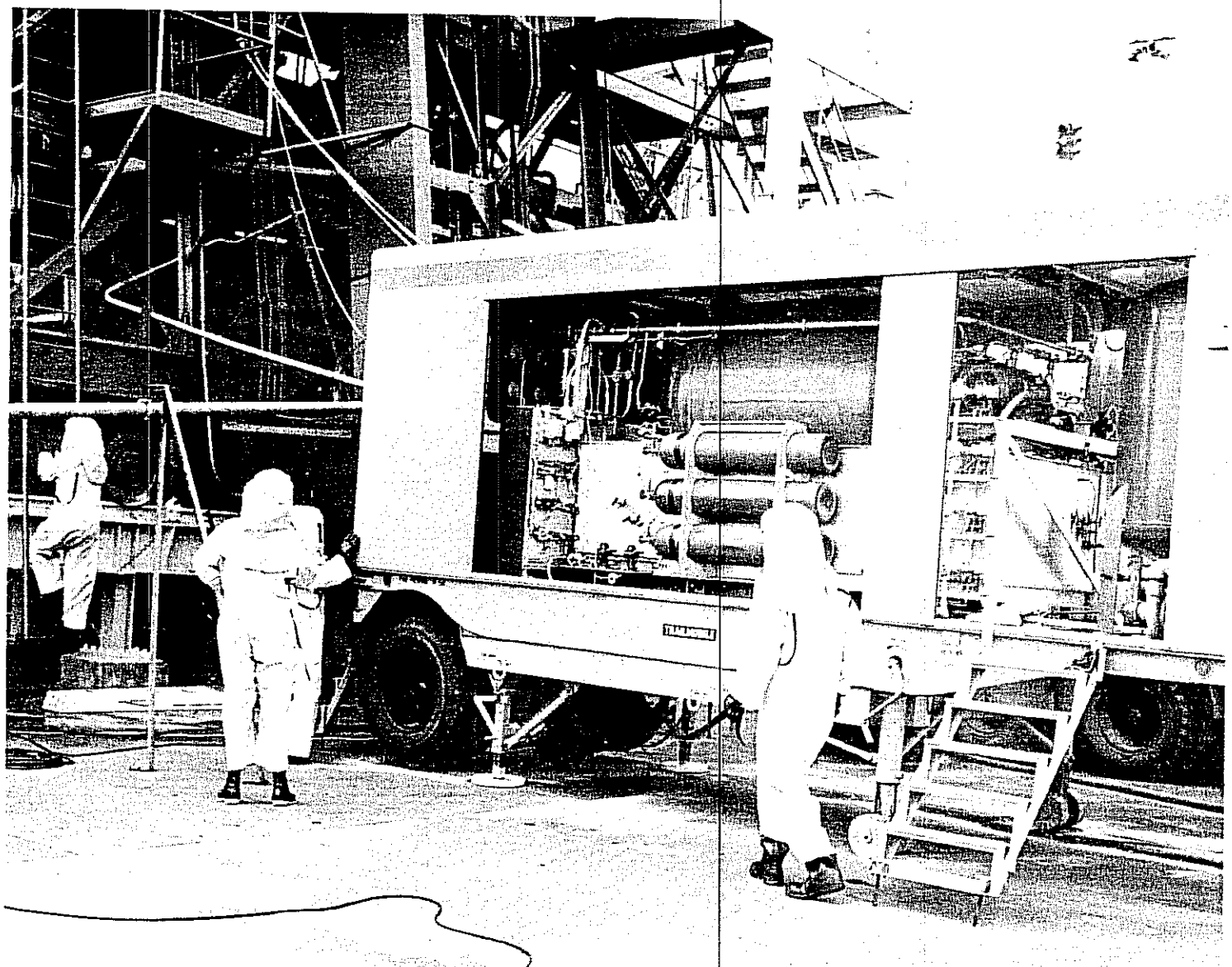


Figure 7. Crewmen in Anti-Acid Suits Fuel the Second Stage with WFNA Oxidizer and UDMH Fuel.

T-1 DAY

23 September

The precount tasks were begun early in the morning when GGS guidance internal preparations were started at 0600 hours. Procedure A/5-23 was followed during the preparations.

The Complex 12 area was declared "Red" at 0800 hours when Convair crewman began fueling of the Atlas booster.

When fueling was completed, setups were made for the sequence guidance link loop test. The test was conducted as prescribed in Procedure A/5-225A; it was designed to demonstrate the guidance r-f link by means of a simulated countdown and flight sequence exercise. After successful completion of the test, the flight batteries were installed in the Stage II control compartment.

On the gantry, the four "fishpole" cable cutter wands were installed between the Stage II forward ring and the paddle tiedown cable. Mechanical cleanup work was performed on the I/II transition section and blast band.

During the afternoon, Aerojet-General personnel began Stage II fueling preparations in accordance with Procedure A/5-265. Propellant servicing was started at 1430 hours as prescribed in Procedure A/5-272. (See Figure 7.) Servicing was completed at 1840 hours as specified in Procedures AFTP-10-101a-222.3 (fuel) and AFTP-10-101a-221.3 (oxidizer). Personnel maintained a fuel watch which would be kept in effect until removal of the gantry during countdown.

A GGS helicopter calibration test was conducted during the late afternoon.

T-0 DAY

24 September

At 0030 hours on 24 September, all personnel were on stations for final missile preparations. Atlas fueling had been conducted the morning of 23 September, and Stage II propellant servicing had been completed during the evening. Incorrect installation of a "wastebasket" cable caused failure in reception of the Stage III/payload separation signal during prelaunch checks. The cable was found to be shorted against a bolt head. The removal of excess shielding from a lead in the Stage I/II transition section was required later. Time consumed in trouble analysis and corrective action used up the 50-minute and 10-minute holding times reserved for T-60 and T-7 minutes.

The terminal countdown was initiated at T-180 minutes, or 0613 hours EDT real time, and proceeded until 0730 hours. At this time, Range Safety scrubbed the operation on two weather counts--increasing gusty winds and lowering cloud ceiling. Launch was rescheduled immediately for the following day, 25 September.

The vehicle was secured as prescribed in the "Preparations for Recycle" Procedure A/5-2 and relevant Convair procedures. Aerojet-General personnel disconnected and shortened the heat generator assembly (HGA). Lox was discharged from the Atlas into the lox storage tank. The flight batteries were removed from the second stage and brought to the hangar for peaking.

The safe-and-arm unit was safetied and removed. All other ordnance was safetied with appropriate shorting plugs. The vehicle was secured at 0800 hours.

Figure 8. Complex 12 Blockhouse at T-45 Seconds. Able Control Console is Shown at Rear. Dr. G.J. Gleghorn, second from right, is Able Test Director.

COUNTDOWN

25 September

The rescheduled countdown was initiated at 0300 hours EDT on 25 September.

The low-pressure trough associated with the dying storm "Florence" had moved inland, giving promise of favorable weather at launch time. Sporadic showers occurred during the early morning hours, lightening as the count proceeded. Launch forecasts indicated 3- to 4-tenths cumulonimbus, with a 3900-foot ceiling and high secondary layer. Surface winds were SE at 5 knots. No appreciable wind shear was predicted.

Final missile preparations were completed in accordance with Procedure A/5-3 exactly on schedule at 0610 hours EDT. The count was picked up at T-180, or 0613 hours real time. The vehicle was secured and the gantry removed and secured by 0735 hours. Final GGS payload and guidance checks were completed satisfactorily just prior to the scheduled T-60 hold. Red tag items (Table 2) were delivered to the test conductor.

At the conclusion of the 50-minute hold, the terminal count was resumed at 0903 hours. Loxing was begun ten minutes later. The count proceeded smoothly to the T-7 hold for a period of 10 minutes. Following the hold, the count proceeded to T-0.

Liftoff occurred at 1013:16.9 hours EST. The vehicle ascended smoothly and positively. Visual observation was made until the vehicle disappeared into the lowering cloud ceiling at approximately T+90 seconds.

Station reports over the VCL loop (MOPS) were made late and, in some instances, hesitantly. Event times were given completely out of sequence Tel-3 (TLM-18) reported loss of lock on coherent transmission at approximately 1027 hours. No confirmations were received from ABMA or Manchester. It was obvious less than 10 minutes after liftoff that the missile had failed It remained now only to find out why

Table 2. Red Tag Items.

ITEM	TO BE REMOVED
P1060	1 Shorting Plug
P-202	1 Shorting Plug
Nose Fairing Bolt Cartridges	4 Shorting Plugs
Nose Fairing Actuators	8 Shorting Plugs
I/II Separation Bolt Cartridges	8 Shorting Plugs
Spin Rockets	10 Shorting Plugs
I/II Blast Band Bolts	3 Shorting Plugs
II/III Separation Bolts	2 Shorting Plugs
ABL 248-A9	1 Shorting Plug
Explosive Cord Cutters (Paddle)	4 Shorting Plugs
S and A Mechanism	1 Shorting Plug
S and A Mechanism (Collected by Pad Safety)	1 Pin
Able Electrical Umbilical Squib	1 Shorting Plug
Able Helium Umbilical Squib	1 Shorting Plug
Weight Drop Cable Cutter	2 Shorting Plugs
H G A	1 Shorting Plug
P-296	1 Shorting Plug
Ames Experiment Cover	1
Engine Cover	1
Desiccant Bag	1
Temperature Experiment Cover	1
Amer Plasma Probe Plug	1
Weight Drop Safety Assembly	3 Bolts, 1 Bar
PSID Transducer*	1 Cap, 1 Cover
PSIA Transducer*	1 Cap

*Located in I/II transition section.

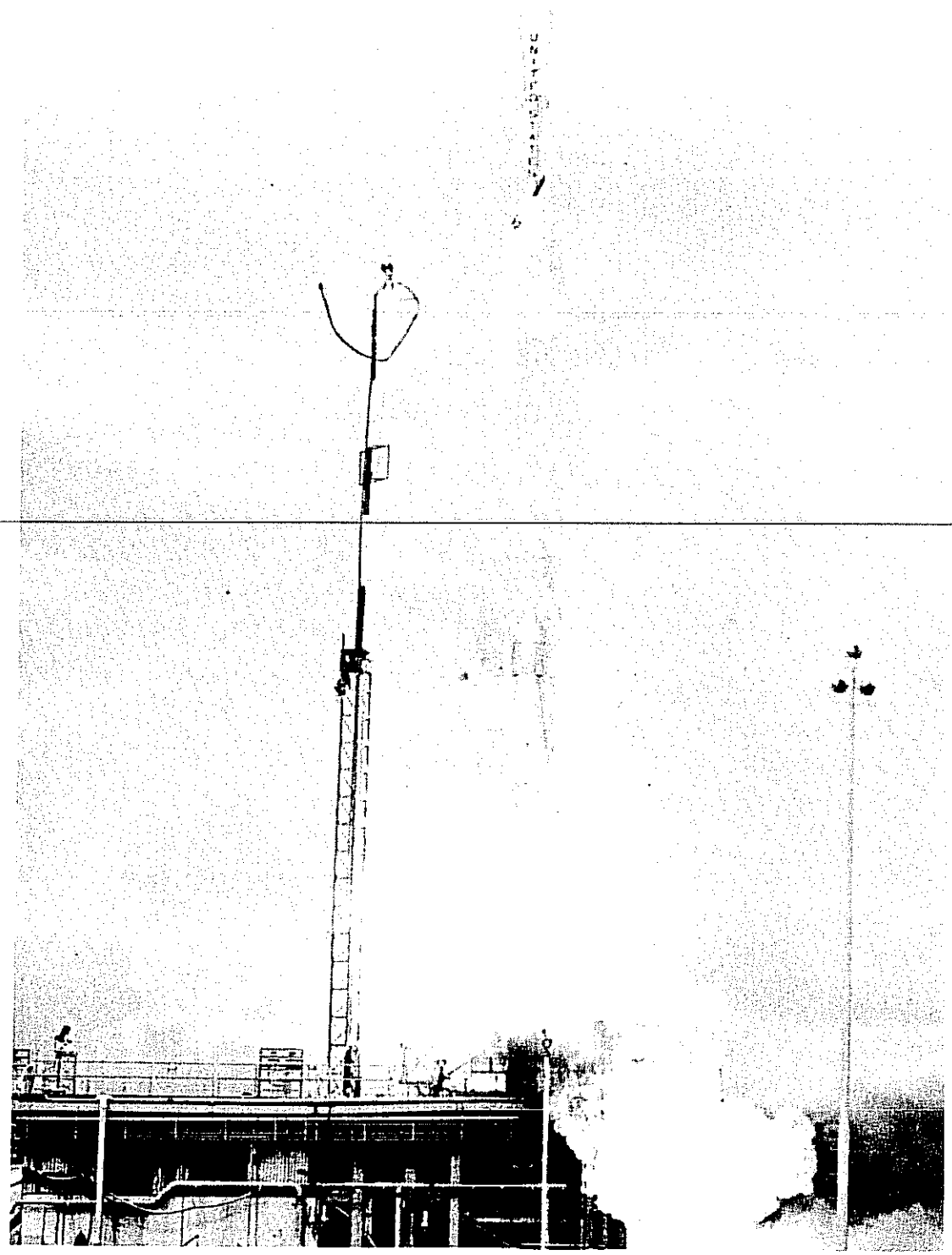


Figure 9. Atlas Able-5A Vehicle Liftoff.

Quick-look analysis of all the telemetry records, including several Convair Atlas tapes, occupied personnel until mid-afternoon. Malfunction was quickly isolated to the Stage II thrust chamber and I/II interstage area.

FLIGHT ANALYSIS

Immediately upon the return to STL-LA of Florida personnel, post-flight analysis was undertaken by several task groups. Each of the groups conducted investigations in specific areas such as structures, propulsion, controls, guidance, and systems integration.

Smooth data was secured from the telemetry tapes. Significantly, the later findings differed only slightly from the on-the-spot quick-look reduction of data to AMR and only in the matter of two flight events.

The availability of a completed PSA 5-2 second stage, identical to the destroyed stage, facilitated study and inspection of the thrust chamber assembly.

The conclusions resulting from data analysis (including some computer runs), and thrust chamber assembly studies reconstructed the Able-5A flight as follows:

After vehicle liftoff, guidance of the Atlas 80D booster by the GE/Burroughs Mod III system was completely successful. The Atlas flight was nominal, except for the fact that the vernier engines failed to cut off after the nominal five seconds of operation. The resulting 100-mile overshoot of the vehicle was well within the dispersion permitted for range safety considerations. In addition, the Mod III system determined the correct values for $\dot{R}$ (range rate), p and q (angular positions) and transferred these values to the Mod I computer.

Staging of the Atlas and Able stages was signalled by a backup event--TVS_2, an oxidizer valve switch set at 80 percent of the valve opening. Separation occurred at essentially 100 percent thrust chamber pressure, rather than 60 percent pressure, as would have been the case had the primary event* occurred correctly. As the result of the delayed

*The primary event is a I/II bolt firing signal initiated in the propulsion sequence box in response to actuation of the TPS thrust chamber pressure switch. This switch was set to actuate at 60 percent thrust chamber pressure. The primary event did not occur because either the K2 propulsion relay or the TPS malfunctioned.

separation, pressure within the blast area of the I/II interstage area--the transition section and Stage II skirt--was higher than normal, increasing the tendency toward asymmetrical flow (flame) separation in the thrust chamber exit cone. However, no actual indications were given of flame separation caused by back pressure in the interstage area. There was no evidence of delay in explosive bolt actuation or bolt hang-up. Within 0.2 second after receipt of the separation signal, Stage II engine chamber pressure diminished below nominal. The pitch servo actuator telemetry signal moved out of hand, indicating a broken wire in the pitch potentiometer. The yaw servo actuator and thrust chamber were driven against the LH stop. Both indications were traced prior to any significant occurrences on the gyro demodulator output.

An oxidizer leak developed, probably in the thrust chamber area. Leakage rate of the WFNA was established as approximately 19 pounds per second, with a corresponding leakage area equivalent to a 0.5-0.6 inch hole

The damping orifice in the yaw actuator cylinder was displaced. As a result, the actuator torque was reduced to approximately 15 foot-pounds; this was insufficient to prevent hard-over movement of the thrust chamber. The Able stages were turning to the right at this time at a rate of 30 degrees in 15 seconds. The stages stabilized for approximately 45 seconds in the pitch axis, then began tumbling about both axes.

Stage II engine shutdown command was transmitted by GGS. This initiated all the following events which occurred at approximately nominal times, as shown in Table 3.

The third stage flight was nominal, although it was spin-stabilized on a downward, vertical trajectory throughout. Engine duration, as determined by NASA Minitrack, was 40 seconds, minimum. Stage III/payload separation was achieved, with no evidence of bumping or hang-up.

Table 3. Flight Events.

EVENT	FLIGHT TIME	
	Actual	Nominal
Liftoff (1013:16.937 EST)	0	0
Arm Stage II	134.928 134.935	140.000
Nose Fairing	170.228	175.000
SECO	271.223	275.000
Stage I/II Blast Band	271.281	275.000
Start Stage II (Fire)	273.270	275.000
Chamber Pressure Starts Increasing	273.543	-------
Stage I/II Separation Bolts Fire	273.785	275.400
Stage I/II Separation	273.823	275.400
Stage II Chamber Pressure at Maximum	273.858	-------
Stage II Chamber Pressure First Minimum	273.883	-------
Stage II Chamber Pressure Small Peak	274.403	-------
HGA	283.639	-------
Start of Chamber Pressure Decay	350.013	-------
Stage II Chamber Pressure Reaches Zero	352.733	-------
GGS Cutoff Command	379.016	-------
Stage II Cutoff	379.036	387.000
Paddle Erection	379.685	382.000
Stage II Spin-Up	381.031	388.000
Strut Release	381.965	389.100
Stage II/III Separation	381.967	389.100
Stage III/Payload Separation	439.013	385.100
First Vernier Firing (Start)	476.663	477.000*
First Vernier Firing (Stop)	600.743	500.000**

*Nominally, Stage II cutoff +95 seconds.

**Nominally, Stage III cutoff +118 seconds.

Signal strength measurements on the payload non-coherent payload transmitter indicated a spin rate of approximately 2.5 rps, which remained constant until loss of the signal. The first vernier engine firing was achieved nominally Angular accelerometer readings described a sawtooth pattern; payload behavior that could cause such a symmetrical series of glitches has not been determined. Shortly thereafter, it became necessary to depress the APT antenna toward the horizon in effort to track the payload at optimum signal strength With the antenna depressed to 12 degrees there was a sudden decrease in signal strength. This drop was followed immediately by complete loss of signal. No signals were acquired by the SpaN Net or other stations beyond the range of Cape telemetry.

Telemetry was received from the vehicle for approximately 14 minutes after liftoff.

No single, specific cause for the Stage II malfunction was determined. An oxidizer leak in the thrust chamber assembly explained the chamber pressure record obtained during the flight, but did not, as such, explain the gimbal actuation abnormalities observed. Possible causes of the oxidizer leak were 1) random structural failure in the thrust chamber assembly or propellant feed system, 2) structural failure induced by asymmetrical flow (flame) separation in the nozzle, 3) structural failure resulting from an abnormal starting transient, or 4) damage resulting from shrapnel effect of explosive bolts or other ordnance items.

There was no indication of unusual starting transients. Nor was there sufficient back pressure in the transition section to lead to a positive conclusion that flow separation occurred.

Measures were undertaken to insure that none of the possible problems identified will occur during future Able flights. These precautions will include earlier separation sequencing for Able and Stage II, staking of gimbal actuator orifice plugs to prevent displacement, increase of blast port area in the I/II transition section to alleviate any flow separation tendency.

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