66SD4375

26 May 1966

NIMBUS C

FIRST ORBIT FLIGHT EVALUATION REPORT

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ORBIT ONE - FLIGHT EVALUATION REPORT

1.0 SUMMARY

Following an uninterrupted terminal countdown, Nimbus C was launched from VAFB into a near circular polar orbit at 00:55:34 PDT on 15 May 1966 aboard a thrust augmented Thor booster with an Agena B second stage.

Following the planned powered flight profile, the spacecraft separated from the Agena B approximately 57 minutes after liftoff. Contact was maintained with the spacecraft through the launch and initial orbit insertion phases. Real time data was received at VAFB for two minutes after liftoff. Forty-eight minutes after liftoff, spacecraft telemetry was acquired at Johannesburg, South Africa. During this pass, spacecraft booster separation occurred and spacecraft initial stabilization was confirmed. In addition, the magnitude of the clock jump, resulting from paddle unfold squib firing, was determined. This information provided confidence in spacecraft performance and also permitted rapid clock reset during the subsequent Ulaska pass. Additional spacecraft confidence performance was observed at Winkfield, England, which monitored the beacon telemetry signal strength.

Following separation from the Agena at the planned pitch attitude, the control subsystem maintained attitude of the spacecraft, within the fine limit cycle deadband, 3.8, 3.6, and 7 minutes respectively in pitch, roll, and yaw.

Available data showed that the power subsystem and power supplies of the various other subsystems that were turned on functioned normally throughout this early flight phase. The values of pressurized components remained constant. The spacecraft's PCM beacon-signal was satisfactorily acquired by the Ulaska tracking station at approximately 09:23:34 GMT with loss of signal occurring approximately 19 minutes later.

2.0 INTRODUCTION

The Nimbus Program is the result of a continuing NASA need for a precisely controlled, near-space, earth-oriented, long-life spacecraft with modularized payload interchangeability for use by the scientific community. Objectives of the Nimbus C flight include operational utilization of the spacecraft control, clock/command, thermal, power and sensory subsystems.

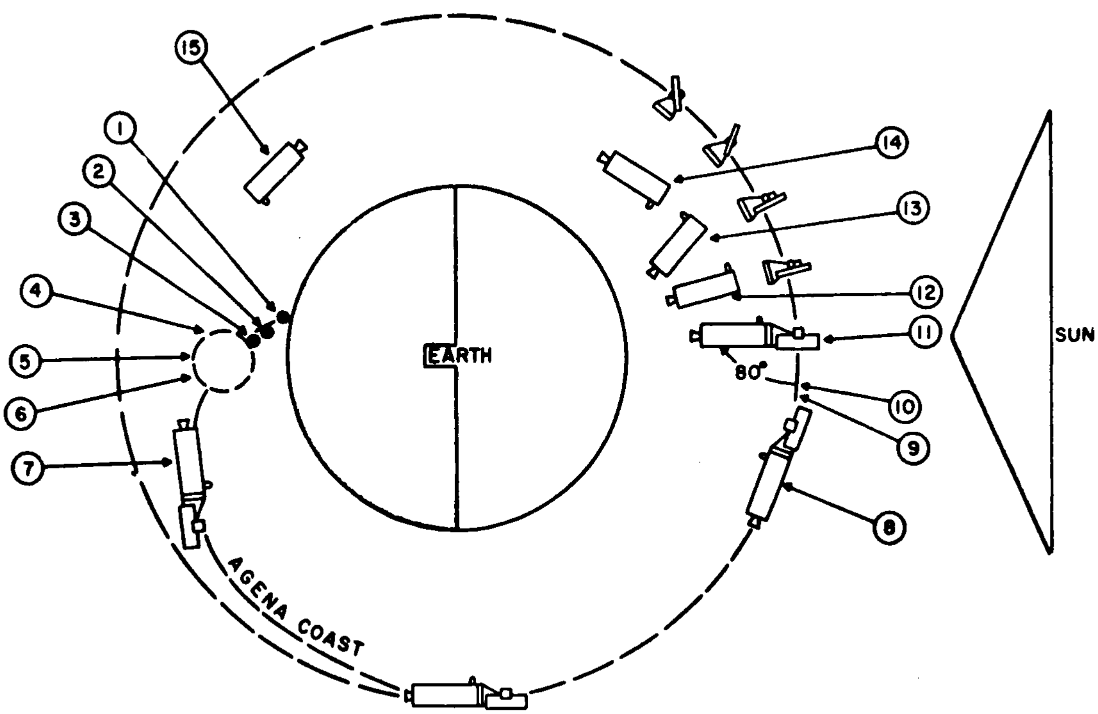
This report presents a discussion of the data obtained during orbit one of the current Nimbus C flight. Conclusions concerning any discrepencies observed in the data have been reserved for inclusion in the First 30-Day Flight Evaluation Report.

3.0 LAUNCH EVENT SUMMARY

Table 3-1 presents a summary of the significant orbit one flight events. Figure 3-1 presents a diagram of the launch sequence.

TABLE 3-1. FIRST ORBIT FLIGHT EVENT SUMMARY

Event	Time of Occurrence (Nominal) (GMT)
Liftoff	07:55:34
Rocket Motor Cutoff	07:56:17
Rocket Motor Ejection	07:56:39
Meco	07:58:03
Veco	07:58:12
Thor/Agena Separation	07:58:19
Agena First Burn Ignition	07:58:47
Nose Shroud Ejection	07:58:57
Agena First Burncutoff	08:02:43
Agena Second Burn Ignition	08:48:14
Agena Second Burn Cutoff	08:48:20
Agena Pitchup Maneuver Initiation	08:51:11
Agena Pitchup Maneuver Termination	08:52:31
Spacecraft/Agena Separation	08:52:42
Spacecraft Paddle Unfold Initiation	08:52:45
Spacecraft Pitch and Roll Control Loops Enabled	08:52:55
Spacecraft Yaw Control and Solar Array Drive Loops Enabled	08:53:35
Alaska Nimbus Beacon Signal Acquisition	09:23:34
Alaska Nimbus Beacon Signal Loss	09:42:34



1. LAUNCH FROM VAFB.
2. TAT MAIN ENGINE CUTOFF (MECO).
3. TAT VERNIER CUTOFF (VECO)
4. TAT/AGENA SEPARATION.
5. AGENA FIRST BURN.
6. NOSE SHROUD SEPARATION.
7. AGENA FIRST CUTOFF.
8. AGENA SECOND IGNITION.
9. AGENA SECOND CUTOFF.
10. INITIATE 60°/MINUTE PITCHUP.
11. TERMINATE PITCHUP.
12. SEPARATE SPACECRAFT.
13. INITIATE YAW/ROLL MANEUVER.
14. TERMINATE YAW/ROLL MANEUVER, FIRST RETRO.
15. SECOND RETRO.

Figure 3-1. Launch Sequence Diagram

4.0 INITIAL ORBITAL PARAMETERS

Table 4-1 presents the initial orbital parameters.

TABLE 4-1. INITIAL ORBITAL PARAMETERS

Parameter	Units	Value
Eccentricity	-	0.00558
Inclination	Degrees	100.311
Argument of Perigee	Degrees	337.710
Nodal Regression	Deg/Day	1.0041
Period	Minutes	108.06
Perigee	NM	590.5
Apogee	NM	636.0
Solar Incidence	Degrees	9.74

*Source: NASA Tracking and Data Systems

5.0 POWER SUBSYSTEM

Normal power subsystem performance was experienced throughout the entire first orbit. The initial current provided by the solar arrays after paddle unfold was 14 amps, one amp greater than normal. Initial power loss in the slip rings was approximately 15 watts.

Figure 5-1 shows specific power subsystem parameter histories for the first orbit which included powered flight, separation, initial acquisition and stabilization. As shown in Figure 5-1, the cell face of the left array was exposed to sunlight as soon as the spacecraft exited the umbra. This was substantiated by the sharp rise in the left array temperature and the sudden appearance of the paddle board voltages at that time. The right paddle board temperature reflects the general spacecraft warmup as it became exposed to sunlight. The left array cell surface was exposed to sunlight rather than the right, because of the 9.7 degree solar incidence angle. The right array surface was therefore shielded from sunlight. As the spacecraft approached more northern latitudes, the cell surface of the arrays began to be shielded from the sun. This is apparent from the sharp initial decrease in paddle board voltages. These voltages again began to rise during the pitch-up maneuver as the cell array surfaces were once more exposed to sunlight. At the time of paddle unfold, and until the solar array drive was enabled, the paddle board voltages were again lost. This was because the back side of the array was facing the sun. As soon as the arrays were properly pointed toward the sun, the unregulated bus current rose to 14 amps, and the batteries began to charge. All batteries charged to identical voltages. The lowest level of discharge was 28.8 volts, which was associated with battery eight.

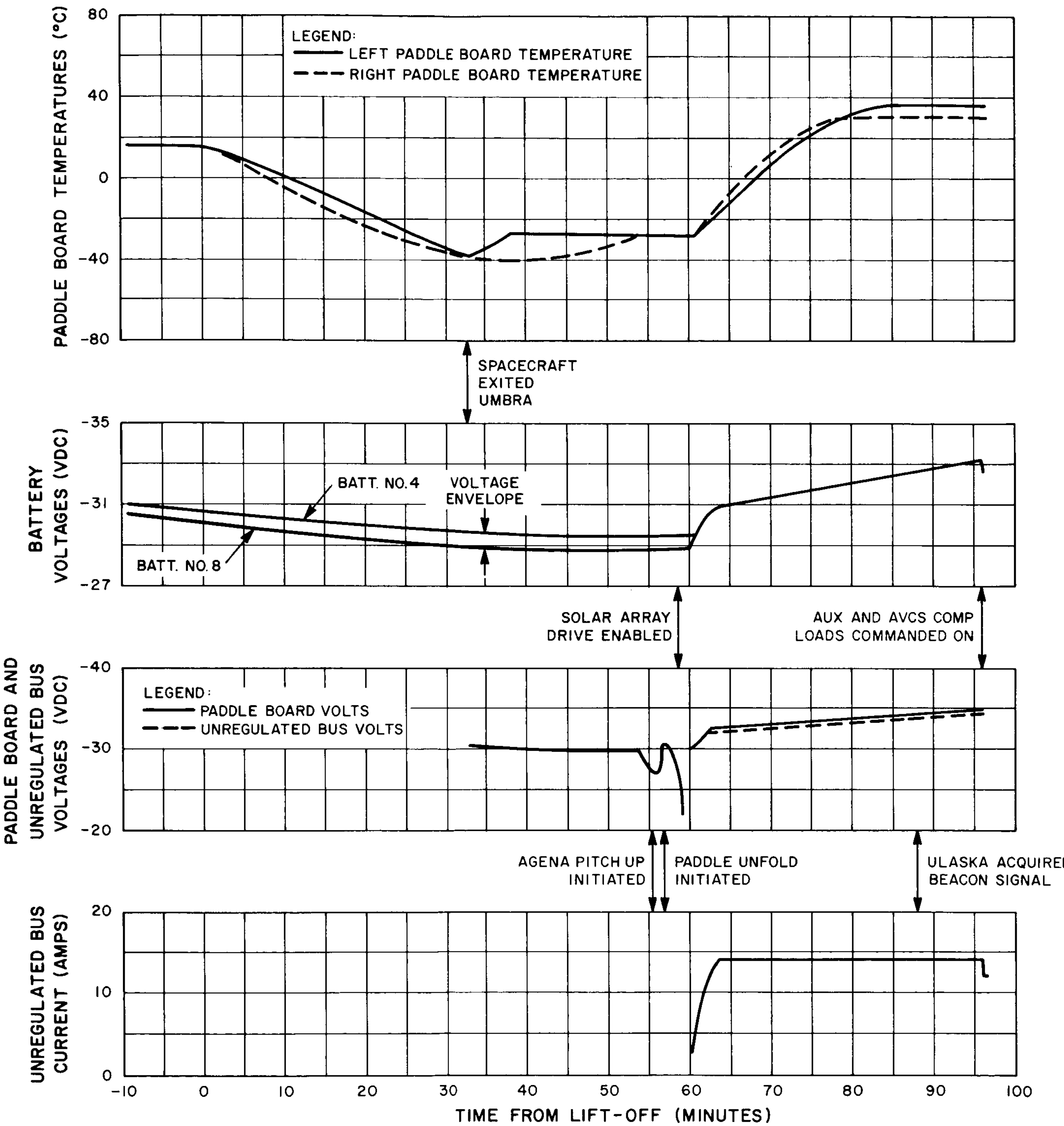


Figure 5-1. Power Subsystem Parameter Histories for Orbit One

6.0 CONTROL SUBSYSTEM

The control subsystem performed in an excellent manner, in that it acquired the earth reference and stabilized the spacecraft within the fine limit cycle deadbands, within 3.6, 3.4 and 6.1 minutes respectively in pitch, roll and yaw after each of these loops were enabled. Following the period of initial acquisition, no further solenoid firings were observed on orbit one. The solar array drive pointed the array surface properly toward the sun within 5.5 minutes after the drive loop was enabled.

Telemetered control subsystem functions verified the acquisition sequence of events which appears in Table 6-1. The useable pneumatic impulse available at liftoff was 715 pound-seconds.

TABLE 6-1. SPACECRAFT SEPARATION AND INITIAL ACTIVATION SEQUENCE OF EVENTS

Event	Elapsed Time (Sec)
Spacecraft/Booster Mechanical Separation (T_o)	0
Solar Array Unfold Initiation	2.5
Pitch and Roll Loops Pneumatics Enabled	12.5
Solar Array Drive and Yaw Loops Enabled	52.5

Figure 6-1 illustrates the period of Agena pitch-up, spacecraft/Agena separation and initial acquisition. The last 15 degrees remaining in the Agena pitch-up schedule was observed in the coarse pitch error channel and is illustrated as a rapidly decreasing pitch error, approximately 1.1 minutes, prior to separation. The Agena yaw limit cycling is illustrated as cyclic variations in the spacecraft roll error prior to separation.

When the pitch and roll control loops were enabled after separation, the positive pitch solenoid fired continuously for six seconds turning off as the pitch error came within the pneumatic deadbands. As the pitch error became positive, the negative pitch solenoid fired continuously for three seconds. The pitch error overshot by five degrees causing a negative pitch solenoid gate to occur. Following two subsequent overshoots of 1.0 and 0.6 degrees, the pitch error was controlled within the fine limit cycle deadbands. These overshoot characteristics are illustrated in a phase plane plot in Figure 6-2.

No roll solenoid firings were required to stabilize the spacecraft on this axis. Overshoots in this axis are illustrated in the phase plane of Figure 6-3.

Following enabling of the yaw loop, yaw flywheel pneumatic gating occurred seven times. The second gate in the series was a timed re-enable gate; a negative gate occurring 30 seconds after the first negative gate. Yaw fine limit cycle control was achieved 6.1 minutes after it was enabled, with a zero average heading error resulting. No further yaw solenoid firings occurred prior to the Ulaska station pass.

The slew of the array is also shown in Figure 6-1. The array drove backwards from the 180 degree position for approximately 5.5 minutes before the SAD sun sensors became nulled.

At Thor engine ignition, sufficient vibration apparently occurred to cause the pneumatic regulator diaphragm to chatter, permitting high pressure gas to leak into the low pressure manifold; this is shown in Figure 6-4 as the pressure going out-of-band high for the sensor monitoring this pressure.

The low pressure control solenoids in the manifold are forced open at 90 psi. Had the regulator not become reseated, a noticeable drop in "tank pressure" (gas locked up in the line down stream of the tank solenoid and up stream of the regulator) would have resulted. However, this did not occur, therefore, the regulator probably became reseated shortly after liftoff (a period of high vibration levels). The manifold pressure returned to normal at the time the pitch and roll loops were enabled.

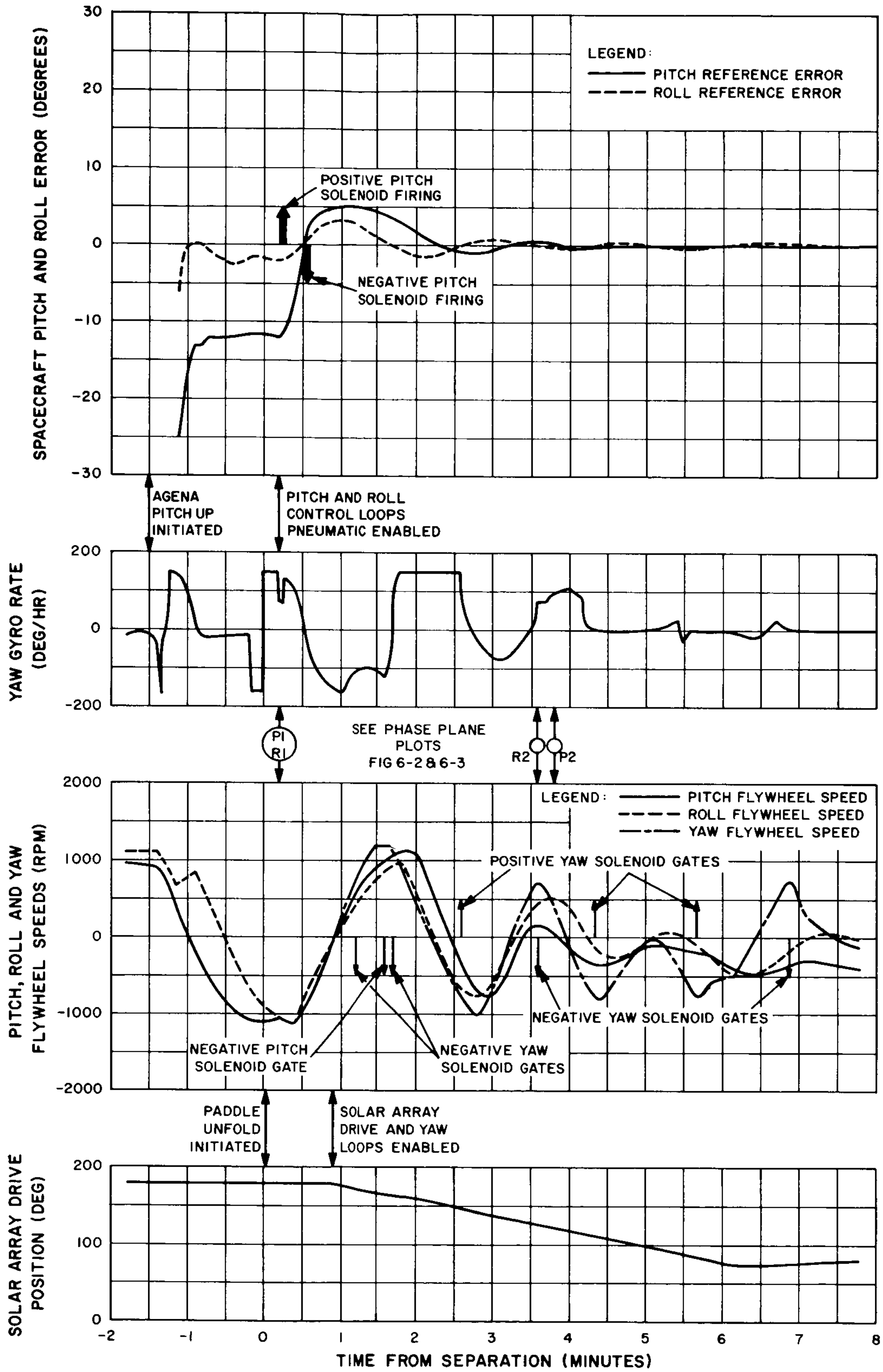


Figure 6-1. Control Subsystem Parameter Histories of Spacecraft Initial Attitude Reference Acquisition

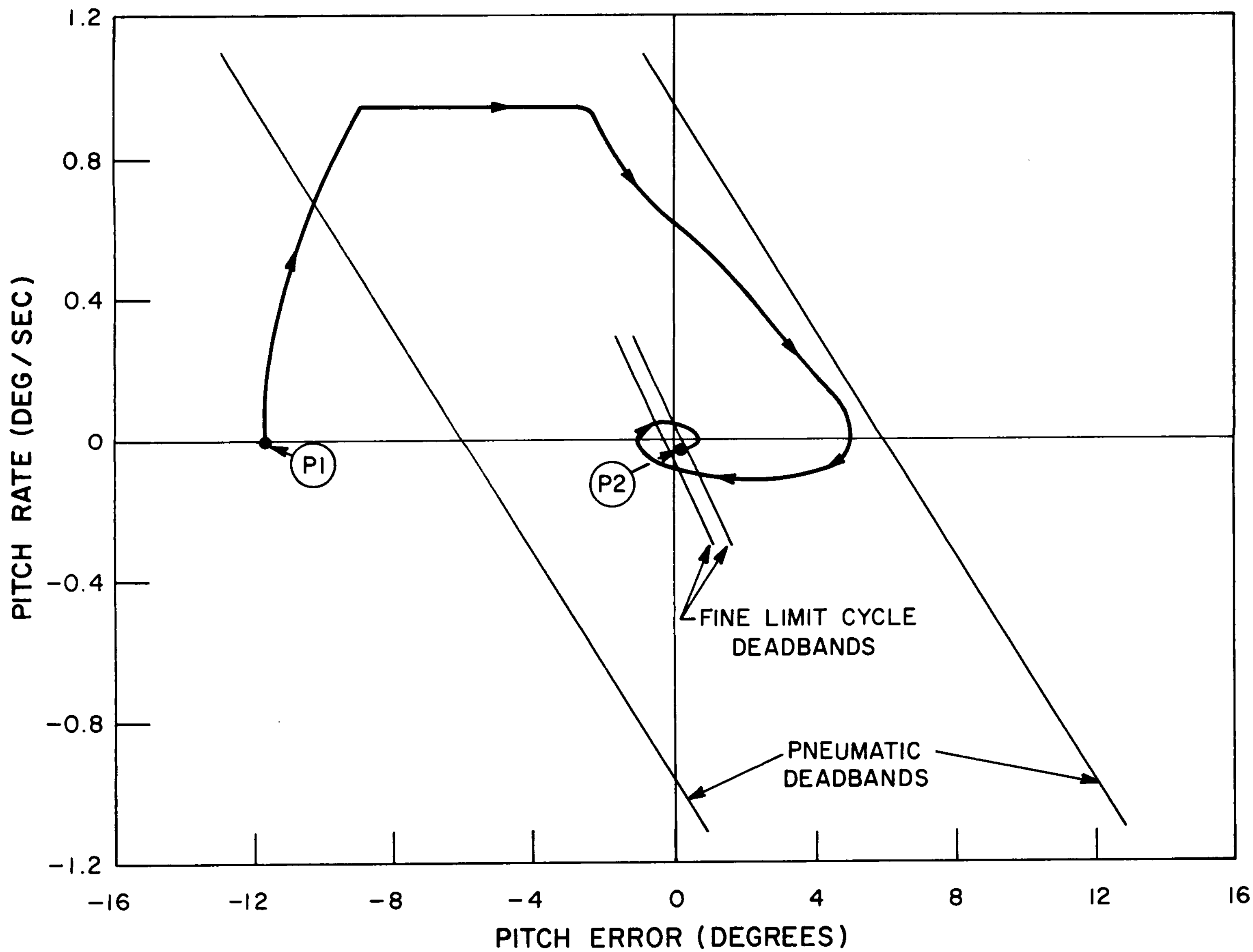


Figure 6-2. Phase Plane Plot Showing Spacecraft Initial Pitch Attitude Reference Acquisition Characteristics

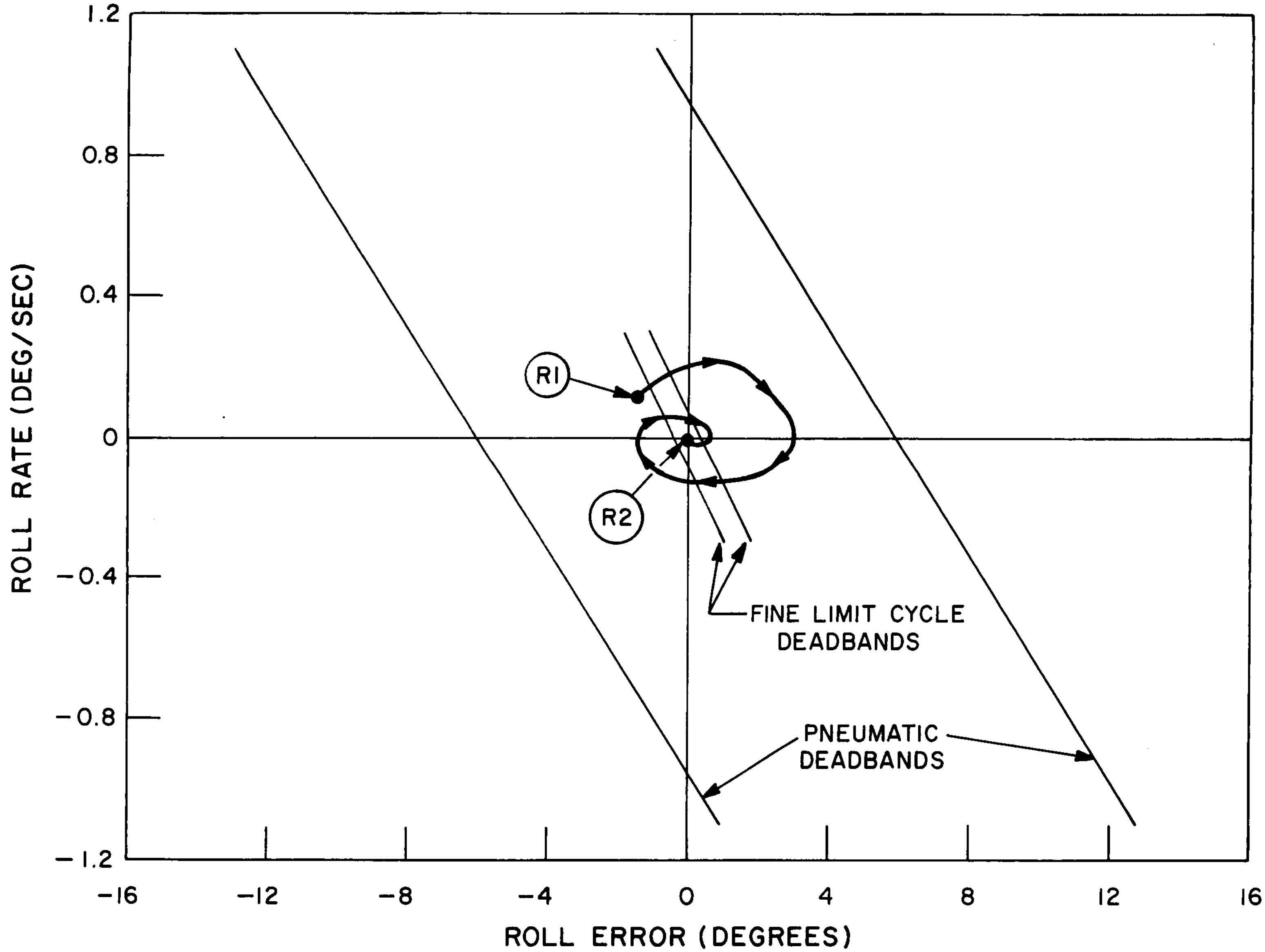


Figure 6-3. Phase Plane Plot Showing Spacecraft Initial Roll Attitude Reference Acquisition Characteristics

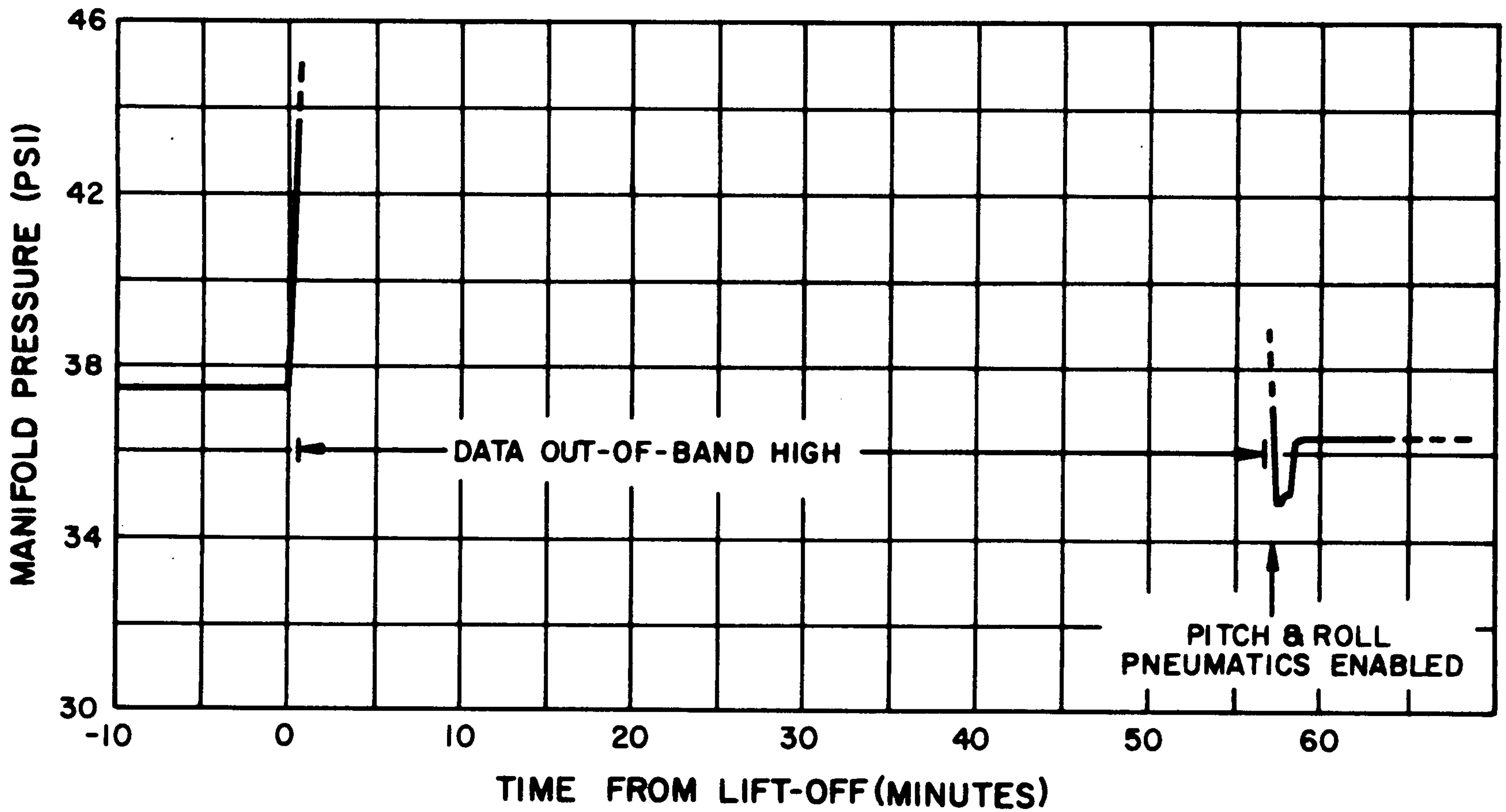


Figure 6-4. Manifold Pressure Launch History
Control Subsystem Housing Temperatures and Thermal Control Shutter

Figure 6-5 presents the launch and initial control subsystem housing panels and thermal control shutters respectively.

On the launch pad, the sensory ring was maintained at approximately 17°C by forced cool air. As can be seen in the figure, the control housing panels were 5 to 10°C hotter than the ring. As a result, the number one and two thermal control shutters were 8 and 6 degrees open respectively, which was normal for their associated panel temperatures.

During the period between MECO and Agena first burn cutoff, shutter No. 2 seemed to be driven further open, up to 53 degrees prior to first burn cutoff. Following engine cutoff, the shutter returned to the 28 degrees open position and began cycling about this level in response to its associated panel temperature.

Shutter No. 1 remained at the proper position until Agena engine second burn ignition, at which time it also went to the 28 degrees open position. This shutter subsequently began responding to its associated panel temperature as it began to warm up. The 28 degree open position finally assumed by the shutters was approximately 20 degrees more than normally would be expected when compared to the associated panel temperatures.

Figure 6-5 illustrates the housing panels temperature responses to the spacecraft exiting the umbra, the pitch-up maneuver and crossing of the ecliptic plane.

The control subsystem component temperatures were maintained within their specified ranges during the launch and orbit injection phases. The gyro fluid temperature was precisely controlled at 74°C while the yaw and roll flywheels were maintained at 30 and 31°C respectively. Figure 6-6 shows the initial cool down of the IR scanner sink temperatures and the solar array drive motor temperature rise during the period of initial sun acquisition.

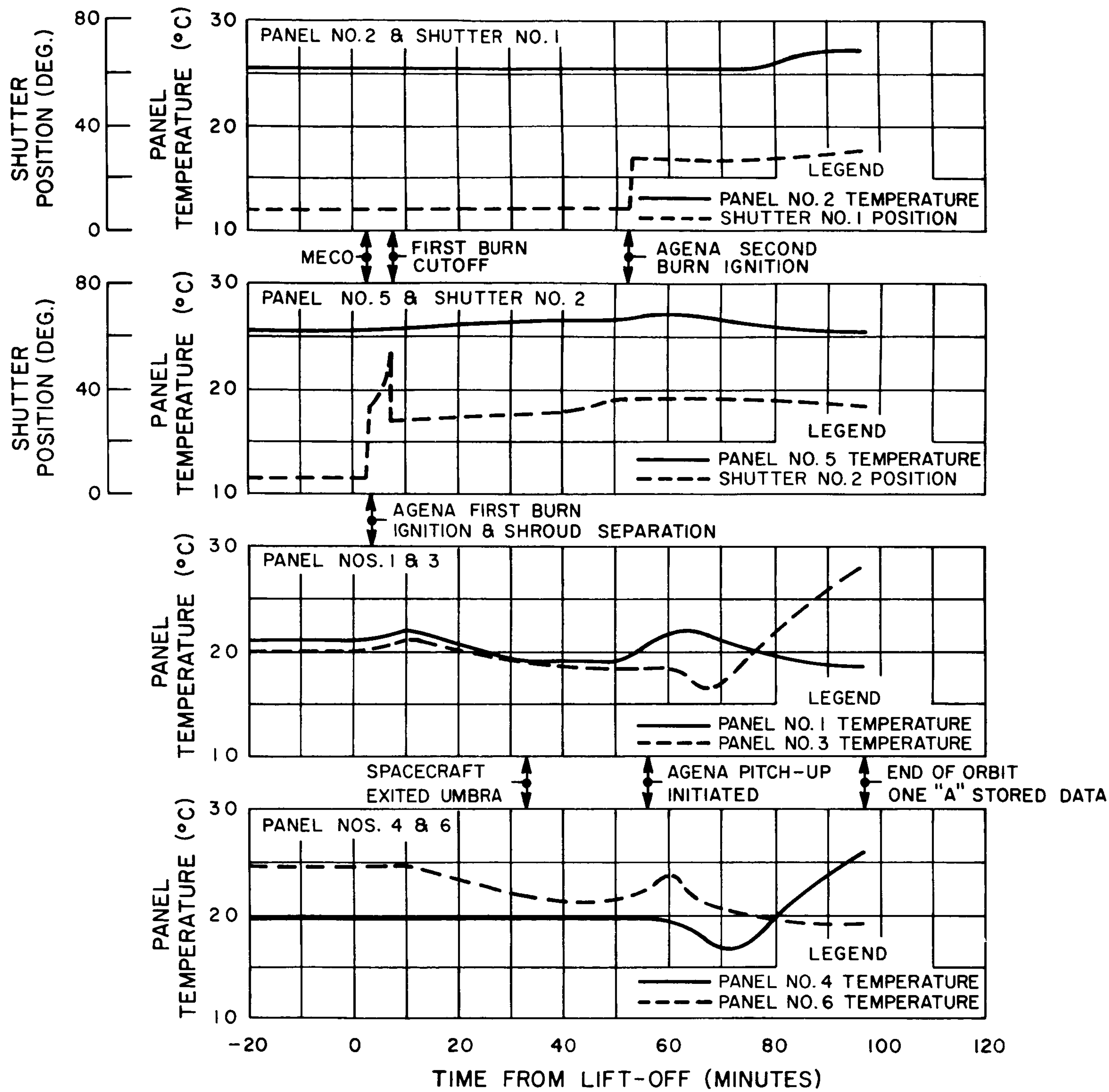


Figure 6-5. Histories, Launch and Orbit Insertion

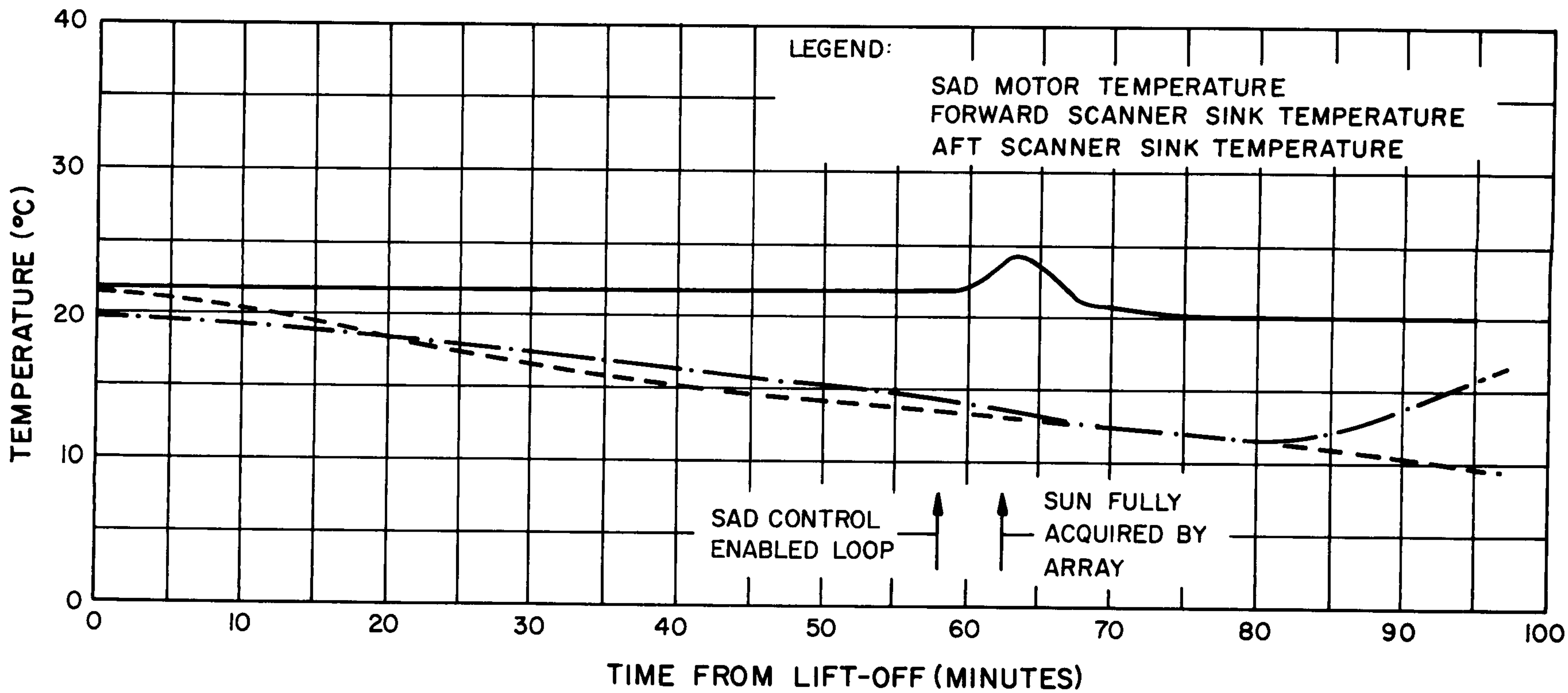


Figure 6-6. SAD Motor and IR Scanner's First Orbit Temperature Histories

7.0 THERMAL SUBSYSTEM

On the launch stand, ground cooling air was used to supercool the sensory ring and its associated components at approximately 15 to 17°C. This was done to ensure that the thermal control shutters would remain closed throughout the launch and injection flight phase, thereby avoiding any damage due to mechanical interference during the various separation events.

After liftoff, a gradual cooling down was experienced until the spacecraft emerged from the umbra. The cooldown trend was then reversed and general heating was observed. The average ring temperature for the first orbit was 15.5°C and the H-frame center section structure averaged about 16°C. The extremes for the average sensory ring component temperatures for the first orbit were 12.5 to 22.3°C.

8.0 PCM AND CLOCK/COMMAND SUBSYSTEMS

The PCM subsystem delivered 98.5% good data in the first interrogation playback. Transmitter power output was 0.42w, operating on beacon No. 2. The first real-time telemetry data frame was processed at an antenna elevation angle of 5.7 degrees. Preflight estimates based on a 0.3w transmitter expected approximately 14 degrees antenna elevation before data would have become usable. The PCM recorder maintained a pressure of 13.7 psi at a temperature of 19°C.

The clock subsystem provided proper reference frequencies and phasing for other spacecraft subsystems during the first orbit. The command section was enabled properly at separation and received, loaded, and executed encoded commands properly during the Alaska station pass. Crystal oven temperature was maintained at 59.5°C.

During the separation and unfold sequence, available data indicated that the following anomalies occurred:

a. A clock jump of 512 days, 60 hours, 10 minutes, 17 seconds.

b. A PCM multicoder jump of one word. This resulted in improper computer sync with PCM data until the start of the next main frame, resulting in loss of meaningful data during unfold.

c. Regulated bus voltage is suspected to have dropped initially to about 21.8 volts then surged to 28.1 volts. Changes in the IRIS position monitor TMV levels during this period, considering its relationship to the regulated bus voltage, was used to derive this variability in regulated voltage.

9.0 SENSORY SUBSYSTEMS

With the exception of the MRIR record motor and HRIR and MRIR radiometer motors, no sensory components were operating during launch. Recorder temperatures and pressures remained constant throughout. (See Table 9-1). The HRIR detector cell temperature showed slight cooling during the initial satellite night period, returning to its original temperature after satellite sunrise, then cooling rapidly again after separation to -55°C at the time of A-stored playback at Ulaska. The temperature eventually stabilized at -75°C.

TABLE 9-1. AVERAGE SENSORY SUBSYSTEM'S RECORDER PRESSURES AND TEMPERATURES

Subsystem	Pressure (Psi)	Temperature, °C
AVCS	17.3	16.2
HRIR	16.4	17.4
MRIR	14.9	19.0

The MRIR record motor current indication dropped from 3.8 to 3.4 TMV at the time of unfold squib firing. This motor is normally in continuous operation whether or not MRIR data is being recorded.