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DISCOVERER XIII

(Agena 1057/Thor 231)

SYSTEM TEST EVALUATION AND PERFORMANCE ANALYSIS REPORT

(35-Day Report)

Contract AF 04(647)-558

Lockheed

MISSILES and SPACE DIVISION

LOCKHEED AIRCRAFT CORPORATION

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FOREWORD

This document is the final system test evaluation and performance analysis report for the launch of Discoverer XIII from Vandenberg AFB on 29 June 1960. It has been prepared for the Air Force Ballistic Missile Division (AFBMD) to meet a requirement of Contract AF 04(647)-558 in accordance with Paragraph 1.4.1 of LMSD-445158-B, Discoverer Program.

44240-57-023

PRESIDENT EISENHOWER INSPECTS DISCOVERER XIII CAPSULE: *With the President are (left to right) Lt. Gen. Bernard Schriever, Air Force Sec. Dudley Sharp, Defense Sec. Thomas Gates, Air Force Chief of Staff Gen. T. D. White, Col. Lee Battle, the AFBMD Discoverer Project Officer, and Col. Charles Mathison, Test Director of 1694th Test Wing*

SUMMARY

Discoverer XIII (Thor 231/Agena 1057) was launched on the first attempt from Vandenberg AFB Complex 75-3-5 on 10 August 1960. All primary, secondary, and tertiary test objectives were met, including the achievement of a significant "first" in world-wide space technology: recovery of a capsule ejected from an orbiting satellite. The capsule was recovered from the ocean northwest of Hawaii by a helicopter operating from the USNS Haiti Victory, after visual acquisition by C-119 aircraft.

Launch countdown commenced at 0600 PDT. Liftoff occurred 7 hours and 38 minutes later, at 1337:54:40 PDT. Separation of the Agena from the Thor was completed at the prescribed time and altitude. Agena engine ignition, signalled by the Agena's D-timer, was followed by 118 seconds of engine operation. The engine was shut down by integrator command after the required inertial injection velocity had been attained.

Satisfactory Agena injection altitude and velocity resulted in an orbital perigee of 137 nautical miles, an apogee of 379 nautical miles, and a period of 94 minutes. Orbital lifetime of the satellite is calculated to be 84 days.

All commands transmitted to the orbiting Agena were successfully received, executed, and verified. Additionally, orbital timer operation was accurate, and all programmed events, including initiation of the recovery sequence on Pass 17, took place as specified.

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ILLUSTRATIONS (Continued)

TABLES

NOMENCLATURE

AET	Advanced Engineering Test
BSTS	Barking Sands Tracking Station
Blossom Time	Time of capsule parachute deployment
Chaff	Metallic radar target scattered at the time of capsule parachute deployment
Countdown	Step-by-step process leading to a missile launching
Countdown	Reduction in response of radar-beacon to interrogations caused by unsynchronized multiple-active tracking by two or more ground radars or by improper spacing between the command and interrogation pulses
CWAT	Continuous-wave acquisition transmitter
DAC	Douglas Aircraft Corporation
ETPD	Estimated time of parachute deployment
GE	General Electric Company
AAFB	Hickam Air Force Base
HCC	Hawaii Control Center
HTS	Hawaii Tracking Station
HATS	High Altitude Temperature Simulator
KTS	Kodiak Tracking Station
Lock-on	Automatic training of the radar antenna on the target, following initial acquisition, accomplished by a servo-control system which nulls-out error signals
MTS	Pt. Mugu Tracking Station
NBTS	New Boston Tracking Station
On-line	Instantaneous or near real-time data
PACC	Palo Alto Computer Center
PAM/FM	Pulse-amplitude-modulated subcarrier; frequency modulated carrier
PRF	Pulse-repetition-frequency

NOMENCLATURE (Continued)

RADARC	A sonobuoy marker device equipped with radio beacon and tracking lights
r-f	Radio frequency
System time	Time in seconds measured from 2400 Greenwich Mean Time (GMT); recycles every 24 hours
TLM-18	A high-gain, narrow-beam, VHF, automatic tracking antenna
TOC	Time-of-crossing of a satellite over a tracking station
Tri-helix	A medium-gain, wide-beam, manually steerable or slavable VHF antenna
VERLORT	Very-Long-Range-Tracking radar
VTS	Vandenberg Tracking Station

SECTION 1
INTRODUCTION

BACKGROUND

In the Discoverer Program a total of 13 flights have been launched from Vandenberg AFB. Eight Agena Satellites have been successfully injected into orbit (see Table 1). Present plans call for the launching of 17 additional vehicles before the program is concluded.

The principal objectives of the Discoverer Flights are the development of Thor-boosted Agena satellites capable of functioning as carrier vehicles for scientific material and the recovery of capsules ejected from these satellites while on orbit.

Additional Discoverer objectives are the perfecting of equipment, techniques, and procedures for launching Thor-boosted Agena satellites; attaining orbit; and acquiring, recording, transmitting, receiving, and processing satellite functional and environmental data, as well as geophysical data. Section 5 of this report lists the objectives of Discoverer XIII. In addition to these specific goals, it is also expected that the ground system operational techniques and procedures at the tracking stations, control center, and launch-base will be refined as the program progresses. Specialized tests, including aero-medical research, will be executed during the series. A propulsion system capability for single restart and extended-duration operation will also be tested.

Finally, an important long-range objective of the Discoverer Program is the refinement of equipment and procedures which will be used in the more advanced MIDAS and Samos programs, as well as in future deep-space probes.

Table 1
DISCOVERER PROGRAM FLIGHT TEST SUMMARY

DISCOVERER VEHICLES AGENA/THOR	LAUNCH COMPLEX, TIME, AND DATE	COUNTDOWNS REQUIRED	PAYLOAD DESCRIPTION	RESULTS
1019/160	Complex 4 Attempted on 21 Jan 59	1	Non-recoverable, consisting of communications equipment	Malfunction during countdown caused ullage rockets, retrorockets, separation bolts, and horizon scanner fairing to fire when hydraulic motor was turned on. Design problem. Discoverer extensively damaged.
Discoverer I 1022/163	Complex 4 1349:16 PST 28 Feb 59	2	Non-recoverable, consisting of communications equipment	Injection angle -2.4° caused 13 day lifetime. No telemetry or radar orbit contact made. Sporadic CWAT contact reported. Vehicle believed damaged structurally and/or thermally at injection or during first pass.
Discoverer II 1018/170	Complex 4 1318:39 PST 13 Apr 59	1	Biomedical Research Capsule, containing four mechanical mice	Orbit achieved. Engine shutdown by command (source unknown, but believed due to relay malfunction). Capsule ejected but not recovered. 13 day lifetime recorded.
Discoverer III 1020/174	Complex 4 1309:20 PDT ? Jun 59	4	Biomedical Research Capsule, containing four live mice	Premature engine burnout due to fuel exhaustion. Insufficient velocity gained for orbit attainment. Below nominal performance (but within specification) achieved by Agena engine.
Discoverer IV 1023/179	Complex 5 1547:45 PDT 25 Jun 59	2	Recoverable Research Capsule	Premature engine burnout occurred, resulting in insufficient velocity for orbit attainment. Under-nominal performance (but within specification) achieved by Agena engine.
Discoverer V 1029/192	Complex 4 1200:08 PDT 13 Aug 59	6	Recoverable Research Capsule	Burnout due to propellant exhaustion. Orbit achieved. Capsule separated but not recovered. Recovery sequence believed not accomplished due to extreme cold effects on mercury battery. 46 day lifetime recorded.
Discoverer VI 1028/200	Complex 5 1224:44 PDT 19 Aug 59	2	Recoverable Research Capsule	Burnout due to propellant exhaustion Orbit achieved. Capsule separated but not recovered. Recovery sequence believed not accomplished. 63 day lifetime recorded.
Discoverer VII 1051/206	Complex 4 1228:41 PST 7 Nov 59	2	Recoverable Research Capsule	Successful launch and orbit. Slow separation experienced. Agena engine shut-down accomplished by integrator command. 400-cycle power failed after downrange telemetry lost signal and vehicle tumbling ensued. Nitrogen gas exhausted prior to Orbit 2 contact by Kodiak. Capsule could not be ejected. 19 day lifetime recorded.
Discoverer VIII 1050/212	Complex 5 1125:24 PST 20 Nov 59	1	Recoverable Research Capsule	Burnout due to propellant exhaustion following accelerometer-integrator malfunction. Excessive injection velocity resulted in eccentric orbit with perigee of 115 sm and apogee of 1047 sm. 103.7-minute period with satisfactory programming of capsule separation on Orbit 15. Re-entry sequence normal. No recovery although Recovery Force reported beacon reception for a short period. Over 90 days lifetime.

Table 1 (Continued)

DISCOVERER VEHICLES AGENA/THOR	LAUNCH COMPLEX, TIME, AND DATE	COUNTDOWNS REQUIRED	PAYLOAD DESCRIPTION	RESULTS
Discoverer IX 1052/218	4	4	Recoverable Research Capsule	Two major malfunctions at liftoff: Umbilical mast retraction delayed, failure of Agena's helium supply quick disconnect. Agena tumbled (no attitude control). Premature Thor main engine shutdown.
Discoverer X 1054/223	5	1	Recoverable Research Capsule	At liftoff, Thor booster pitch oscillations began diverging until main engine was gimballing from stop to stop. Discoverer deviated excessively from programmed flight path angle and destruct signal was transmitted at T + 56.36 seconds.
Discoverer XI 1055/234			Recoverable Research Capsule	Near polar orbit attained. Agena nose-down re-orientation for capsule separation accomplished. Retro and despin rocket firing confirmed as was thrust cone separation. Capsule beacon and telemetry recorded. Spin deficiency led to insufficient retro velocity. Capsule re-entry trajectory high and beyond predicted recovery area.
Discoverer XII 1053/160	4	1	Recoverable Research Capsule	Liftoff and ascent trajectories and injection velocity met requirements. However, Agena's velocity gain not horizontally directed. A nose-down attitude (caused by incorrect horizon scanner signals) resulted in a -8.3 degree injection plane.

SCOPE OF THIS REPORT

This document contains the detailed evaluation of all data relating to the Discoverer XIII flight. Included are the results of investigations into problem areas; and, if indicated, recommendations. This report amplifies the information given in LMSD-445905-57, *Discoverer XIII Preliminary System Test Report (7- to 10-Day Report)*, and supersedes the earlier document in any instance where the data is at variance.

Organization of this report is in three parts. The first part, Test Description, describes the configuration of Discoverer XIII, and gives a chronological history of the flight. The second part, Test Evaluation, analyzes performance of important elements. The third part is the Appendix, which includes additional data to support the discussions in text.

TEST DESCRIPTION

SECTION 2
DESCRIPTION OF FLIGHT ELEMENTS

The system configuration for Discoverer XIII consisted of a DAC Thor first-stage booster (Figure 1) and an LMSD Agena second-stage satellite vehicle (Figure 2) with the necessary first- and second-stage support equipment, launch complex, command and communication system, and capsule Recovery Force. The configuration was similar to that of previous Discoverer Flights, with the exception of flight and ground system elements related to capsule recovery. The notable configuration differences for the flight elements are given in this section; those for the ground elements are given in Section 3.

COMBINED VEHICLES

The Agena satellite vehicle Model 2205, Serial 1057, was mated by a structural adapter section (supplied by LMSD) to a modified IOC Thor booster SM-75, Serial 231, utilizing an MB-3 Block I engine. The length of Discoverer XIII was approximately 79 feet, and its total weight at liftoff was 117,260 (±250) pounds. The Agena weight statement and the Discoverer cg and moment of inertia are presented in Appendix A.

RECOVERABLE CAPSULE

The recoverable capsule payload (Figures 3 and 4) for this flight was a special "diagnostic" configuration which contained a five-channel FM/FM telemetry system to transmit separation, re-entry, and recovery equipment operations data to ground stations. The additional equipment permits a

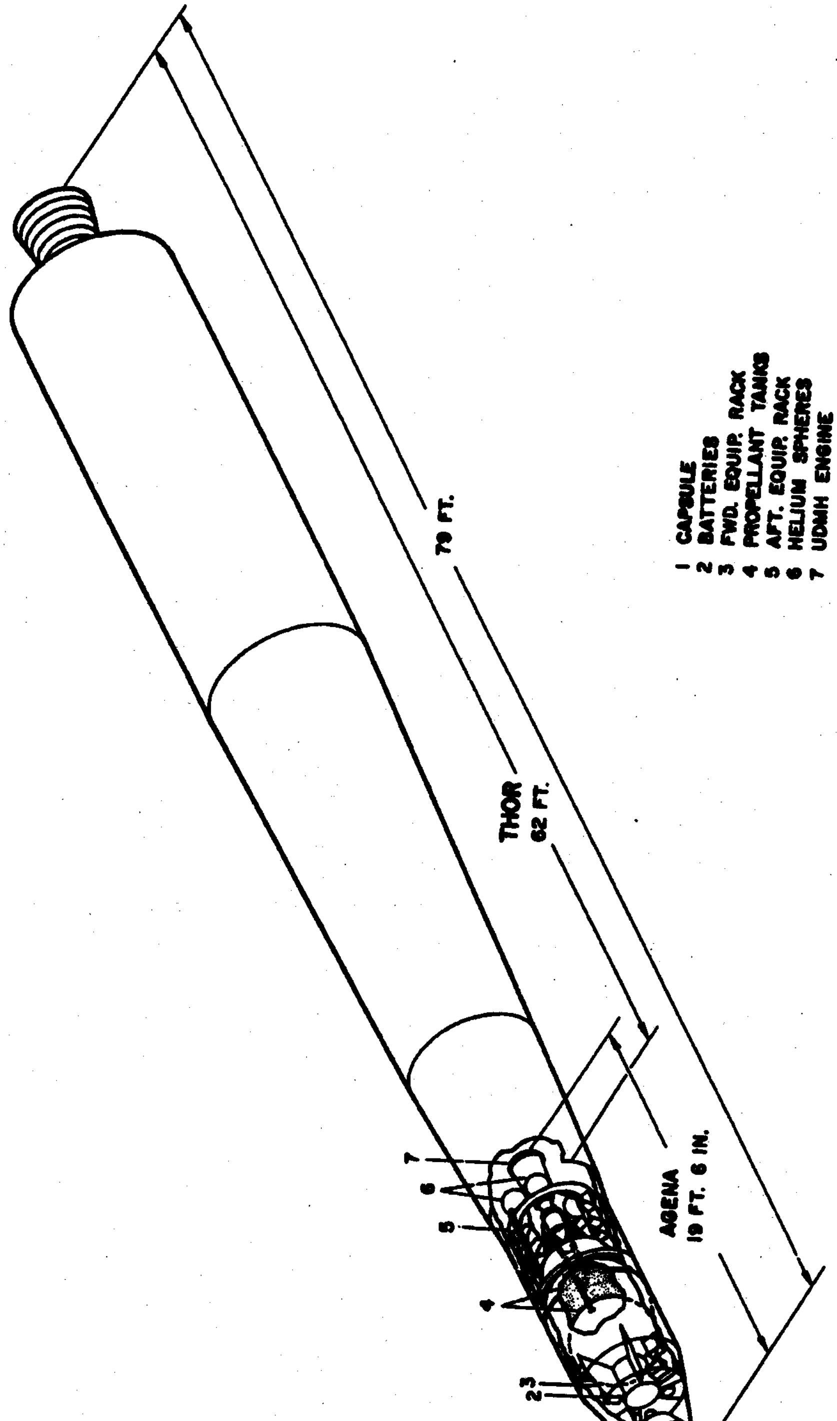

Figure 1 Agena 1057/Thor 231 Configuration

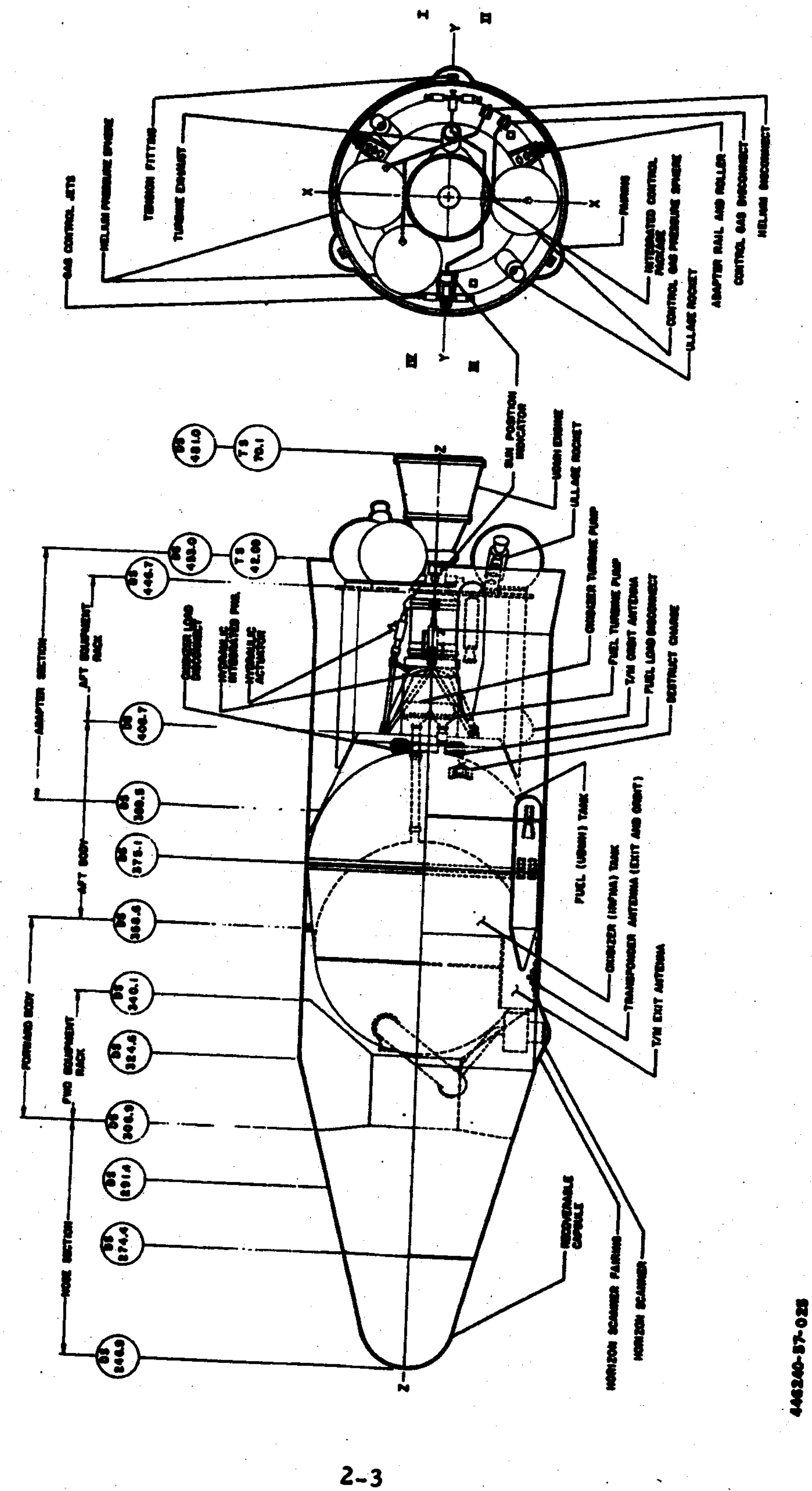

Figure 2 Agena Inboard Profile

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Figure 3 Discoverer XIII Diagnostic Payload Undergoing Postflight Inspection at LMSD

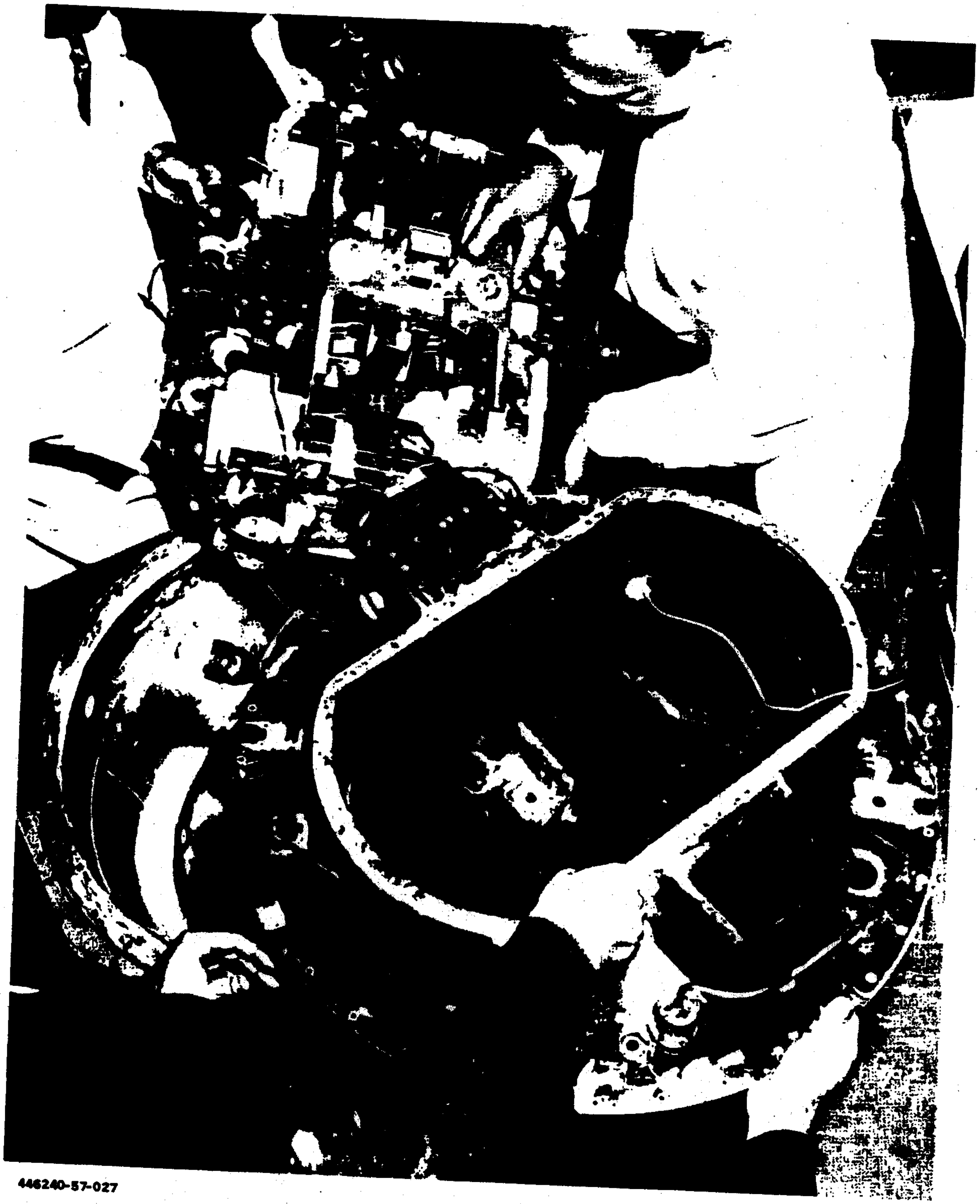

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Figure 4 Discoverer XIII Diagnostic Payload Postflight Inspection: Several Components were Removed more complete postflight qualitative analysis of the recovery operations than has been possible on previous flights.

An 8-watt transmitter replaced the 1.2-watt transmitter normally installed to relay the following data: gyro, accelerometer, battery voltage, temperature, pressure, and breakwire telltale functions from capsule separation until parachute deployment. A continuous-tape recorder was installed to record the capsule re-entry and recovery functions in real-time and to play back through the transmitter with a 2-minute time delay so that telemetry data during capsule descent through the ionization layer would not be lost.

In addition to the instrumentation and the capsule VHF beacon, a transistorized S-band beacon transponder and its power supply were installed on the capsule thrust cone so that computer determinations of the re-entry trajectory and impact location could be made.

A cold gas manifold system replaced the separate spin-up and de-spin rocket system. Following ejection of the capsule from the satellite, the required impulse to spin and de-spin the capsule was provided from 3000-psi pressurized cold gas (Freon-nitrogen) spheres (one for each system), activated by squib valves.

To ensure pod separation prior to spin-up, the thrust-cone programmer times were changed as follows:

Function	Time (sec)*
Pod Separation	T + 1.5
Spin-up	T + 3.4
Retro-rocket Fire	T + 4.65
De-spin	T + 15.40
Thrust-Cone Separation	T + 16.9

* *T-0 is defined as electrical disconnect from the Agena power supply*

To enhance the possibility of recovery in the event of extended surface search, an additional battery was installed to power the VHF beacon after impact for approximately 20 hours, rather than 10 hours. The water-soluble plug installed to initiate capsule submersion after 30 hours was removed from this capsule.

AGENA SATELLITE

A principal difference in the Agena vehicle for this flight was brought about by a weight reduction program. In order to accommodate the required capsule instrumentation and to achieve the required performance margin, it was necessary to remove all AET equipment, the JHU/APL Doppler beacon, and optical tracking lights.

The 5.0-degree yaw program (left) for realigning velocity vectors during the ascent coast period was removed on this flight so that the desired orbital path on Pass 17 could be achieved. The D-timer PAYLOAD-EJECT command was changed from 93.4 to 94.5 seconds after D-timer restart. To achieve a higher orbit, the nominal D-timer hold was increased from 20 seconds to 39 seconds, to delay Agena ignition an additional 19 seconds. For improved low-rate capabilities, the rate gyro telemetry sensitivities were increased from ±10 to ±2 deg/sec. Control gas loading was reduced from 40 to 37 pounds as part of the general weight reduction effort. The horizon scanner was modified to reduce transient susceptibility, and the rubber gasket between the case and cover was replaced with a beryllium-copper gasket to shield against r-f radiation.

To ensure that the Agena engine would operate to propellant exhaustion prior to integrator cutoff (in the case of a minimum Command 6), the maximum integrator setting was changed from 13,800 to 14,200 (±30) ft/sec.

SECTION 3
DESCRIPTION OF GROUND ELEMENTS

Configuration of the ground elements of the Discoverer XIII flight was essentially the same as that for previous flights. The nominal capsule impact point was moved from that of previous tests to latitude 24° N. This change was to provide HTS with telemetry coverage of the parachute deployment sequence at the nominal latitude for all orbit periods within 1 minute of nominal. This impact latitude also provided KTS coverage of the complete separation and retro sequence.

The launch telemetry ship USS *King County* was replaced by the FS Ship *AG-161*. The replacement ship was equipped with a quad-helix antenna in addition to a single helix. There was no Doppler receiving or recording capability on board the vessel. Otherwise, the configuration of the ship was basically the same as that of the *King County*.

The Recovery Force and recovery tracking system consisted of the following: Six C-119J and two RC-121 aircraft and the *Haiti Victory* were dispersed in the primary recovery area; and the *Dalton Victory*, three C-119J, two RC-121, one WV-2, four JC-54 telemetry receiving, one C-130 recovery aircraft, and the *Pvt. Joe E. Mann* telemetry ship were deployed to provide capsule detection and telemetry reception capabilities from the recovery area extending 1800 nautical miles downrange. The facilities at Barking Sands, Kauai, and South Point, Hawaii, were used to determine the approximate capsule trajectory. A temporary telemetry receiving station was installed on Christmas Island to extend further the capsule detection and telemetry receiving range.

The newly activated New Boston Tracking Station (not yet operational) participated in tracking operations to check out equipment and to train personnel.

SECTION 4
CHRONOLOGICAL DESCRIPTION OF TEST

PRELAUNCH OPERATIONS

After pre-launch system tests were completed, all stations were evaluated as being fully operational with the exception of Vandenberg Tracking Station. That station's Doppler coder remained inoperative throughout the launch. New Boston Tracking Station was not an operational station for this flight, but it was active for checkout and training purposes.

The one countdown required to launch Discoverer XIII began at 0600 PDT on 10 August 1960 and proceeded smoothly to a successful liftoff 7 hours and 38 minutes later. A countdown chronology is presented in Table 2.

LAUNCH AND ASCENT

Liftoff was successfully accomplished at 1337:54:40 PDT with a clean umbilical separation and only minor pad damage.

The vehicle was launched vertically and then rolled to a departure azimuth of 174° (172° predicted). All programmed events occurred in proper sequence. The ascent, as determined by VTS and MTS real-time data, appeared to be slightly high and west of the nominal flight path. Thor main-engine cutoff was approximately 1.5 seconds sooner than expected, but within required tolerance. Separation was successfully completed at the prescribed time.

Data received and utilized by the Reeves computer at MTS during vehicle ascent and coast resulted in the transmission of 49.27 seconds of Command 5 (which extended D-timer hold to 51.60 seconds) and 13.03 seconds of

Table 2
COUNTDOWN CHRONOLOGY

Task	Time Scheduled		Actual Countdown Time		
	Start Time (min)	Duration (min)	Start Time PDT	Start Time (min)	Duration (min)
1. Pre-Countdown Operations and Countdown Initiation	T-375	10		T-375	14
2. Shelter Removal Vehicle Erection	T-365	35	0614	T-361	29
3. R-F Checkout	T-350	40	0643	T-332	93
4. Lanyard Connection and Fuel Truck Activation	T-330	35	0812	T-243	26
5. Destruct Test	T-295	30	0838	T-217	52
6. Orbital Stage Arm	T-265	35	0930	T-165	31
7. Connect First Stage Destruct System	T-265	35	0930	T-165	39
Hold 1*			0945	T-150	76
8. Propellant Line Fill	T-230	50	1009	T-150	54
9. Countdown Evaluation	T-180	30	1101	T-150	1
10. Electronics Warm-up	T-150	90	1105	T-146	15
11. Range R-F Checks	T-145	30	1107	T-144	15
12. Propellant Tanking	T-115	30	1126	T-125	40
13. Secure Propellant Trucks	T-85	25	1206	T-85	26
14. Guidance and Flight Control Checkout	T-60	30	1232	T-76	30
15. Pressurization	T-60	30	1232	T-59	30
16. Countdown Evaluation	T-30	17m15s	1246	T-45	17
Hold 2**			1303	T-15	11
17. Terminal Countdown	T-12m 45s	12m45s	1316	T-13	22
Hold 3***					
Hold 4****			1317	T-12	6
Liftoff	T-0		1333	T-2	3
			1337:54		

Table 2 (Continued)

HOLD SUMMARY

* Hold 1 was imposed for work to catch up with the count after earlier delays. Use of a diagnostic capsule instead of the standard AET package increased the time required for completion of Task 3. In addition, a DAC destruct receiver had to be replaced during Task 5

** Hold 2: At completion of Task 16 at 1303 PDT, the count was T–28 and jumped to T–15. The count was held until 1314 PDT to await approval of the Range Safety Officer before starting terminal countdown (train schedule conflict). Effectively, this was a countdown jump of 2 minutes.

*** Hold 3 was called during Phase I of the countdown when a Thor power supply did not come on. The problem was solved when personnel were sent to the DAC pad electrical trailer to reset a circuit breaker.

**** Hold 4 was called during Phase V of the terminal countdown because of a misunderstanding involving VERLORT radar van personnel and the Range Safety Officer.

Command 6 (controls velocity-integrator setting). Both commands were received by the vehicle and were executed.

Agena engine start (90 percent thrust) occurred at T + 302.45, and nominal thrust was obtained. The duration of engine burning was 118.99 seconds as compared to 121.93 seconds nominal. However, engine shutdown was by integrator command and was not due to fuel depletion.

Telemetry contact was maintained until T + 784 seconds (downrange telemetry ship fade).

Table 3 compares the predicted times of launch events with the actual times these events occurred. Table 4 tabulates the trajectory and initial orbit parameters.

ORBIT OPERATIONS

Prior to launch, nominal acquisition messages were sent to all stations. On the basis of launch tracking data received by the PACC from MTS and VTS, initial orbit elements were calculated and a new acquisition message generated and sent to KTS for Pass 1. Acquisitions messages were also sent to the other tracking stations (HTS, VTS, and MTS) for use during Pass 1.

Pass 1

Pass 1 acquisition of the Agena's CWAT by KTS was made 88 seconds later than predicted by the PACC. KTS also tracked the vehicle on radar and recorded Agena telemetry. Since beacon acquisition was later than predicted, a RESET command was sent at System Time 79799. The 65°N and 60°N reference latitude crossings were 123 seconds later than the computer acquisition message had predicted for KTS. An INCREASE command was sent and verified and four STEP commands were sent, which extablished an orbital timer period of 5655 seconds. No difficulty was experienced in verifying RESET, INCREASE, DECREASE and STEP commands.

Table 3
LAUNCH SEQUENCE OF EVENTS

Event	Predicted Time (sec)	Actual Time (sec)
Liftoff *	0	0
Main Engine Cutoff	164.5	163.0
Vernier Engine Cutoff	173.5	172.47
Start Fairchild Timer	179.0	179.28
Explosive Bolts Fire	180.5	180.91
Pneumatics ON	180.5	180.91
Retrorockets Fire	181.0	181.41
Command -45°/minute Pitch Rate	192.0	192.42
Start D-timer Hold	221.0	221.31
(D-timer Hold Duration)	37.78	51.60
Command -2°/minute Pitch Rate	221.0	221.31
Command 5 ON	223.0	223.64
Command 5 OFF	258.78	272.91
(Duration)	35.78	51.60
Command 6 ON	258.78	272.91
Command 6 OFF	274.60	285.94
(Duration)	15.82	13.03
Fire Ullage Rockets	288.6**	288.97
Preactivate Hydraulics	288.6**	288.97
Helium Bypass Valve Open	300.6**	300.96
Thrust Attainment (90% P_c)	302.1**	302.45
Engine Burnout (70% P_c)	424.03**	421.42
(Duration)	121.93	118.97
Command -40°/minute Yaw Rate	431.6**	431.92
Fire Vent Valves	431.6**	431.92
Hydraulics OFF	431.6	431.92

* 1337:54.40 PDT; System Time 74274.40 seconds ; 2037:54.40 GMT. Times are accurate to ±0.2 sec. (commutated data)

** Based upon actual D-timer hold of 51.6 seconds

Table 3 (Continued)

Event	Predicted Time	Actual Time
VTS T/M Fade	---	500.0
MTS T/M Fade	---	476.0
Remove -40°/minute Yaw Rate	701.6	701.9
T/M Ship Fade	---	784.0

Table 4
TRAJECTORY AND INITIAL ORBITAL PARAMETERS

Trajectory

Event	Time (sec) Predicted	Time (sec) Actual	Altitude (n.m.) Predicted	Altitude (n.m.) Actual	Range (n.m.) Predicted	Range (n.m.) Actual	Inertial Velocity (ft/sec) Predicted	Inertial Velocity (ft/sec) Actual
Thor Main-Engine Burnout	164.5	163.00	44.40	47.0	82.16	79.8	13,613	13,588
Agena Engine Ignition	288.28	302.45	110.32	125.8	329.79	354.2	12,722	12,501
Agena Engine Burnout	410.21	421.42	124.0	139.7	667.28	679.2	25,900	25,786
Thor Coast Apogee	367.6	382.1	122.11	137.67	485.21	507.07	12,530	12,304

Initial Orbital Parameters

Event	Predicted	Actual
Injection Velocity, ft/sec	25,900	25,786
Injection Agnle, deg	0	.18
Inclination Angle, deg	81.69	82.87
Perigee, nm	124	137
Apogee, nm	361	379
Eccentricity	.0323	.0326
Period, min	93.5	94.1
Lifetime, days	25	84

VTS, HTS and the USNS Joe E. Mann were able to acquire on Pass 1 for approximately 1 minute, but because the pass was low on the horizon, contact was marginal. The CWAT signal was reported by KTS and VTS to be weak.

Pass 2

KTS and HTS tracked the vehicle on all equipment during this pass. KTS transmitted and verified one RESET Command 3 at a System Time of 85441 as the satellite crossed reset latitude. One DECREASE step was commanded and verified by HTS. All real-time telemetry readouts indicated normal Agena performance, but the Beckman monitor of the orbital timer period fluctuated slightly.

Pass 8

Agena acquisition and fade times were on schedule. No commands were sent. The predicted reset-monitor ON time was 31539 System Time, and VTS reported the reset monitor ON at 31539, MTS at 31534, and HADC at 31534. A RESET command was not sent since observed reset monitor turn on showed exceptional agreement with predicted time. Tracking coverage was accomplished by HAFB, VTS, and MTS. VTS reported 20 percent countdown on the S-band beacon, which was usual for this time of night.

Pass 9

The VTS VERLORT was designated "active" and MTS "passive" to limit radar tracking interference. Christmas Island reported acquisition of telemetry at 36947 System Time and tracked for 59 seconds. VTS acquired at 36947, MTS at 36945, and the downrange telemetry ship AG 161 at 36946 System Time. The orbital timer readout was reported as DECREASE 25 (5643 seconds). A RESET command was sent and verified by VTS at 37170 System Time. The reset latitude 30°N time of crossing (TOC) was 37183

System Time. The reset command was sent early to confirm command capability of the vehicle.

Pass 10

HTS acquired approximately 36 seconds earlier than predicted. A RESET command was specified to be sent at System Time 42655. HTS reported that time of crossing the reset latitude 20°N occurred at System Time 42655. KTS reported that the orbital timer period readout was erratic during the pass. Acquisition and fade times were nominal, with solid tracking reported.

Pass 14

NBTS actively searched for approximately 5 minutes but failed to acquire due to the low elevation angle of the Agena.

HAFB acquired and tracked the Agena's telemetry as programmed. All requested readouts were made. The reset monitor came on within 2 seconds of the programmed time.

Pass 15

KTS acquired the satellite on this pass at near the predicted time. A RESET command was issued and verified at the proper time for proper phasing of the recovery sequence. During the pass, both VTS and MTS had difficulty in obtaining continuous radar lock-on. MTS was locked on when the beacon was turned off by the orbital timer (refer to Section 10). Reset Monitor OFF time was observed by both stations to be within 6 seconds of the expected time. Real-time readouts were all normal.

Pass 16

KTS acquired the satellite as programmed and achieved excellent tracking on all parameters. The reset monitor was observed to turn on 4 seconds early, and a RESET command was issued at the proper time (4 seconds after reset monitor on).

MTS and VTS acquired the vehicle on all parameters and experienced no trouble in tracking on this pass. VTS observed telemeter OFF 4 seconds earlier than expected, based on reset on the timer. All parameters were normal.

Pass 17

KTS acquired on all parameters and reported good track and signals. The track was nominal, with the deviation in elevation of only 0.5° from the preplot at fade. The D-timer was observed to restart at the proper time. All other re-entry events were verified, and the capsule was tracked on the preplot. HTS acquired the satellite and verified all recovery events. Successful tracking was achieved by KTS of the capsule's S-band beacon and the telemetry.

HTS and the Barking Sands tracking station successfully tracked the capsule's VHF beacon and telemetry. HTS also radar-tracked the Agena and recorded its telemetry during this pass.

Post-Recovery Orbits

Passes 24, 25, and 26 were tracked by KTS and used for command exercises. Contact was gained by NBTS on Pass 29, VTS, and KTS on Pass 31, and HTS and KTS on Pass 32. Both CWAT and telemetry were effective on Pass 32, but radar contact was poor. Command exercises were performed during these orbits. Continuous tracking activities terminated after Pass 32 to allow stations to prepare for Discoverer XIV activities.

The Agena 1057 was also tracked on the following passes.

Date, August	Pass	Station
15	76	VTS
16	92	KTS
16	93	KTS
16	93	
17	107	KTS
17	108	HTS
17	109	KTS
18	120	NBTS
19	138	MTS

A steady decrease in the CWAT frequency was reported after Pass 107, indicating the life of the battery was nearly expended. When the Agena was last contacted on 19 August, the transmitter's frequency was reported as being 25.5 kc below nominal. On 22 August VTS attempted to acquire the vehicle on Pass 183, but failed, thus indicating the battery life had been expended as expected.

CAPSULE RE-ENTRY AND RECOVERY

Recovery operations began with briefings of all Recovery Force elements and continued through post-recovery shipment of the capsule to Washington, D. C. Surface force elements, including representatives for the Victory ships and the PMR tracking stations, were briefed on 8 August. Air elements were instructed the following day.

Impact area revisions were received by the Hawaii Control Center (HCC) and were relayed to the Recovery Force as refined ephemeris data became available:

Impact Prediction	Time of Message (GMT)	Estimated time of parachute deployment (GMT)	Location (N Latitude)	Location (W Longitude)
1	(Final pre-launch)	2035:18.50	23° 59.8'	158° 23.4'
2	2312 - 10 Aug	2326:18.50	24° 00.2'	161° 45.9'
3	0150 - 11 Aug	2325:58.0	24° 00.0'	161° 42.0'
4	1328 - 11 Aug	2324:27.0	24° 00.2'	161° 34.6'
5	2116 - 11 Aug	2325:18.50	24° 00.2'	161° 32.4'
6	2206 - 11 Aug	2325:18.55	23° 51.6'	161° 31.0'
7	2322 - 11 Aug	2325:00	24° 10.0'	160° 37.0'
8	0015 - 12 Aug	2325:00	25° 20.0'	161° 35.0'

The 11 August recovery operation commenced with a fully operational Recovery Force (refer to Section 3). All RC-121 aircraft were airborne and on station at 2006 GMT. At 2252 GMT the eight C-119 aircraft were on station. Deployment at this time was based on Impact Area 6. The remainder of the Force (C-130, WV-2, four JC-54's and two Victory ships) were deployed and on station prior to estimated time of parachute deployment (ETPD) as dictated by advance planning directives. JC-54 No. 3 aborted its mission when a fuel leak developed, and one C-119 aborted its mission because of an oil leak. At ETPB, Recovery Force deployment was as shown in Figure 5.

At 2320:15 GMT, 12 August, acquisition of the re-entering capsule was obtained by the Haiti Victory. By 2328:30, all Recovery Force aircraft had received the beacon's signal. (Appendix Table A. 3 lists all acquisition data reported by the Recovery Force.) At 2324:25 GMT, C-119 No. 1 recorded a signal (not relayed to the RC-121) that saturated its FLR-2 equipment, with a resultant "no bearing". The aircraft was vectored to 273 degrees by RC-121 No. 1, but the vector led to cumulus clouds. By this time (2342 GMT) the C-119 was in a position too far away for aerial recovery of the descending capsule. The C-119 then obtained a bearing on the VHF beacon, vectored to 070 degrees, and eventually sighted the capsule

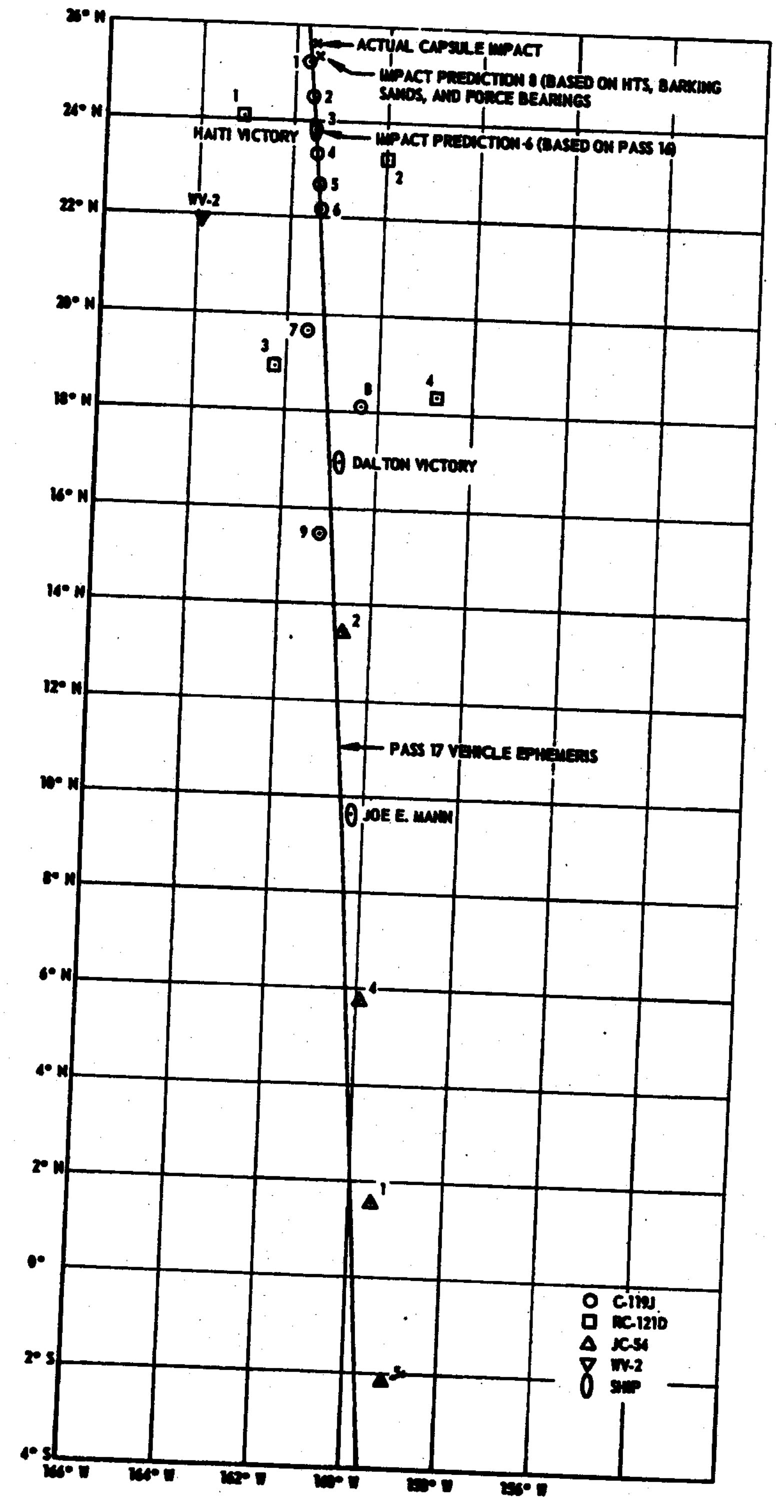

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Figure 5 Recovery Force Deployment at ETPD in the water approximately 24 nautical miles from the aircraft's initial station. At 2352 GMT, the beacon signal was observed to fade abruptly and then return at a 6-mc higher frequency. At 2325 GMT the SPS-8A radar on the Haiti Victory acquired a target that appeared to be the capsule's chaff. The initial target was at 40, 000 to 50, 000 feet altitude, at a distance of 100 nautical miles, and at the same bearing as its VHF beacon and telemetry signals.

From 2320:15 GMT onward, numerous data were obtained from the tracking stations concerning location of the capsule. These data, along with C-119 bearing information, were plotted at the HCC to obtain a most probable area of capsule descent and impact. Data from HTS, Haiti Victory, Barking Sands Tracking Station and the C-119's were plotted. The resultant triangulation indicated descent at a point 25° 20' N, 161° 35' W.

The first visual sighting of the water-impacted capsule was made by C-119 No. 2 at 0007 GMT, 12 August. At this time, it was apparent that the force of water impact had shifted the capsule frequency. By 0012 GMT, C-119 No.'s 1 through 4 had made visual sighting of the capsule and were circling the area. C-119 No. 1 dropped a RADARC (sonobuoy) at the impact point, but the RADARC failed and sank. C-119 No. 4 then deployed a RADARC, which operated properly as a marker of the capsule's impact location. The point of capsule impact was recorded by the C-119 aircraft as:

C-119 Aircraft	Latitude	Longitude
1	25° 41.5' N	161° 31' W
2	25° 36' N	161° 34' W
3	25° 38' N	161° 33' W
4	25° 40' N	161° 35' W
5	25° 36' N	161° 34' W
6	25° 36' N	161° 34' W

The aircraft reported that the impacted capsule was apparently operating normally, with the flashing light and beacon both operational. When first sighted, the parachute was still partially inflated and about 1/3 out of the water.

After visually sighting the capsule, RC-121 No. 1 remained in the area to vector the other sighting aircraft and ships. Two helicopters were sent from the Haiti Victory to retrieve the capsule from the ocean. A frogman was lowered into the water from a hovering helicopter to attach a winch line to the capsule, and the capsule and parachute were reeled into the helicopter. Retrieval was accomplished at 0222 GMT, and the capsule was flown to the Haiti Victory. The ship then proceeded to Honolulu where the capsule (in its shipping container) was flown by helicopter to Hickam AFB at 2050 GMT, 12 August. The capsule was transferred immediately to a C-130 aircraft for shipment to Washington, D. C., via LMSD Sunnyvale where an inspection of the capsule was made and several components were removed.

TEST EVALUATION

SECTION 5
TEST OBJECTIVES AND RESULTS

Flight test objectives for the Discoverer Program have been defined in LMSD-445725, Detailed Test Objectives for Discoverer Satellite System. The following is a tabulation of these objectives and subsequent achievement in this flight test.

	Achievement		
	Yes	Partial	No
A. PRIMARY OBJECTIVES			
Basic objectives of the flight were as follows:			
1. To place the Discoverer satellite with a recoverable capsule on a near-polar prescribed orbit.	X		
2. To eject the capsule within range of the Kodiak Tracking Station.	X		
3. To secure adequate telemetered data during launch, orbit, the re-entry sequence, and the parachute deployment sequence for determination of objectives achievement.	X		
4. To adequately track the re-entering capsule for computed impact point prediction.	X		
5. To recover the capsule.	X		
To achieve the basic objectives, it was necessary that the following specific objectives be attained:			
1. The ground support equipment must provide adequate support and checkout required for the launch of the Discoverer Agena satellite and Thor booster.	X		

	Achievement		
	Yes	Partial	No
2. The Thor booster must carry the Agena satellite to the planned separation altitude, achieve the planned attitude at separation, and provide the required velocity at separation.	X		
3. Agena airframe and adapter must demonstrate the ability to withstand control system perturbation and flight environment.	X		
4. The Agena propulsion system must provide the additional total impulse required to attain orbital velocity following booster separation.	X		
5. The Agena auxiliary power unit must demonstrate acceptable performance of components, and supply power requirements at least through the recovery orbit pass.	X		
6. The Agena guidance and control system must demonstrate the ability to:			
a. Derive the time to initiate orbital boost and the velocity-to-be-gained during orbital boost, using automatic computation equipment;	X		
b. Initiate and terminate orbital boost at proper time;	X		
c. Maintain proper vehicle orientation during coast, orbital boost, and the orbiting phase until ejection of the recoverable capsule.	X		
7. The Discoverer satellite airborne and ground telemetry, tracking, and command system must demonstrate the ability to:			
a. Satisfactorily monitor all primary functions (Thor and Agena) and produce adequate ground telemetry records of these functions;	X		

Objective	Achievement		
	Yes	Partial	No
b. Properly transmit, receive, act upon, and verify all required ground-space commands;	X		
c. Determine an ephemeris of orbit, sufficiently accurate to assure acquisition on each successive intercept and to allow the vehicle timer to be adjusted with sufficient accuracy to program the required vehicle functions.	X		
8. The Agena satellite recovery system must demonstrate:			
a. The ability of the recoverable capsule components to obtain and transmit data;	X		
b. Compatibility of the recoverable capsule with the Discoverer satellite in its ascent and orbit, and during the ejection phase;	X		
c. Proper capsule functioning during re-entry to facilitate recovery by the related airborne and surface system;	X		
d. Compatibility and suitability of the related surface and airborne recovery system components and techniques.	X		
B. SECONDARY OBJECTIVES			
Secondary objectives were to:			
1. Test and evaluate Agena vehicle systems and their effective functional inter-relationships;	X		
2. Test and evaluate temperatures at a sufficient number of locations on the Agena vehicle, so that the heat-flow patterns established in theoretical design can be verified and the temperatures environment for later flights established;	X		

Objective	Achievement: Yes	Partial	No
3. Test and evaluate the interstation communications network; and	X		
4. Demonstrate the capability of the system personnel to perform all checkout, launch communications, orbital and recovery procedures necessary to the attainment of test objectives.	X		
C. TERTIARY OBJECTIVES			
Tertiary objectives were to:			
1. Evaluate overall system performance for the planning of future programs	X		

SECTION 6
GENERAL EVALUATION OF DISCOVERER XIII INSTRUMENTATION

AGENA AND CAPSULE INSTRUMENTATION

Instrumentation of Agena 1057 was similar to that of previous flights. The special "diagnostic" recovery capsule, however, was changed considerably, and will be discussed at length in this section. The Agena instrumentation included an FM/FM telemeter which provided much valuable real-time data. (Instrumentation discrepancies are reported in a later paragraph.)

A Summary of Instrumentation performance follows:

Measurements		No. Lost	Recovery (%)	No. Inadequate	Adequate Data (%)
Agena	97	0	100	1	99
Capsule	52	1	98.2	0	98.2
Total	149	1	99.4	1	98.7

Capsule Instrumentation

The objectives for instrumentation of the "diagnostic" recovery capsule were to provide the following data during capsule separation, retrograde propulsion and re-entry:

a. Thermal and dynamic environments
b. Stability of attitude
c. Systems operation.

Analysis of flight data indicated that these objectives were achieved.

Resistance thermometers and ablative shield char sensors were installed at strategic locations to determine thermal environments of material and equipment. Accelerometers, gate gyros, voltage monitors, and break-wire and micro-switch type tell-tales were used to determine dynamic environments, stability, and systems operation. An airborne Speidel tape recorder was installed to (1) record all data during capsule passage through the ionization layer where the real-time r-f signal would be lost and (2) delay playback of these data until after the r-f blackout ended.

Complete data coverage was not obtained during the capsule descent trajectory. However, good coverage of the retro phase was obtained from KTS, with loss of signal attributed to distance, not ionization layer blackout. The northern WV-2 aircraft also received capsule signal during the retro phase, but no data were received beyond that obtained by KTS.

Usable telemetry data during the recovery phase were obtained by HTS at 84220 seconds, System Time, or approximately 106,000 feet capsule altitude. Analysis of capsule signal strength records from HTS indicate a rise from noise level to 50 microvolts in about 12 seconds. This rather abrupt increase in signal level is not typical of the gradual oscillating increase which accompanies an over-the-horizon type track. However, it can be interpreted as evidence of capsule emergence from the blackout area. Other influencing factors such as antenna lobing, antenna azimuth and elevation prior to acquisition, capsule height, distance from tracking station, and capsule attitude, are presently being evaluated in an effort to resolve this problem. (No definite conclusion concerning the extent of the blackout period has yet been reached.)

The quality of capsule telemetry during the r-f check prior to liftoff (Task 3) was exceptionally good. All monitors were operative and indicated all instrumentation was in good condition with the exception of Shield Temperature B, measurement P-13. The resistance of this thermometer was approximately 1.2 percent of bandwidth high. This resulted in a slightly high temperature reading prior to and during flight. During the r-f blackout period, but after peak temperature was recorded by the airborne tape recorder, P-13 malfunctioned in a manner which indicated a broken wire and infinite resistance. (A bad solder joint could account for the high resistance indicated prior to liftoff and the type of malfunction experienced later.)

Instrumentation measurements performed properly and telemetry transmission was of good quality during flight and re-entry, with the exception of P-13. Difficulty was encountered by Data Processing personnel in compensating the airborne tape recorder data for wow and flutter. Consequently, data from Channel 14 (recorded during r-f blackout) required hand reduction. Its accuracy was sightly degraded but easily correlated with real-time data. Thus, all data required for analyses were recovered.

Capsule signal strength was not recorded at KTS but it was sufficient to yield good telemeter records from 0.5 until 299 seconds after capsule ejection. HTS acquired for a period of 1028 seconds at signal strength levels from 10 to 50 microvolts. Coverage was not obtained for a period of 345 seconds during the recovery sequence because the capsule was out of range of the tracking stations.

INSTRUMENTATION DISCREPANCIES

Two Agena and two capsule telemetry instrumentation discrepancies were reported:

a. D82 Horizon Scanner Temperature, was reported reading 60°F higher than anticipated. A subsequent investigation disclosed that the resistance thermometer had been relocated. Consequently, the reading was correct.

b. H110, Timer Motor Frequency, was reported as unusable for real-time operational display.

c. P12, P15, and P19, Char Sensors, installed on the ablative shell were reported as inoperative. Subsequent analysis of the data indicated that temperatures did not reach predicted values. Therefore, charring action did not follow.

d. P13, Shield Temperature B, circuitry opened after signal loss from KTS. Data were not obtained after this time.

THOR INSTRUMENTATION

Of the 23 Thor booster measurements recorded, only two yielded non-usable data.

SECTION 7
VEHICLE PERFORMANCE EVALUATION

THOR/AGENA LAUNCH AND ASCENT

Thor liftoff was normal, and the Thor rolled properly to a departure of 174 degrees (172 degrees programmed) from 2 to 9 seconds after liftoff.

Main-engine propulsion performance was normal, with a recorded 153,000 pounds total liftoff thrust. The main engine operated for 163.0 seconds, somewhat less than the predicted 164.5 seconds, and the vernier engine solo operation time was 9.5 seconds. Oxidizer depletion caused main-engine cutoff. Propellant utilization was 99.6 percent, with a 400-pound fuel residual remaining.

From T + 133 to T + 162 seconds, non-critical pitch plane oscillations were recorded by Thor and the Agena pitch-rate channels. The frequency built up from approximately 0.3 cps at 137 seconds to approximately 0.5 cps, reaching an estimated amplitude of 3 to 4 deg/sec at 159 seconds. The Thor pitch rate reading indicated a diverging oscillation. Agena instrumentation indicated pitch accelerations of 0.1 to 0.2 g's at the engine mount ring at Missile Station 409.

Engine oscillations during this time were approximately ±1.2 degrees in pitch, but they appeared to damp out approximately 3 seconds prior to main-engine cutoff at 163 seconds.

Longitudinal acceleration at booster burnout was approximately 10.0 g's, as determined from the roll accelerometer. The design conditions of 10.5 g's longitudinally and approximately 0.35 g laterally were not exceeded by the measured 10 g's longitudinally and approximately 0.2 g laterally.

Preliminary DAC and LMSD investigations into the pitch oscillations have revealed that an 8 microfrared capacitor in the rate shaping network either was shorted out or failed. Remedial studies are in progress.

After vernier engine shutdown (T +172.5 seconds) yaw attitude errors developed. However, the angular rate of 0.13 deg/sec was not excessive.

Launch Trajectory

The launch trajectory, as presented in Figures 6, 7, 8, and 9 and Table 4 has been determined from MTS VERLORT data. The ascent data has been substantiated by trajectory coverages from the VERLORT at VTS and the FPS-16 skin track radar and metric optics of PMR. A summary of critical data is included in Appendix Table A. 4.

Thor boost trajectory was within tolerance, although it was slightly west, high, and steep compared to nominal. At the time of main-engine cutoff, the azimuth heading was approximately 2 degrees west of nominal, and the altitude was approximately 2.6 nautical miles higher than nominal. The velocity was 25 ft/sec low, and the flight path angle was 1.84 degrees high compared to the predicted value. At Thor main engine burnout, the Discoverer apogee altitude was 15.7 nautical miles higher and the apogee velocity was 226 ft/sec lower than predicted.

Ascent Heating

VTS and Telemetry ship launch data indicate that the operating temperatures of the equipment were safe and well below their specified maximum operating values during the recording of 760 seconds of ascent data. The equipment temperature rise, as shown in Appendix Table A.5, corresponds closely with data from previous flights. As expected, the temperature rise due to power dissipation accounted for a significant portion of the total temperature rise. The maximum temperatures and temperature rise values based on TM ship data could be 10°F lower than indicated in view of the discrepancy between VTS and Telemetry ship data. Telemeter ship launch data from Channel 15 indicated approximately 10°F higher temperatures than VTS for the same components (10°F is within overall system accuracy). These

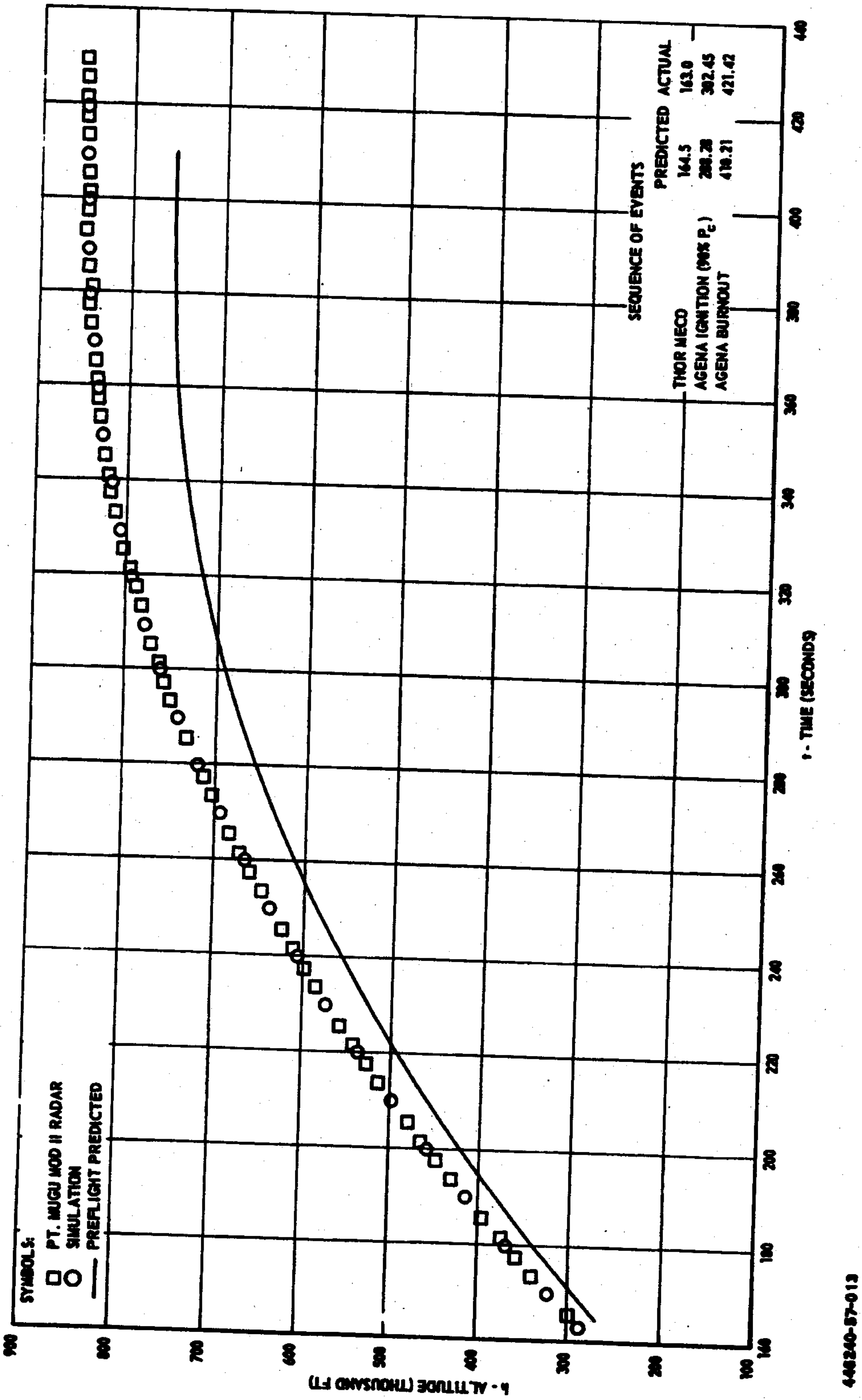

Figure 6 Altitude vs Time During Agena Boost

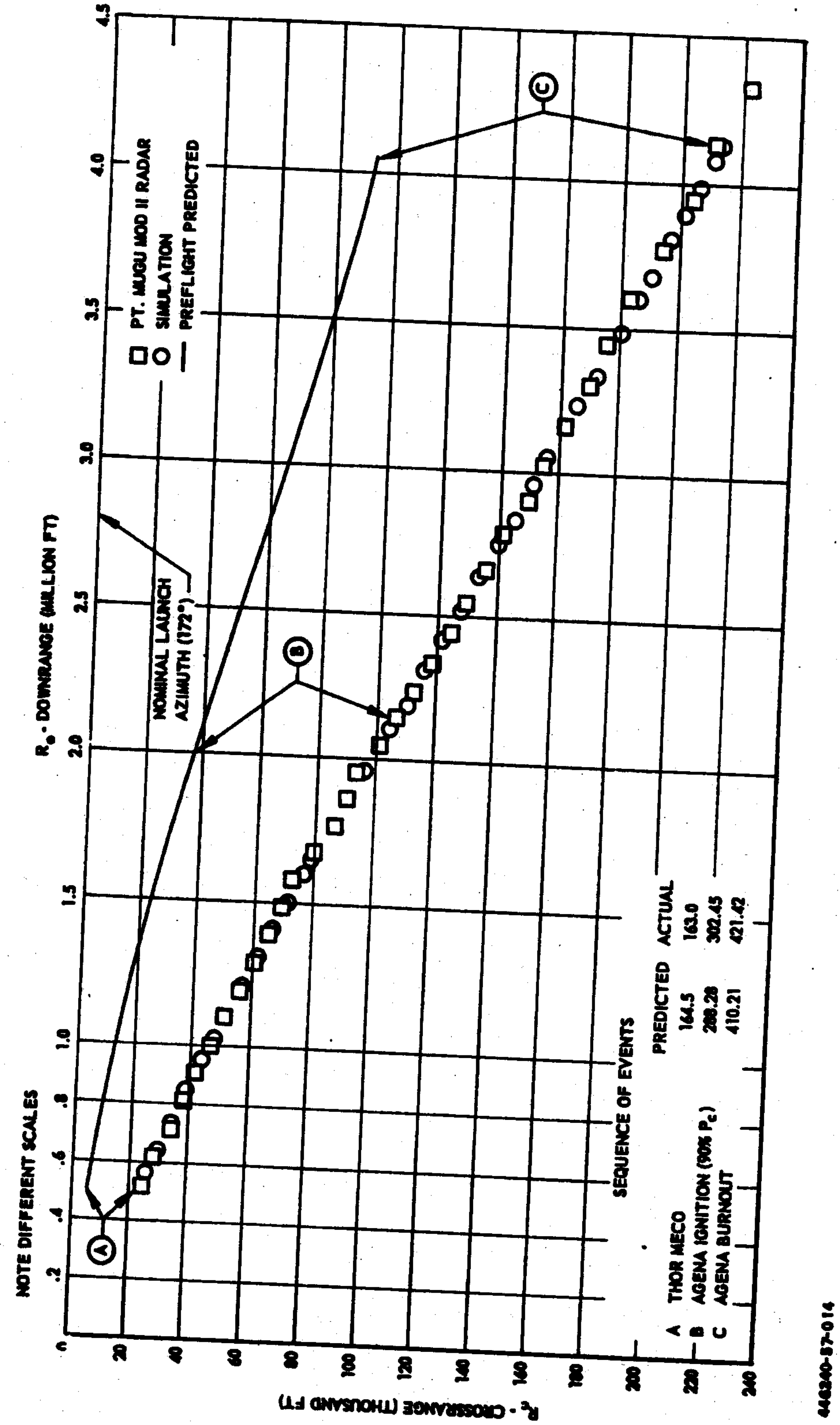

Figure 7 Crossrange vs Downrange Following Thor Main Engine Cutoff

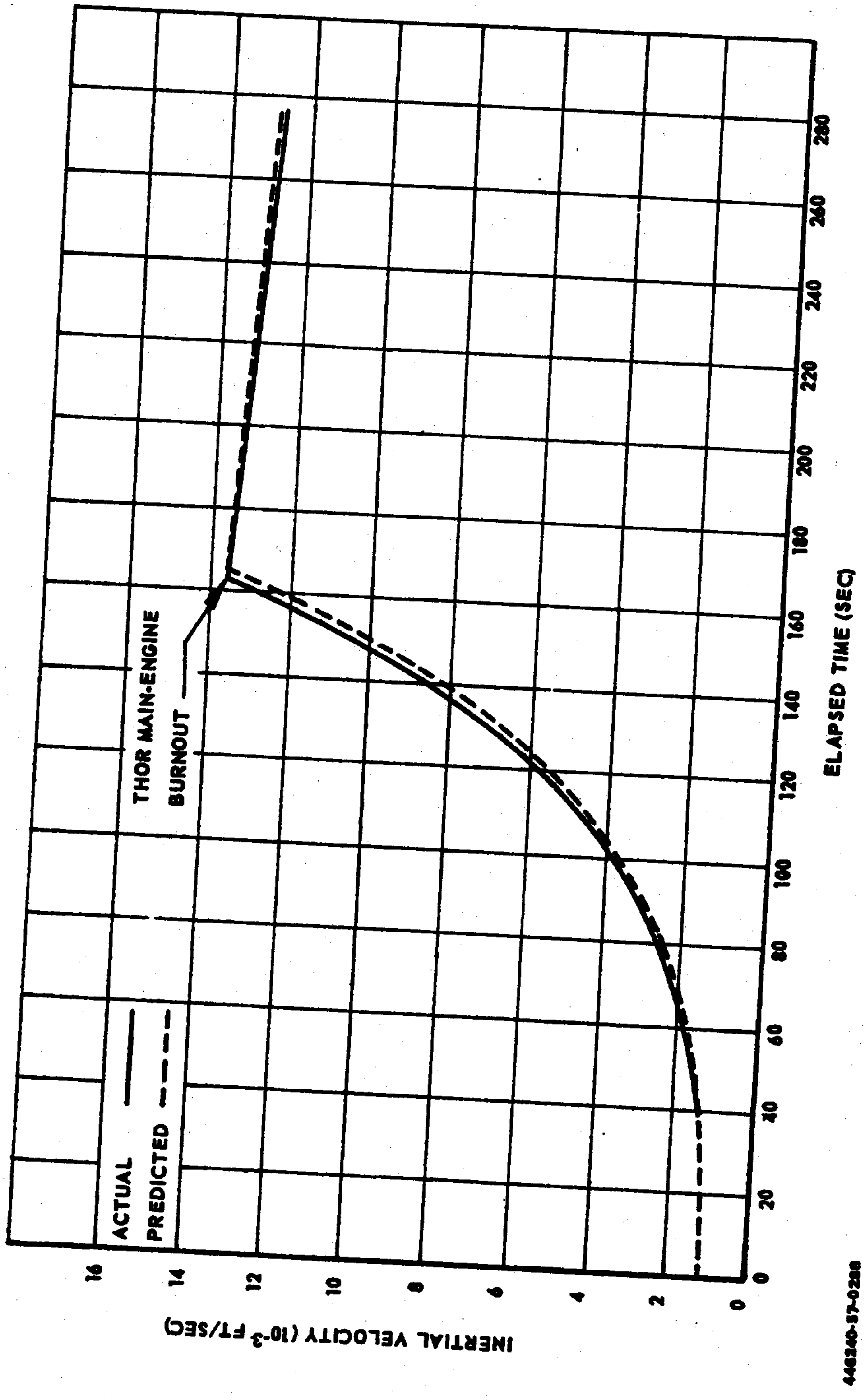

Figure 8 Velocity vs Time During Thor Boost

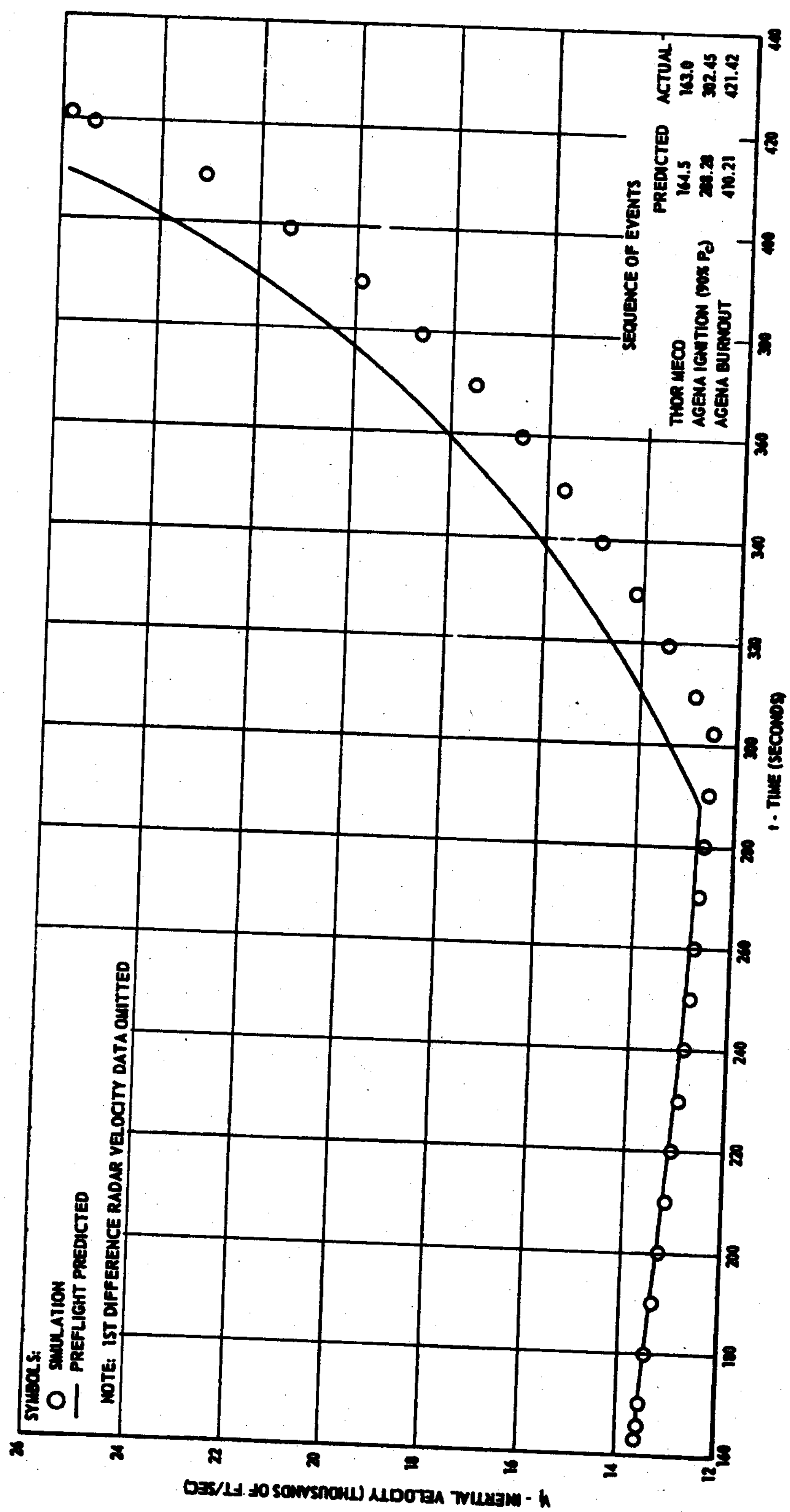

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Figure 9 Velocity vs Time During Agena Orbital Boost data were obtained from digital plots in LMSD-650853, Final Data Report, Vehicle 2205-1057.

SEPARATION AND THE COAST PHASE

Separation transients were normal, indicating a maximum displacement of -2 degrees in yaw and +1 degree in pitch.

Pitchover during coast was normal, the horizon scanner indicating +4 and +0.8 degree overshoots in pitch and roll respectively.

Adequate damping followed all transients occurring during the ascent phase.

All ascent phase events were verified and near nominal performance characteristics were indicated by all subsystem monitors.

Coast Trajectory

Although the Agena's velocity was only slightly lower than predicted during the coast period, its altitude was higher than predicted. As a result, second-stage ignition was delayed approximately 15 seconds. Based upon the MTS Reeves computer computation, a horizontal velocity-to-be-gained of 13,515 ft/sec was commanded.

ORBITAL BOOST

Following receipt of an ignition signal by the propulsion system at 300.96 seconds after liftoff, thrust attainment was reached within 1.49 seconds. Engine shutdown was commanded by the integrator after a gross equivalent velocity increment of 13,495 ft/sec had been gained. Shutdown transients, like ignition transients, were normal.

At Agena ignition, the maximum transient was in roll at 3.5 deg/sec. The average thrust misalignment was 0.1 degree in pitch and 0.5 degree in yaw, misalignments which were consistant with the indicated injection errors.

The results of the engine performance calculations are shown in Table 5. These calculations indicate that the specific impulse was 279.0 lbs-sec/lb. This value is the average of those "actual" values given in Columns 1 and 3 (Table 5) which have nearly equal deviation bands of approximately 1 percent. The value of 280 shown in Column 2 is from the radar data trajectory simulation and has an unknown deviation band due to unknowns in radar accuracy for this flight. Although the tolerances are now known, this value is not discounted in the analysis. However, the average of the lower values is quoted as the "most probable" specific impulse. The calculated flow rates (from turbine speed) show that an additional velocity increment of approximately 90 ft/sec was available. The oxidizer flow rate indicates that approximately 13 pounds of impulse oxidizer were remaining in addition to the 79 pounds of predicted non-impulse oxidizer. This could have provided an additional thrust duration of 0.33 second.

The new chamber pressure measurement (accuracy of ±0.75 percent) yields performance values (Column 1) consistent with values from other calculation methods.

Pressurization System

The oxidizer and fuel pump inlet pressures were satisfactorily maintained by the tank pressurization system, with no problems indicated.

Auxiliary Rockets

Satisfactory retrorocket and ullage rocket operation were confirmed by normal Agena separation and by Agena attitude control system off-sets at the scheduled time of ullage rocket ignition.

ORBITAL STATUS

Orbital status was successfully achieved, and all subsystem equipment operated within specification on orbit. Agena orbit tracks for Passes 0, 1, 2, 15, 16, and 17 are shown in Figures 10 and 11.

Table 5
PROPULSION PERFORMANCE

	Specification	Predicted *	Actual 1	Actual 2	Actual 3
A. PERFORMANCE DATA					
1. Velocity increment, ft/sec	—	13593	13471	13501	1513
2. Specific Impulse, lb-sec/lb	278.0 min	280.2	279.4	280.0	278.5
3. Thrust Duration, seconds	120 ± 6	120.13	118.97	118.97	118.97
4. Engine Thrust, pounds		15,230	15293	15327	15284
5. Combustion Chamber Pressure, psig	500 nom	491.0	493.1	494.2	492.8
6. Engine Total Flow Rate, lb/sec	—	54.35	54.74	54.74	54.88
7. Turbine Speed, rpm	24000 nom	23820	23866	—	—
8. Acceleration at engine shutdown, G	—	8.20	8.14	8.15	8.23
B. WEIGHT AND FLOW DATA					
1. Total Oxidizer Loaded, pounds	4801	4801	4801	4801	4801
2. Total Fuel Loaded, pounds	1870	1868	1868	1868	1868
3. Total Propellant Loaded, pounds	6671	6669	6669	6669	6669
4. Oxidizer Flow Rate, lbs/sec	—	39.25	39.52	39.53	39.63
5. Fuel Flow Rate, lb/sec	—	15.10	15.22	15.22	15.25
6. Total Flow Rate, lb/sec	—	54.35	54.74	54.74	54.88
7. Vehicle Weight at Ignition, pounds	—	8387	8387	8387	8387
8. Vehicle Weight at Shutdown, pounds	—	1857	1874	1874	1857
9. Engine Propellant Mixture Ratio	2.57 nom	2.599	2.598	2.598	2.598
10. Remaining Oxidizer Impulse Weight, pounds	—	0	13	13	1
11. Remaining Fuel Impulse Weight, pounds	—	12	16	16	0
C. SYSTEM DATA					
1. Oxidizer Pump Inlet Pressure, psia	40 min	65 to 71	67 to 73	—	—
2. Fuel Pump Inlet Pressure, psia	34 min	55 to 57	56 to 58	—	—
3. Oxidizer Pump Inlet Temperature, °F	—	50	48 to 49	—	—
4. Fuel Pump Inlet Temperature, °F	—	50	46.5 to 47.5	—	—
5. Thrust Overshoot, percent	50 max	24	23.7	—	—
6. Thrust Attainment Time, seconds	1.3 to 1.9	1.44	1.48	—	—

* *Predicted performance is based on the engine acceptance performance and on oxidizer exhaustion.*

1. *Based on telemetered propulsion data. Performance calculated from turbine speed (for flow rates) and the narrow-band chamber pressure measurement (for thrust).*

2. *Based on trajectory simulation of radar data. Velocity shown is calculated from specific impulse and thrust from the simulation. The simulation resulted in a net horizontal velocity increment of 13480 ft/sec.*

3. *Based on the acceleration integrator.*

Performance and operation of the propulsion subsystem was satisfactory and nominal in all respects. No potential problems were indicated by any of the received data.

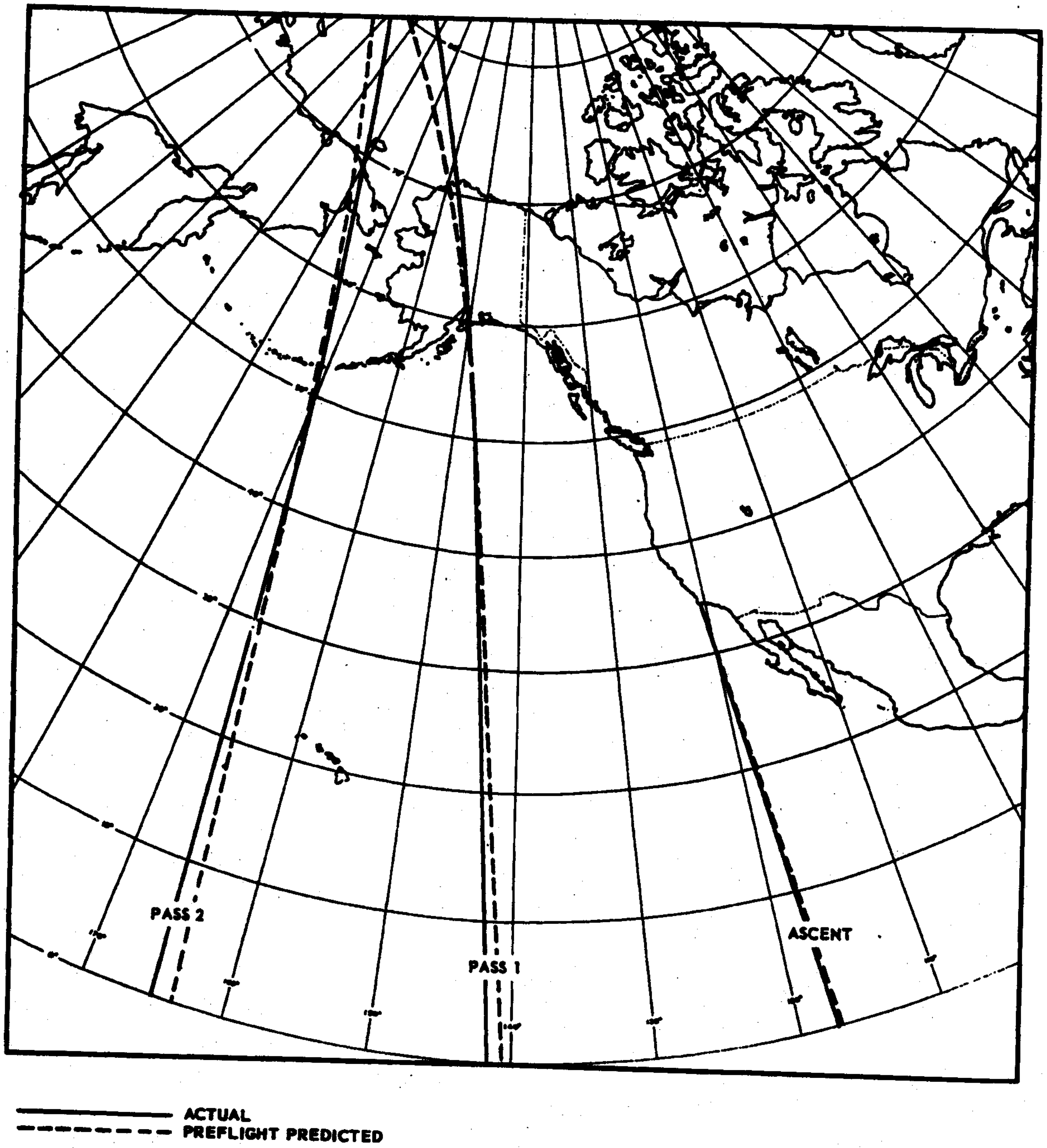

Figure 10 Agena Orbit Tracks, Passes 1 and 2

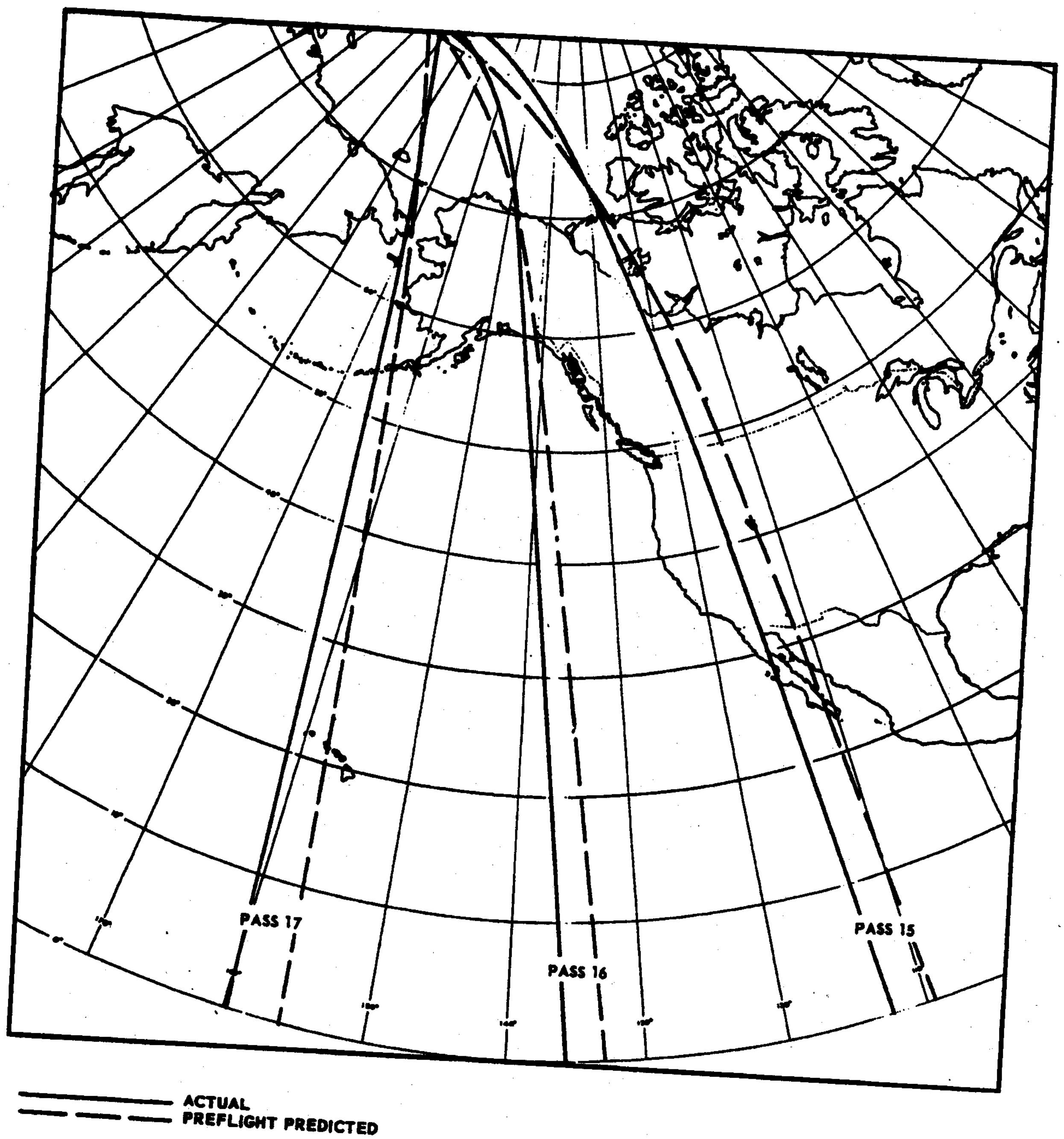

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Figure 11 Agena Orbit Tracks, Passes 16 and 17

Attitude

The Agena vehicle did not achieve the orbital period desired. However, the period was established within 0.6 minute of the desired period. Agena thrust attitude showed 0.15 degree pitchup and a 1.55 degrees yaw to the right (west). The plane of the orbit was shifted to the west (longitude of ascending mode shifted 1 degree west), and the orbit inclination was increased (approximately 1.2 degrees greater than intended).

A simulation was prepared using MTS Mod II radar data fitted to the following degree of precision:

Coast Phase	Mean	RMS	Order of Fit
Slant Range, feet	1.7	44.8	6th
Elevation, radians	0.81×10^{-5}	64.5×10^{-5}	6th
Azimuth, radians	0.11×10^{-5}	74.2×10^{-5}	6th
Orbital Boost			
Slant Range, feet	2.0	48.6	6th
Elevation, radians	-1.6×10^{-5}	43.4×10^{-5}	6th
Azimuth, radians	$-.0015 \times 10^{-5}$	35.3×10^{-5}	5th

Using this fit data (after being converted to curvilinear coordinates) as the basis for an equations of motion simulation, a postflight simulation was made. This simulation, when compared to the raw radar, has the deviations given in terms of curvilinear coordinates:

	Mean	RMS
Altitude, feet	110	823
Downrange, feet	42.6	445
Crossrange, feet	-34.4	643

The yaw reorientation program following orbital injection was properly accomplished, and the near nominal orbit parameters adhered to are indicative of proper vehicle attitude and injection velocity.

The orbital telemetry data indicated that required attitude control was maintained throughout each orbit (Fig. 12). Limit-cycle amplitudes and period were consistent with preflight predicted values. The horizon scanner indicated roll and pitch limit cycle amplitudes of ±0.6 degree with a period of approximately 270 seconds. The steady state nose-down offset in pitch is normal and is due to the difference in programmed pitch rate, pitch gyro drift rate, and the actual orbital rate. The near-zero roll attitude indicates a low yaw-gyro drift rate, and the steady-state yaw gyro offset is mainly due to the nominal roll gyro drift rate. Control gas expenditure was near the minimum predicted rate (Fig. 13) and was consistent with the normal cyclic variations in attitude indicated on the horizon scanner monitors.

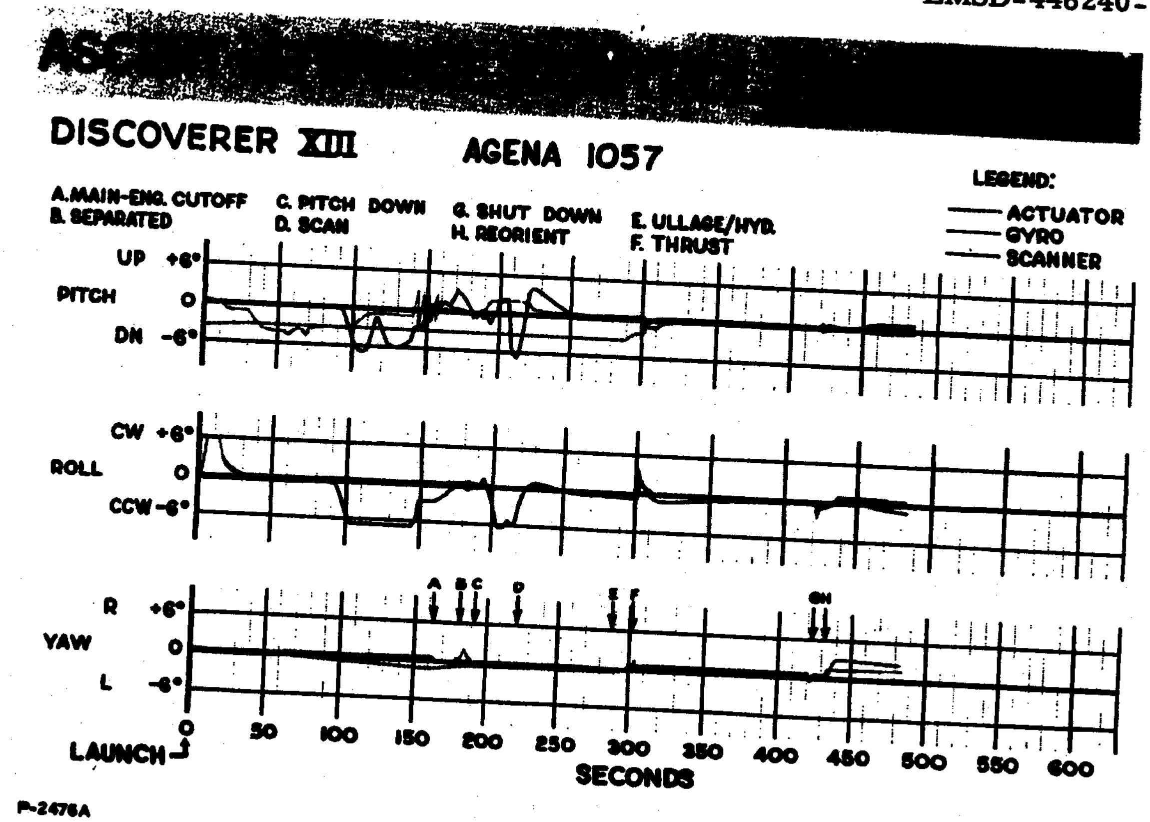
Temperatures

Orbit temperature data shown in Appendix Table A. 5 indicate that the instrumented components were operating within specified limits throughout the orbital operating phase. Orbit temperature data for the retro-rocket motor confirmed predicted trends obtained from High Altitude Temperature Simulator (HATS) Chamber tests of the re-entry capsule and fairing. These tests indicated that the retrorocket motor would stabilize at approximately $40^{\circ}F$.

Transient sun effects appeared on Pass 9 data as predicted, but they had no significant affect on the satellite's attitude control.

Auxiliary Power

An analysis of the auxiliary power data indicated normal operation for all electrical power system equipment. Appendix Table A. 6 is a summary of these data and shows all voltages at or near their nominal value. Proper operation of the +28 volt No. 2 regulator was indirectly confirmed from the performance of the S-band beacon. This beacon operated through the 31st pass at which time the vehicle battery (Primary Type IA) was exhausted.



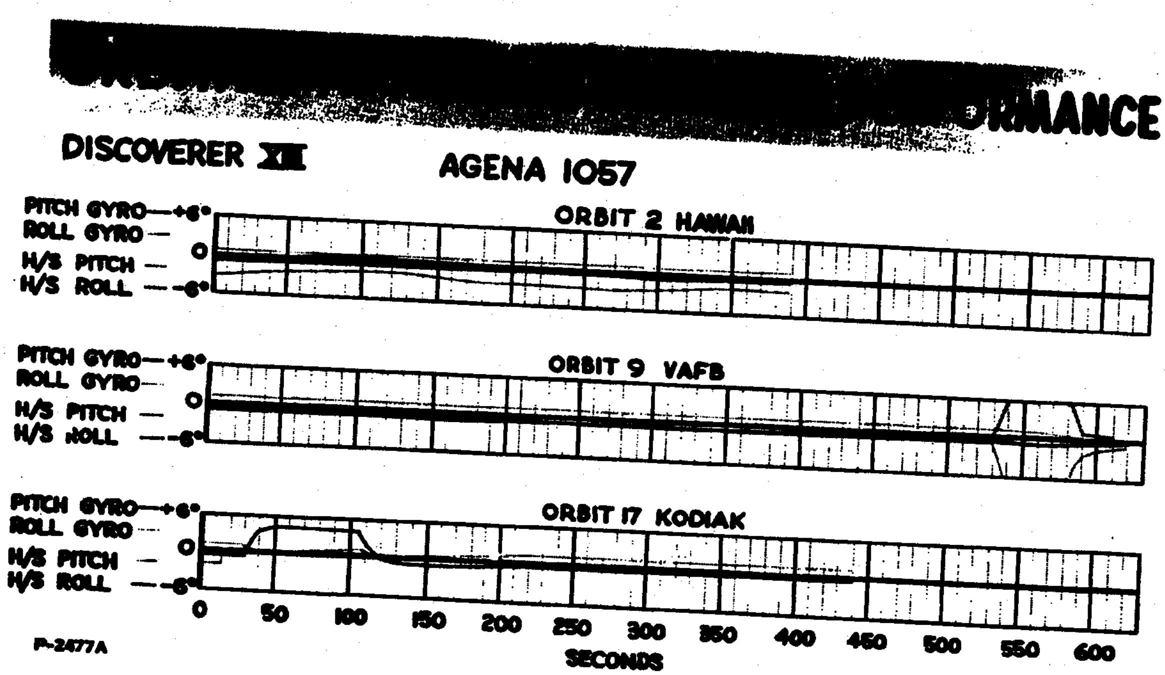


Figure 12 Attitude Control Performance

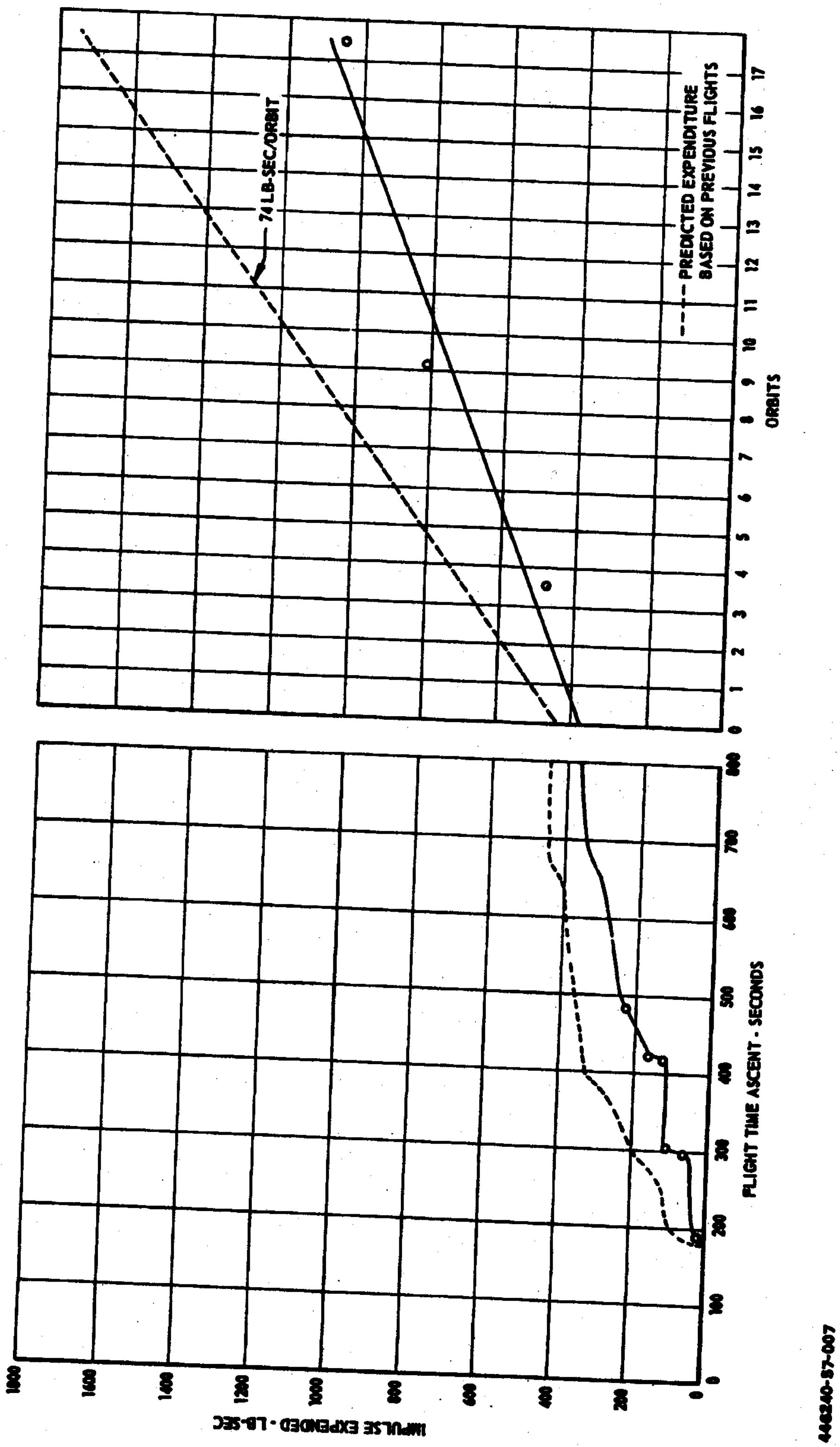


Figure 13 Control Gas Expenditure vs Time

The CWAT operated through the 138th pass or approximately nine days. This beacon and the hydraulic motor are supplied from a separate battery (Primary Type IV).

Appendix Table A. 6 data from 400 through 700 seconds after liftoff were taken from ship telemetry. Telemetry data were missing from launch to 300 seconds for the hydraulic battery voltage. However, from 300 seconds thereafter, the data indicate normal operation. Also missing from telemetry records were the 2000-cps inverter voltage and phase AB of the 400 cps 3 phase inverter for Pass 9. Data from Pass 17 indicate that the inverters were operating normally.

SECTION 8
CAPSULE PERFORMANCE EVALUATION

SEPARATION

All events subsequent to D-timer restart and initiation of the recovery sequence occurred as specified, and no anomalies were indicated. The mechanical separation of the capsule from the Agena occurred at System Time 83705.5. At this time the following conditions existed:

<u>Agena Position</u>	
Altitude	997,164 feet
Geodetic Latitude	65.58° N
Longitude	171.73° W
<u>Agena Velocity</u>	
Velocity Magnitude	25,690 ft/sec
Flight Path Angle	-1.041°
Velocity Azimuth	162.54°

<u>Agena Attitude</u>

Before the pitch maneuver, the Agena's sun position indicator (SPI) indicated the attitude of the satellite to be -5 degrees nose down in pitch and +3 degrees nose east in yaw, where yaw is measured from the orbit plane (3 degrees of yaw remained constant). Agena altitude at mechanical separation was as follows:

Pitch Attitude (measured from horizontal)

-61 ± 5 degrees

Yaw Attitude (measured from orbit plane)

3 degrees nose east ± 5 degrees

(These tolerances reflect an overall uncertainty of 5 degrees because of errors in SPI calibration, telemetry, and data analysis.)

Computations, using gyro and horizon scanner data, indicate that the Agena's attitude at capsule separation was -61.7 degrees in pitch (specification 60 degrees ±2 degrees), -0.4 degrees in roll (specification 0 degrees ±2 degrees), and within an estimated ±2 degrees in yaw, (specification 0 degrees ±2 degrees).

Total vehicle pitchdown at capsule separation (Fig. 14) was determined from:

	Degrees
Initial pitch-gyro offset from horizon as indicated by horizon scanner and gyro position	-1.1
Pitch torque program (+3.55 deg/min for 17.5 seconds)	+1.1
Pitch torque program (-45 deg/min for 77 seconds)	-57.7
Change in local horizon	-6.2
Vehicle lagged gyro at command separation	+2.3
Vehicle position relative to the horizon at capsule separation	-61.7

RETRO PHASE

Capsule Programmer

Table 6 summarizes the performance of the capsule programmer during capsule ejection from orbit. The capsule programmer initiates an event at a prescribed time after the previous event except for spin-up, which is initiated at a time measured from electrical disconnect.

As indicated in Table 6, the capsule programming sequence of events during the ejection and recovery phases performed within the design tolerances, except in the cases of the spin and de-spin events. Although these two events were near or just outside tolerance limits, they both fell within acceptable performance limits. All times in the ejection sequence were obtained from "tell-tale" breakwires.

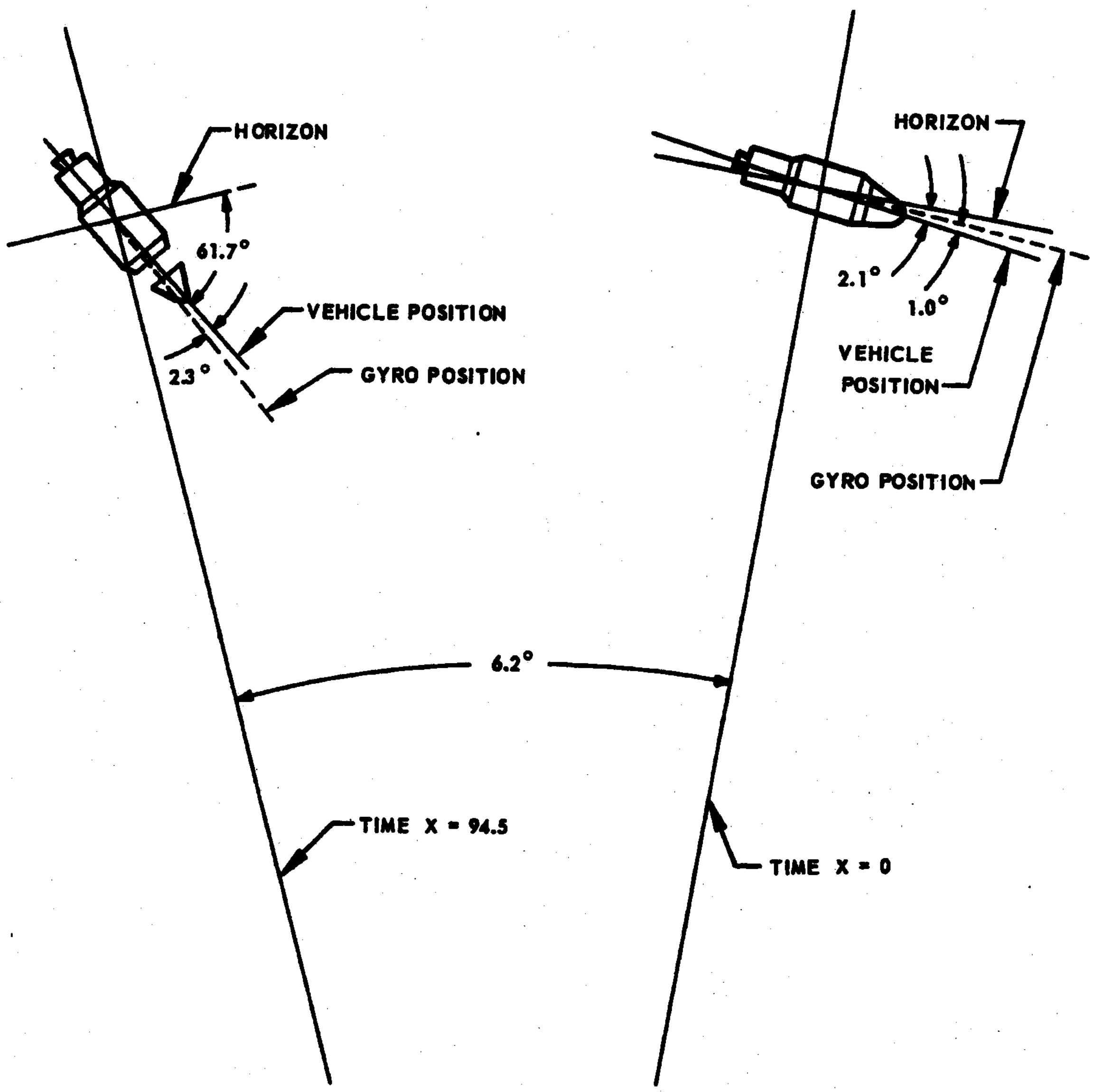


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Figure 14 Pitchdown Prior to Capsule Separation

Table 6

RECOVERY SEQUENCE

Event	Nominal Time and Tolerances (sec)	Actual Time (sec) Prior Event		Actual Time (sec) Post Event	System Time (sec) Prior Event	System Time (sec) Post Event	Source
KTS Acquire Satellite T/M					83494		
KTS Acquire Capsule T/M					83580		
KTS Acquire Capsule CWAT					83600		
D-timer On	T-93(± 0.6)	T-94.11		T-92.91	83509.76	83510.96	(S) TT
Horizon Scanner Off	T-93(± 0.6)	T-93.11		T-93.08	83510.76	83510.79	(S) Pitch and Roll Indications
-45 deg/min Pitch Rate Command	T-78(± 0.1)	T-77.99		T-77.76	83525.88	83526.11	(S) Pitch Rate Data
+3.55°/min Pitch Rate Command	T-1 (± 0.1)	T-1.07		T-0.42	83602.80	83603.45	(S) Pitch Rate Data
Electrical Plug Separation	T-0 (-0.5, +0.32)		T-0		83603.87		(C) A_Z
Capsule Separation	T+1.5(± 0.1)	T+1.35		T+1.79	83605.22	83605.66	(S) Separation Monitors
Spin-Up	T+3.23 to 3.57	T+3.19		T+3.25	83607.06	83607.12	(C) TT
Retro-Rockets Fire	*T+1.15 to 1.35	T+1.14	to	T+1.34	83608.22	83608.40	(C) TT
De-Spin	*T+10.21 to 11.29	T+11.52	to	T+11.78	83619.92	83620.00	(C) TT
Thrust Cone Electrical Disconnect	*T+1.35 to 1.65	T+1.44	to	T+1.71	83621.44	83621.63	(C) TT
Thrust Cone Separation		*T+1.44	to	T+1.71	83621.44	83621.63	(C) TT
KTS Lost Capsule T/M					83879		
KTS Lost Capsule CWAT					83877		
5 G Switch Closure	T+513(+84, -60)		T+563.74		84167.61		(C) TT
Mechanical Timer Closure	ΔT=238(±5)		T=128.39		84296.0		(C) TT
Parachute Cover Off		ΔT+1.17		ΔT+1.36	84297.17	84297.36	(C) TT
Ablative Shell Wirecutters		ΔT+1.60		ΔT+1.78	84297.60	84297.78	(C) TT
Parachute Deploy (Tell-Tale)		ΔT+2.06		ΔT+2.24	84298.06	84298.24	(C) TT
Parachute Deploy (Accelerometer)		ΔT+2.46		ΔT+2.54	84298.46	84298.54	(C) TT
Ablative Shell Jettison		ΔT+2.44		ΔT+2.63	84298.44	84298.63	(C) TT
Parachute Disreefed			ΔT+3.5		84302.5		(C) A_Z

(S) Agena Satellite
(C) Capsule
A_Z Continuous Channel Accelerometer
TT Tell-Tale
T Capsule Programmer Time
ΔT Time from 5 g switch closure

* Times are measured from previous event

Figure 15 represents roll, pitch, and yaw gyro data recorded during the retro phase. The roll rate reached a magnitude of 43 rpm at the end of spin-up. Signal attenuation indicated an average rate of 45 rpm during retro-rocket burning. (The predicted value was 55 rpm.) Findings indicate the low spin rate was due to an improper nitrogen-Freon gas mixture. The gas mixture was premixed without sufficient storage time for self diffusion and then charged into the spin bottles, resulting in an almost pure nitrogen charge. (The calculated spin rate for pure nitrogen would be 46 rpm.) Although the spin rate was lower than expected, capsule stability during retrorocket burning was excellent. The pitch and yaw rate gyro readings have been analyzed and indicate the pitch and yaw torques due to thrust misalignment and radial center of gravity offset did not exceed 5 ft-lb. (The maximum expected transverse torque is 12 ft-lb.) As a result, the total body precession angle during rocket burning did not exceed 12 degrees, and the resultant retro velocity was within 3 degrees of the desired direction. The roll rate after despin, as determined from the roll gyro, was 10 rpm as was predicted. The residual roll rate of 10 rpm was confirmed by signal attenuation.

Figure 16 presents the ±5 g longitudinal accelerometer reading during retro-rocket burning. The +8 to -20 g range accelerometer reading is also presented, although its function was to measure decelerations during atmospheric entry. Integration of the low range accelerometer curve indicated the retro velocity would have been 949 ft/sec if burning occurred without precessional motion, while the high-range accelerometer indicates 958 ft/sec. The nominal retro velocity for burning without precessional motion is 1021 ft/sec. The values obtained by integrating the accelerometer traces are about 6% low. (From retro balloon tests it was found that integration of the accelerometer traces could be in error by ±10 percent. Therefore, the retrorocket performance could not be precisely established on the basis of the accelerometer traces.)

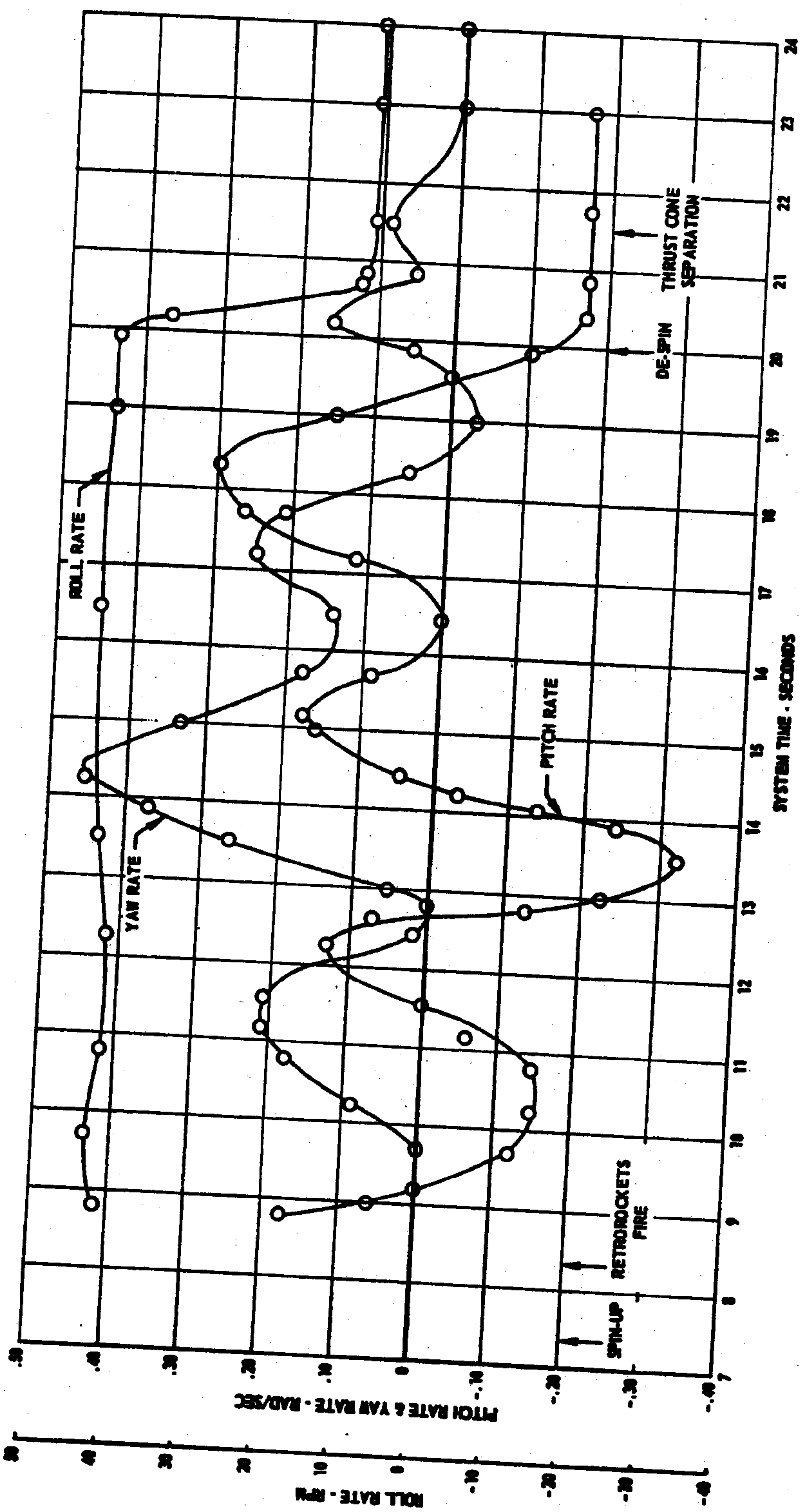

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Figure 15 Capsule Retro Phase Roll, Pitch, and Yaw Rates

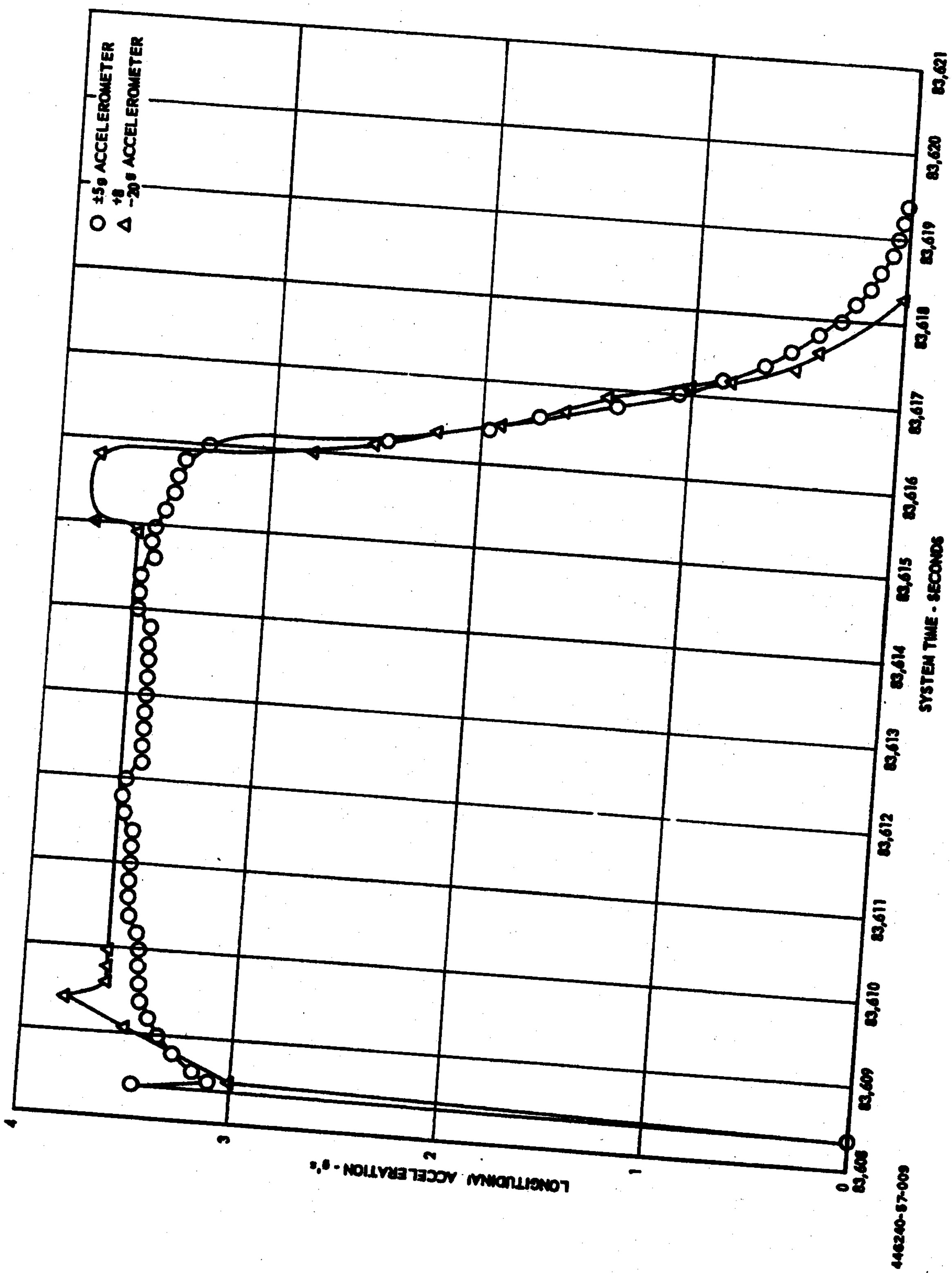

Figure 16 Capsule Retro Phase Longitudinal Acceleration

RE-ENTRY PHASE

Trajectory

Figure 17 presents the variation of altitude, geodetic latitude, longitude, axial deceleration, and flight path angle with time. The circled points on the altitude, latitude, and longitude curves are KTS tracking data corrected for refraction. The circled points on the axial deceleration curves are values obtained from the +8 to -20 g longitudinal accelerometer.

The continuous curves were obtained from a computer simulation using the six degrees of freedom equations of motion. The simulation was obtained by varying the velocity magnitude and flight path angle following retrorocket burning until the tracking data, impact point, and time of peak deceleration were matched. The initial conditions required for the simulation were as follows:

System Time	83617.33
Altitude	987,126 feet
Geodetic Latitude	64.83 degrees North
Longitude	171.23 degrees West
Velocity	25,060 ft/sec
Flight Path Angle	-2.89 degrees
Velocity Azimuth	163.04 degrees

It should be noted the velocity and flight path angle required for this simulation are not exactly the values obtained using nominal retrorocket burning starting with the initial orbit elements.

Assuming that the orbital position and velocity vector at retro-rocket ignition (as obtained from the ephemeris generated after Pass 15) are correct, and that the retrorocket impulse magnitude and direction were nominal, then the resulting re-entry trajectory showed three discrepancies:

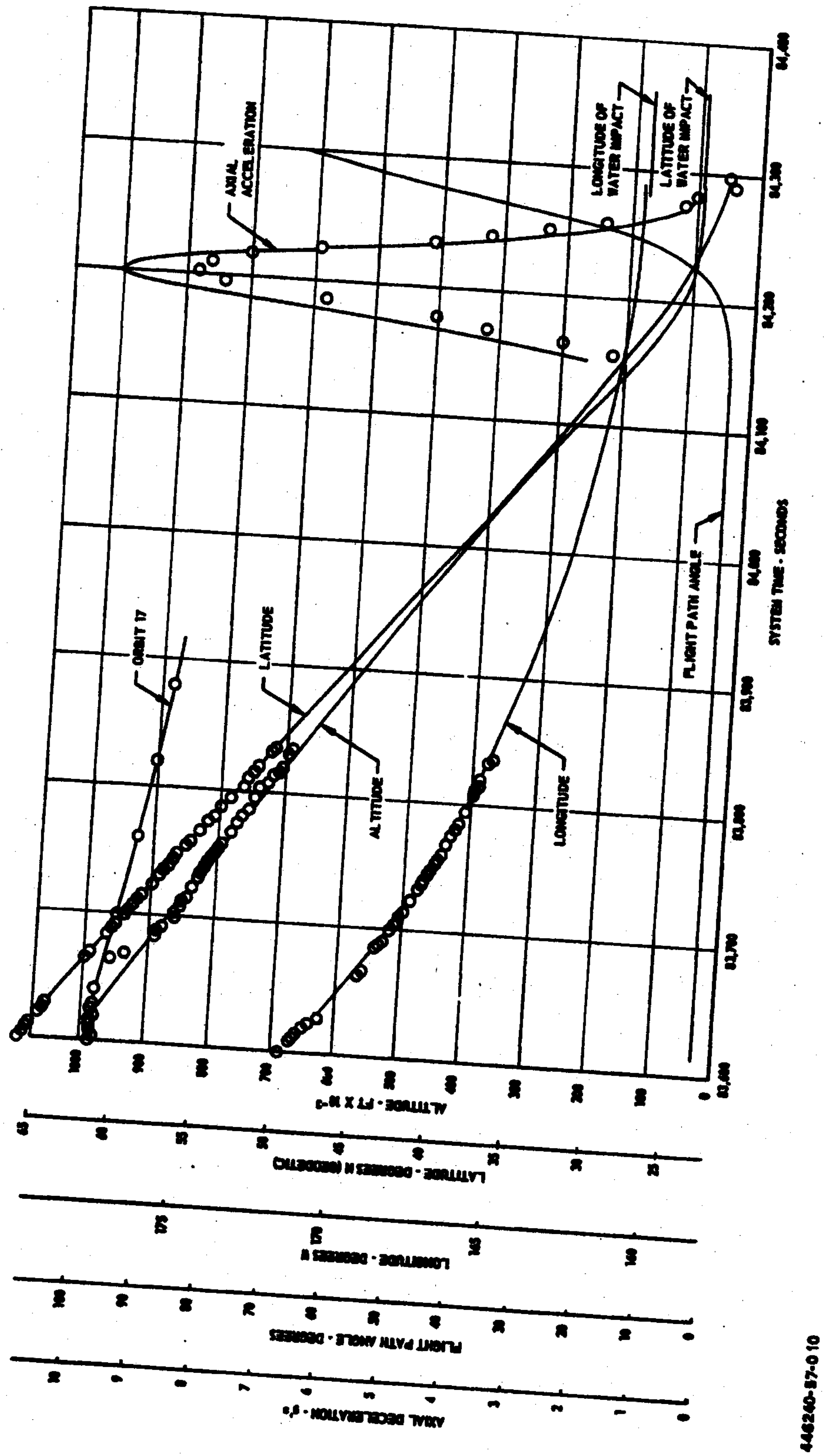

Figure 17 Capsule Trajectory Parameters in Relation to Time

(1) The trajectory did not fit the tracking data.

(2) The trajectory had peak deceleration occur 17 seconds too late.

(3) The trajectory impact point was 60 miles south of the water recovery point.

If the orbit elements and the above initial conditions are correct, then the retro velocity magnitude would be 895 ft/sec and the retro velocity direction would be -66 degrees. Both numbers are unlikely, particularly the magnitude which is 12 percent below nominal.

Further, if the retro velocity vector were nominal and the preceeding re-entry trajectory initial conditions are correct, then (also assuming the orbital altitude is correct) the orbital velocity would be 25,541 ft/sec and the path angle would be -0.851 degree. These are discrepancies of approximately 150 ft/sec in magnitude and 0.185 degree in direction. Errors of this magnitude also appear unlikely.

Because of the sensitivity of the re-entry trajectory in relation to the initial velocity vector and relative insensitivity to initial position, it is likely that the trajectory simulation, using the previously stated initial conditions, is valid. The problem of resolving this initial velocity vector into the orbit velocity vector and the retro velocity vector can not be resolved due to the lack of data for precise determination of either quantity.

Re-Entry Stability

Figure 18 presents the roll rate and the envelope of the yaw and pitch rate during re-entry. It should be noted that no data is available from 83875 to 84120 System Time, which covers an altitude range from 620,000 to 270,000 feet. All data after System Time 84120 were obtained from the tape recorder playback to HTS. Note in the figure that the spin rate changed from 10 rpm to -17 rpm during re-entry. This spin reversal causes no detrimental effects on the stability of the capsule as it descends through the atmosphere. Preliminary findings indicate that the reversal is due to a

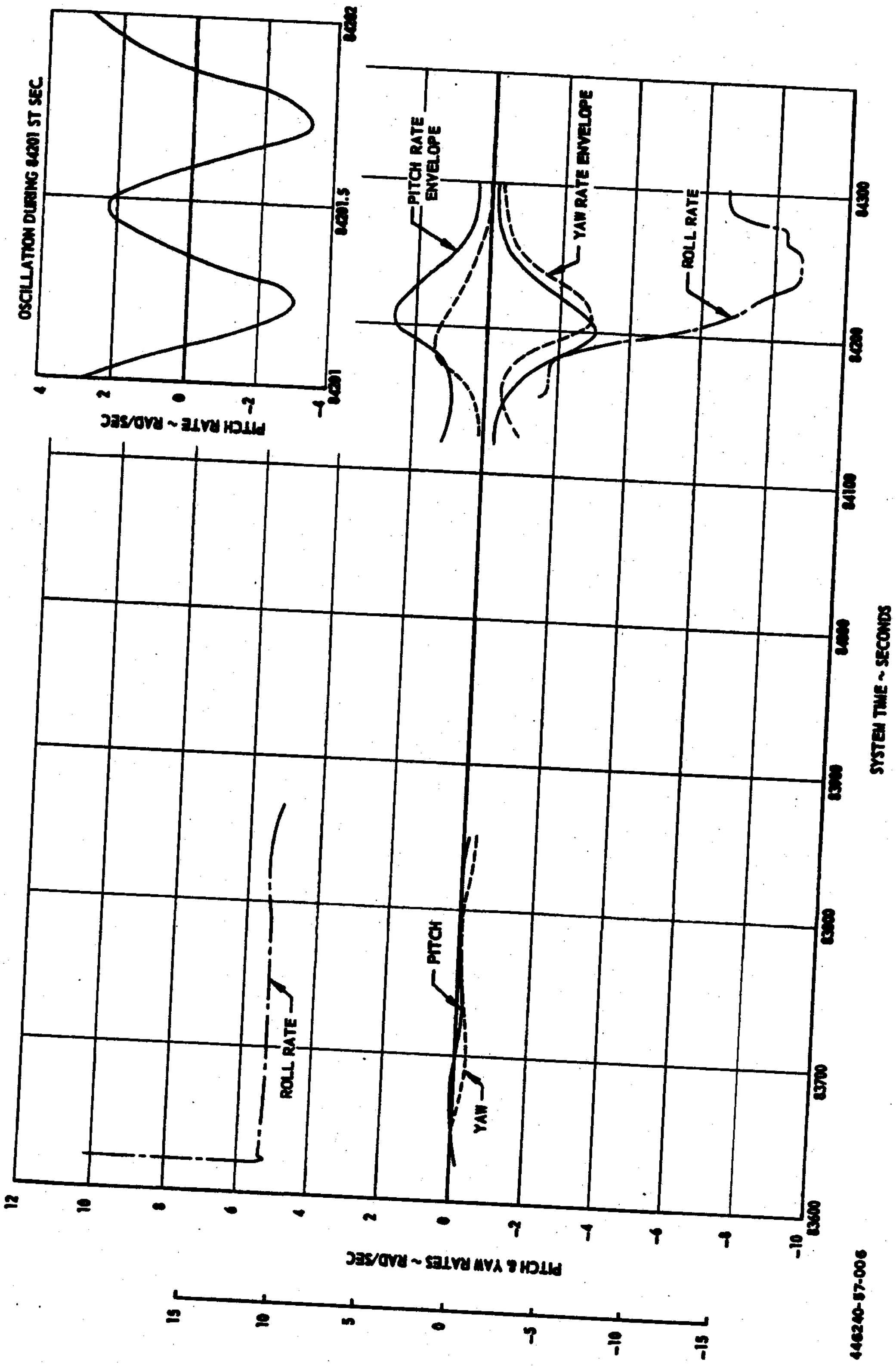

Figure 18 Roll, Pitch, and Yaw Rates During Capsule Re-entry

radial center of gravity offset, the pitch-yaw product of inertia, or the differences in pitch and yaw inertias.

Figure 19 presents the pitch and yaw accelerations of the center of gravity as obtained by the fore and aft accelerometers. Using capsule aerodynamic data obtained from wind tunnels and ballistic ranges, coupled with the dynamic pressure and Mach number corresponding to the trajectory simulation of Figure 17 (these are shown on Figure 20), the total angle-of-attack envelope of Figure 20 is obtained. This total angle of attack does not exceed 15 degrees over the range of peak longitudinal deceleration and aerodynamic heating. Also presented in Figure 20 is the total angle of attack envelope associated with the re-entry trajectory simulation of Figure 17. The data points indicate a more rapid convergence at altitudes above 270,000 feet and slower convergence below hypersonic speeds. Figure 21 is included to portray capsule re-entry motion.

Re-Entry Thermodynamics

The major events occurring during the re-entry phase are included in Table 6. Figure 22 illustrates the location of the structural temperatures. The specific locations are detailed in Table 7.

Heat Shield Temperatures. Measurement data indicate the following:

a. Stagnation point: Within the accuracy of the data from the single resistance thermometer, no temperature rise of the inside surface was indicated.

b. Skirt: Six resistance thermometers and four char sensors were located in the skirt region. All skirt temperatures were substantially lower than expected, and none of the char sensors indicated charring. The outermost char sensor was located 0.06 inch below the outside surface of the phenolic-glass heat shield. Data temperature histories, indicating an average inside surface temperature rise of about 240°F, are shown in Figure 23, a and b.

c. Base: Two resistance thermometers indicated temperatures slightly less than expected. These histories are shown in Figure 24.

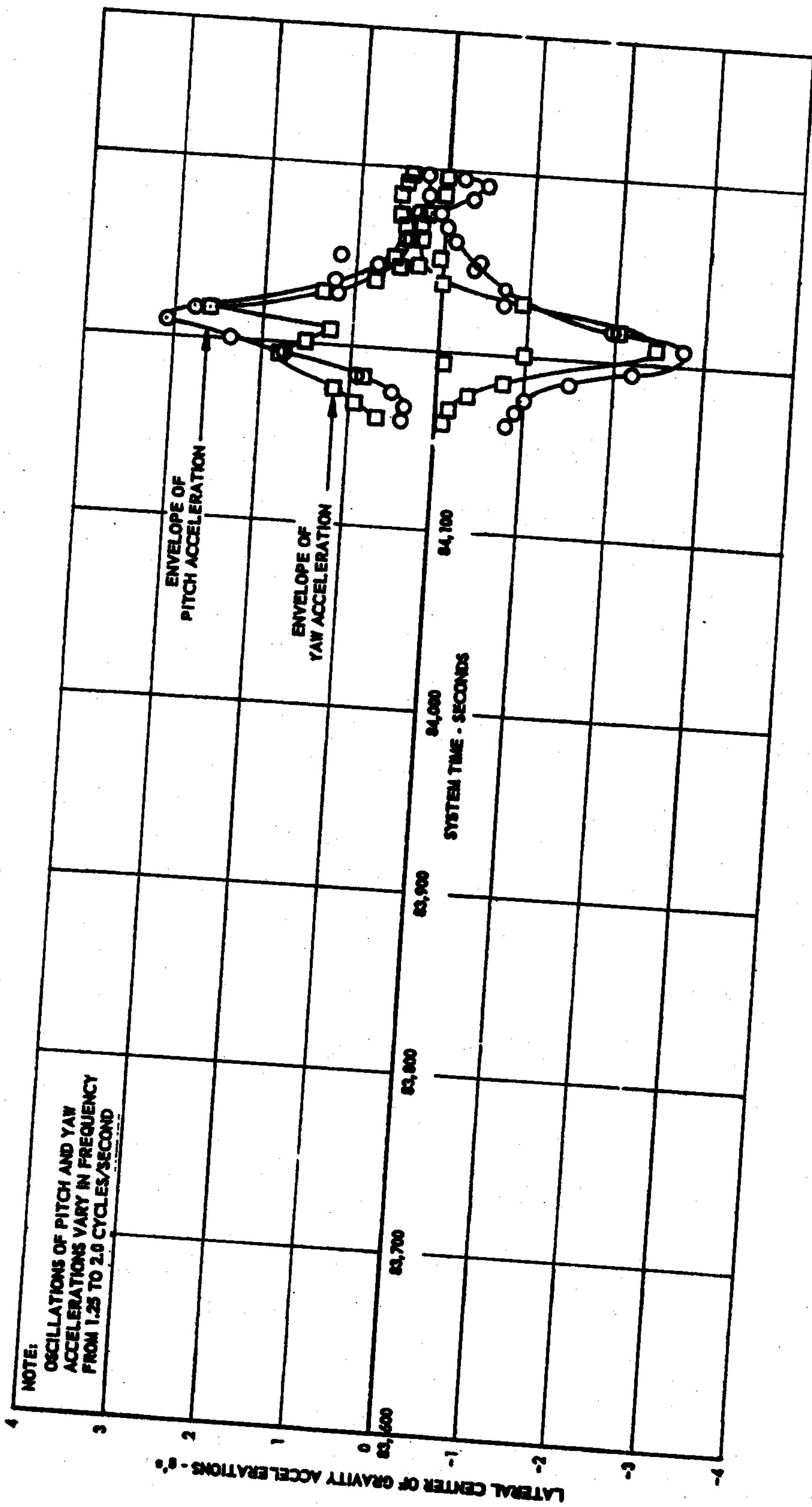

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Figure 19 Variation of Lateral Acceleration in Relation to Capsule Center of Gravity

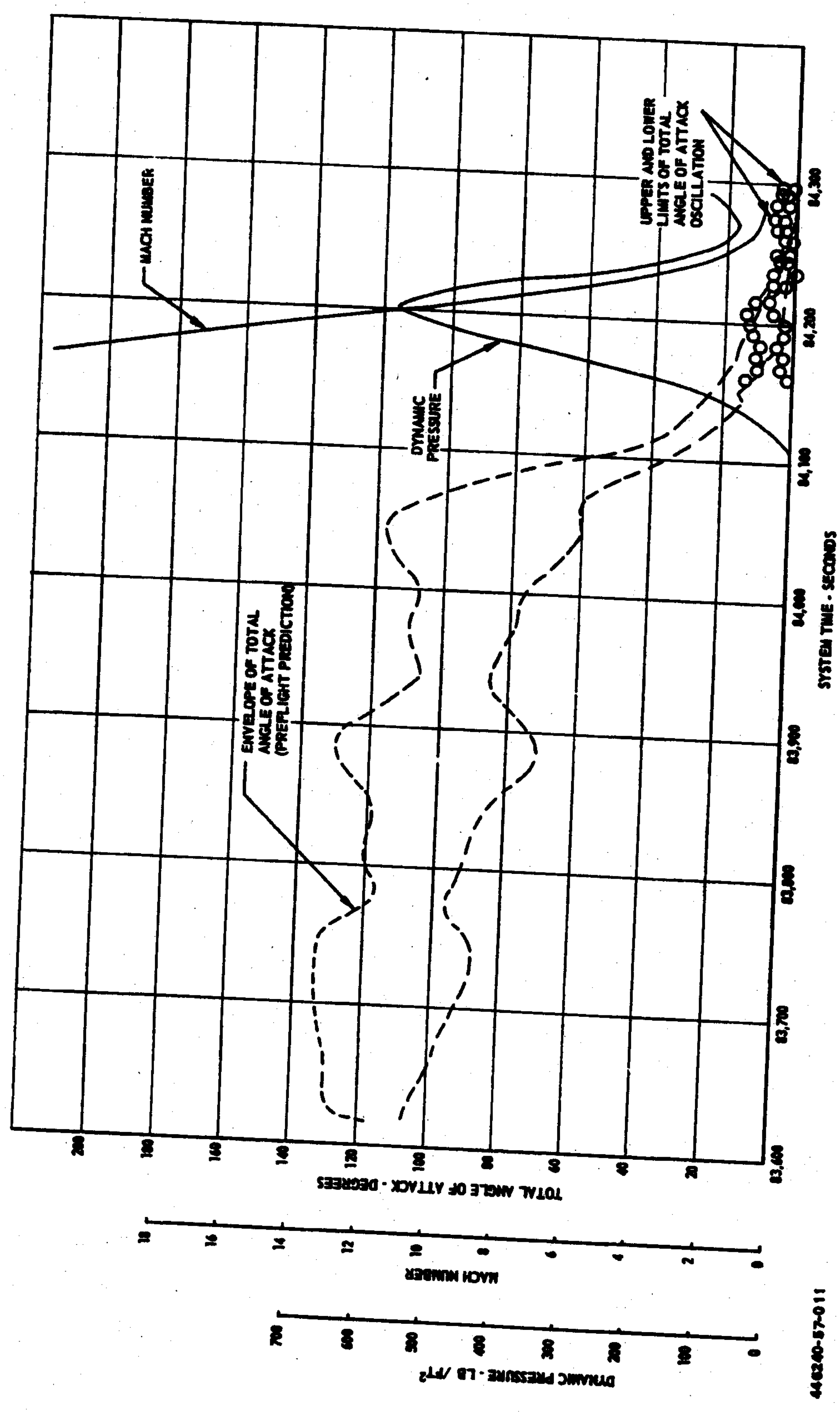


Figure 20 Capsule Angle of Attack Envelope

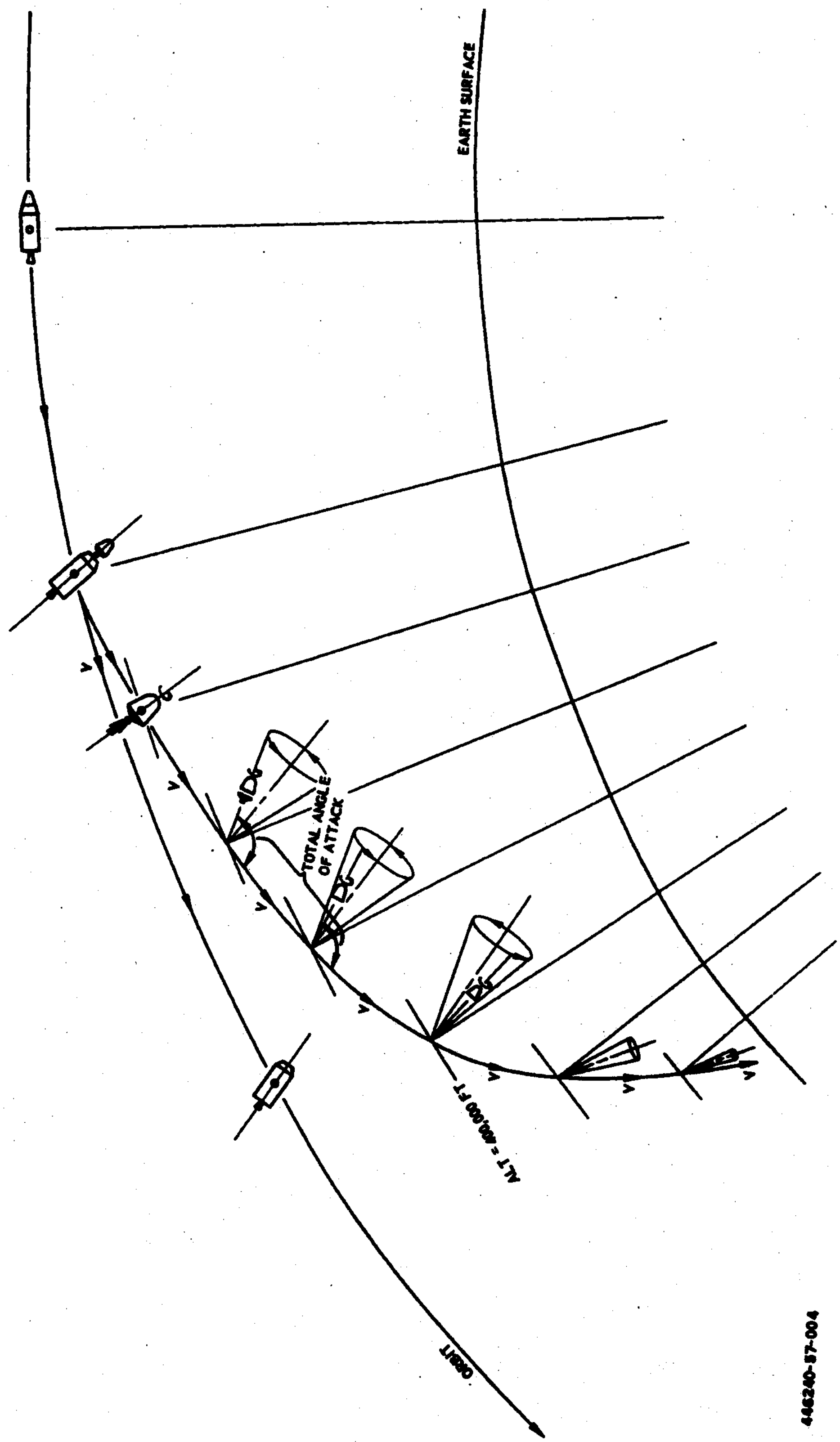


Figure 21 Capsule Re-entry Motion

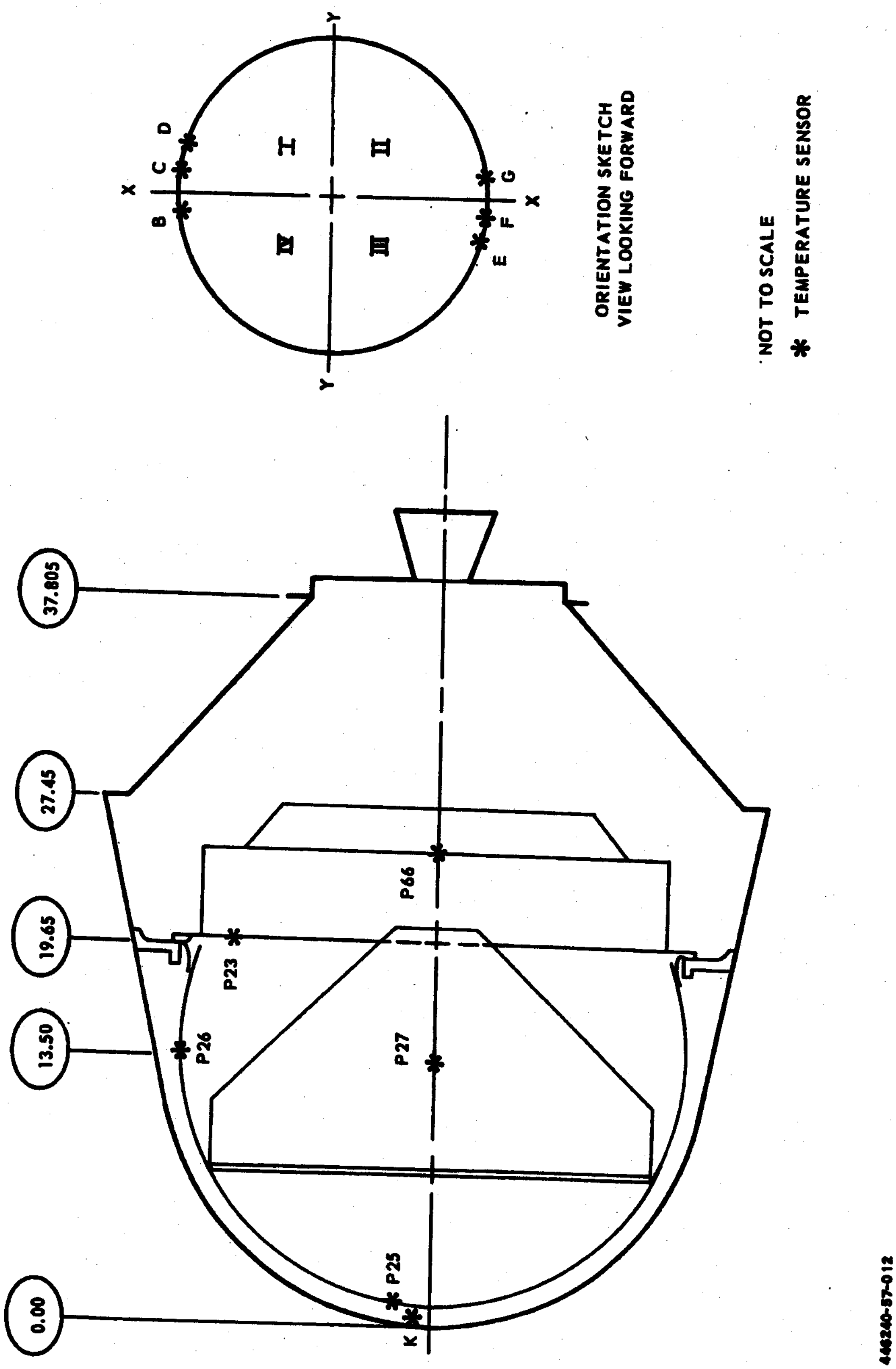
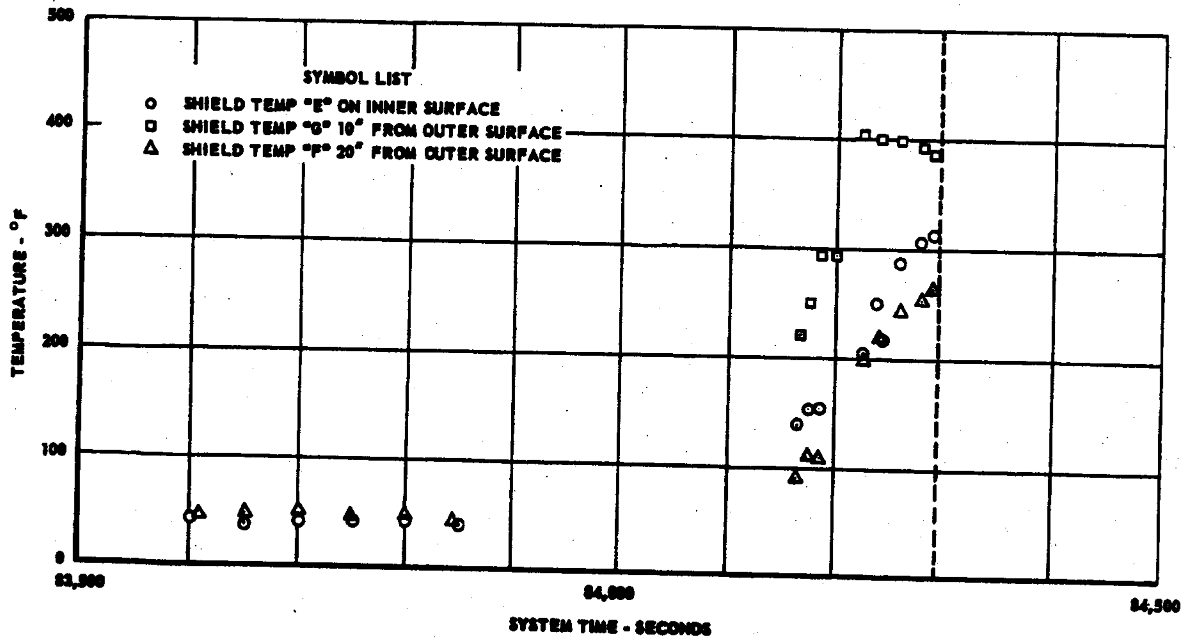


Figure 22 Capsule Temperature Sensor Locations



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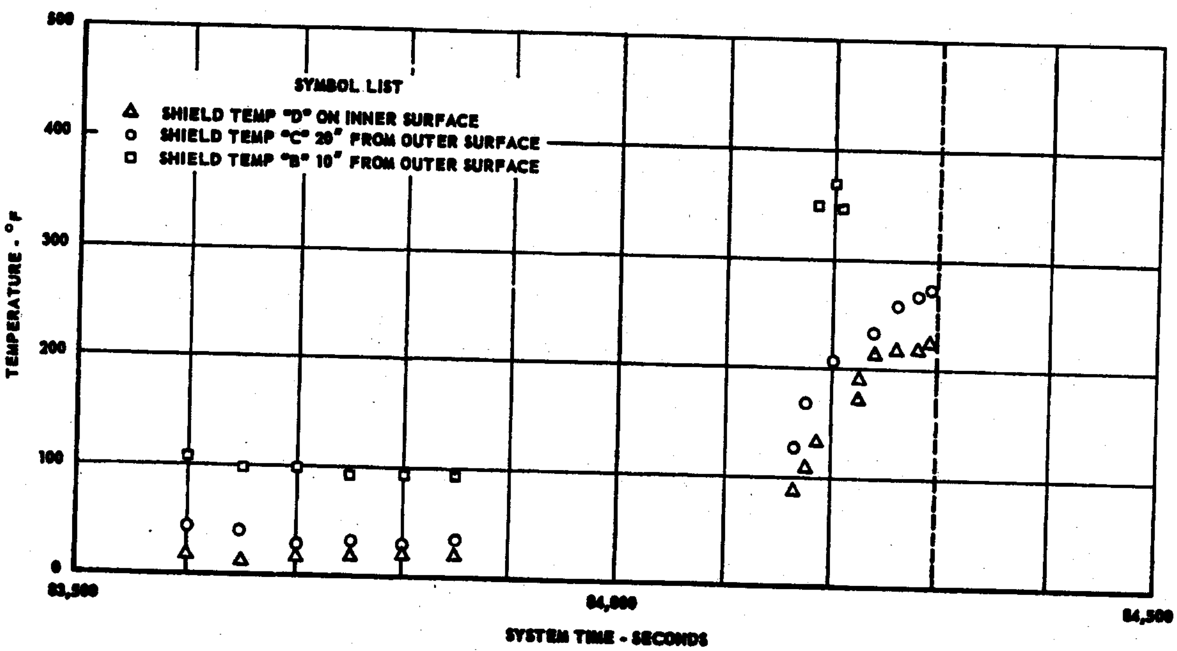

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Figure 23 Capsule Heat Shield Skirt Temperatures

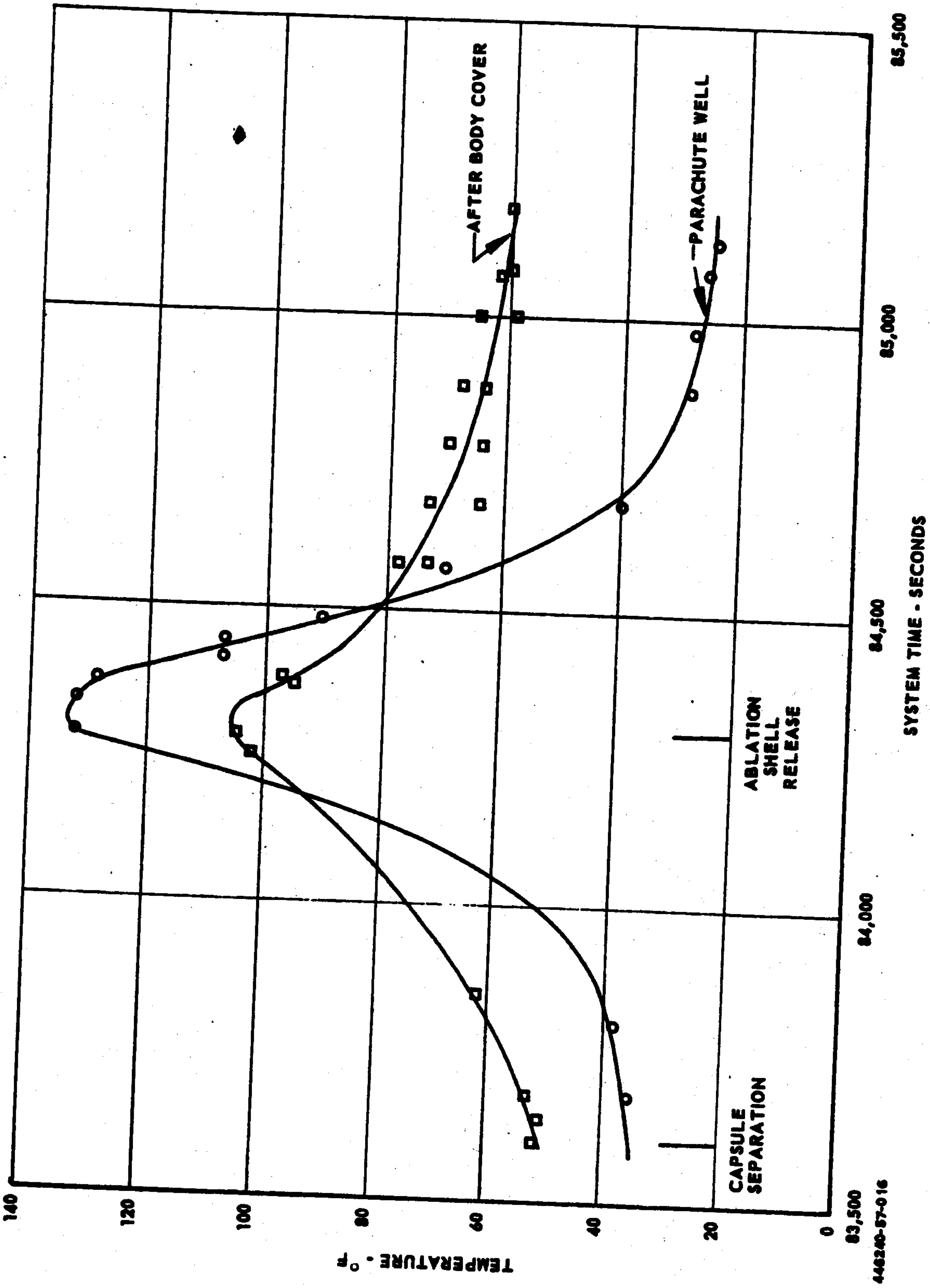

Figure 24 Capsule Temperatures Recorded by Resistance Thermometer

Table 7

CAPSULE TEMPERATURE SENSOR LOCATIONS

Measurement Number	Temperature Measurement	Location X	Location Y	Location Z	Quad	Depth From External Surface (Inches)
P 13	Shield B	13.7	0.3	13.5	IV	.108
P 14	Shield C	13.7	0.4	13.5	I	.204
P 16	Shield E	13.6	1.6	13.5	III	.30*
P 17	Shield F	13.6	0.4	13.5	III	.204
P 20	Shield G	13.6	0.4	13.5	II	.108
P 21	Shield D	13.6	1.6	13.5	I	.30*
P 23	Afterbody Cover	0	12.5	19.6	III, IV	
P 24	Stagnation Point K	2.5	0	1.2	I, IV	
P 25	Bucket	3	0	2	I, IV	
P 26	Bucket	12.8	0	13.5	I, IV	
P 27	Bucket	0	12.8	13.5	I, II	
P 28	Tape Recorder	7	1	10.6	III	
P 29	Beacon	4.5	1.3	9.5	I	
P 30	T/M Battery	2	4.3	9.2	II	
P 66	Parachute Well	0	11.7	22.9	I, II	

* *Assuming no epoxy-polysulfide coating*

Preliminary data reduction indicates the angle-of-attack during significant heating was much lower than assumed in preflight aerodynamic heating analyses. As a result, the effect of angle-of-attack on heating was reduced. Three other factors which could explain the low temperature rise at the stagnation point and skirt are the following:

a. Approximately 0.07 inch of an epoxy polysulfide coating covered the entire external surface of the main heat shield prior to launch. During ascent this coating was probably ablated from the stagnation point region, but it is unlikely that any skirt damage occurred. Therefore, at the start of re-entry, the skirt heat shield was probably thicker than the design value, and the temperature and char sensors were farther from the outside surface.

b. Higher heat-shield performance than previously allowed for, such as lower conductivity, higher heat capacity, and greater fraction vaporized.

c. Lower-than-expected aerodynamic heating at high altitudes due to low atmospheric density, noncontinuum flow effects, etc.

Within the accuracy of available information, all data from the temperature and char sensors appear compatible.

Capsule and Component Temperatures. Temperature data for the bucket and three instrumented components are shown in Figure 25 and 26. Temperature rise experienced during the significant heating portion of the re-entry sequence was negligible. This was to be expected since the bucket is effectively insulated from the shield. After parachute deployment (and jettisoning of the heat shield) at approximately 58,000 feet, the temperature of the bucket decreased rapidly to a minimum of -16°F.

The maximum temperature rise observed was 16°F for the tape recorder during 26 minutes of operation. The higher initial temperatures for the telemeter battery and the VHF beacon resulted from effects of internal heaters installed in these components.

A simplified thermal analysis of the bucket and equipment during re-entry indicates that the equipment temperature rise (excluding thermal batteries)

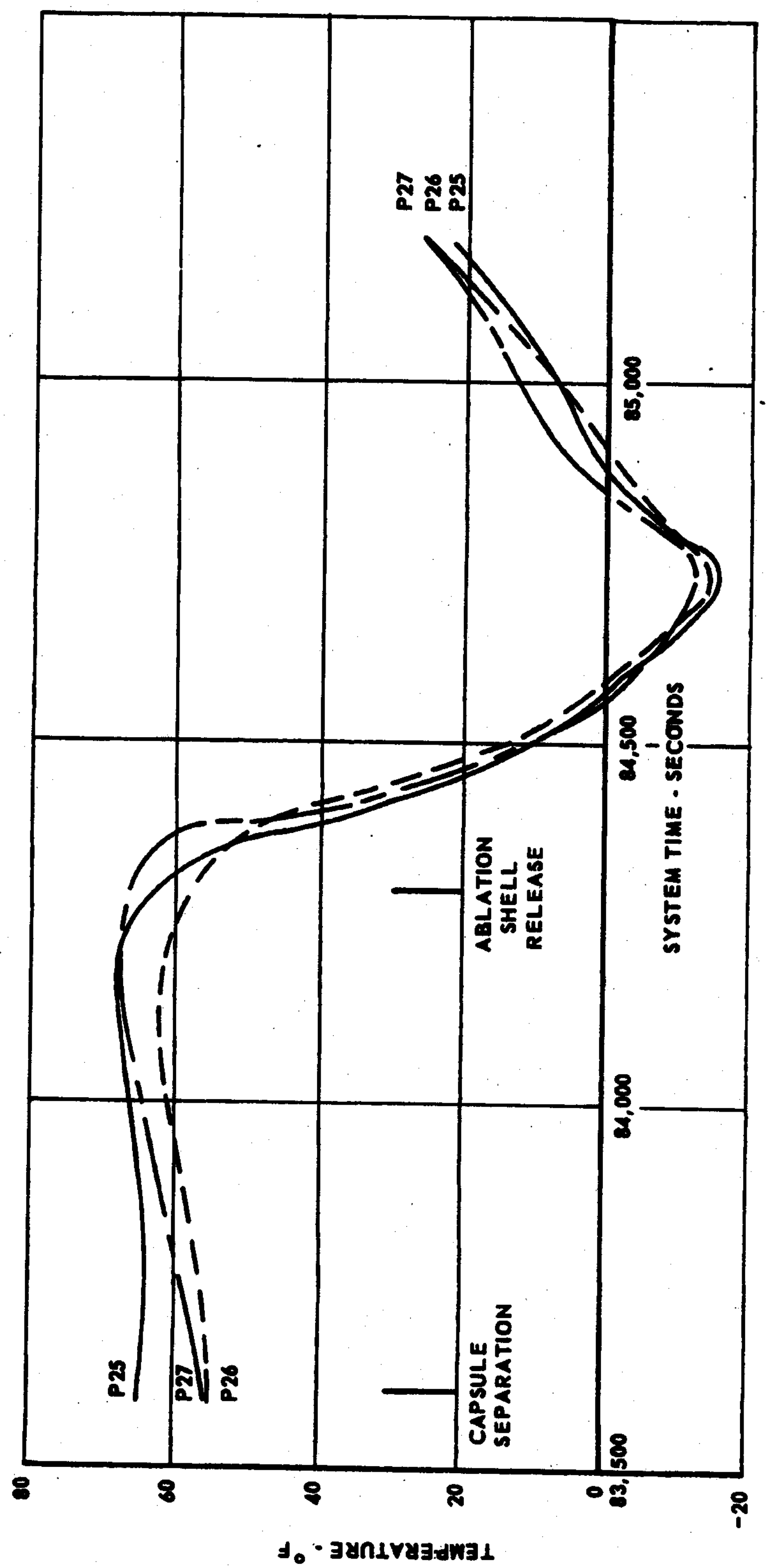

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Figure 25 Capsule Bucket Temperatures

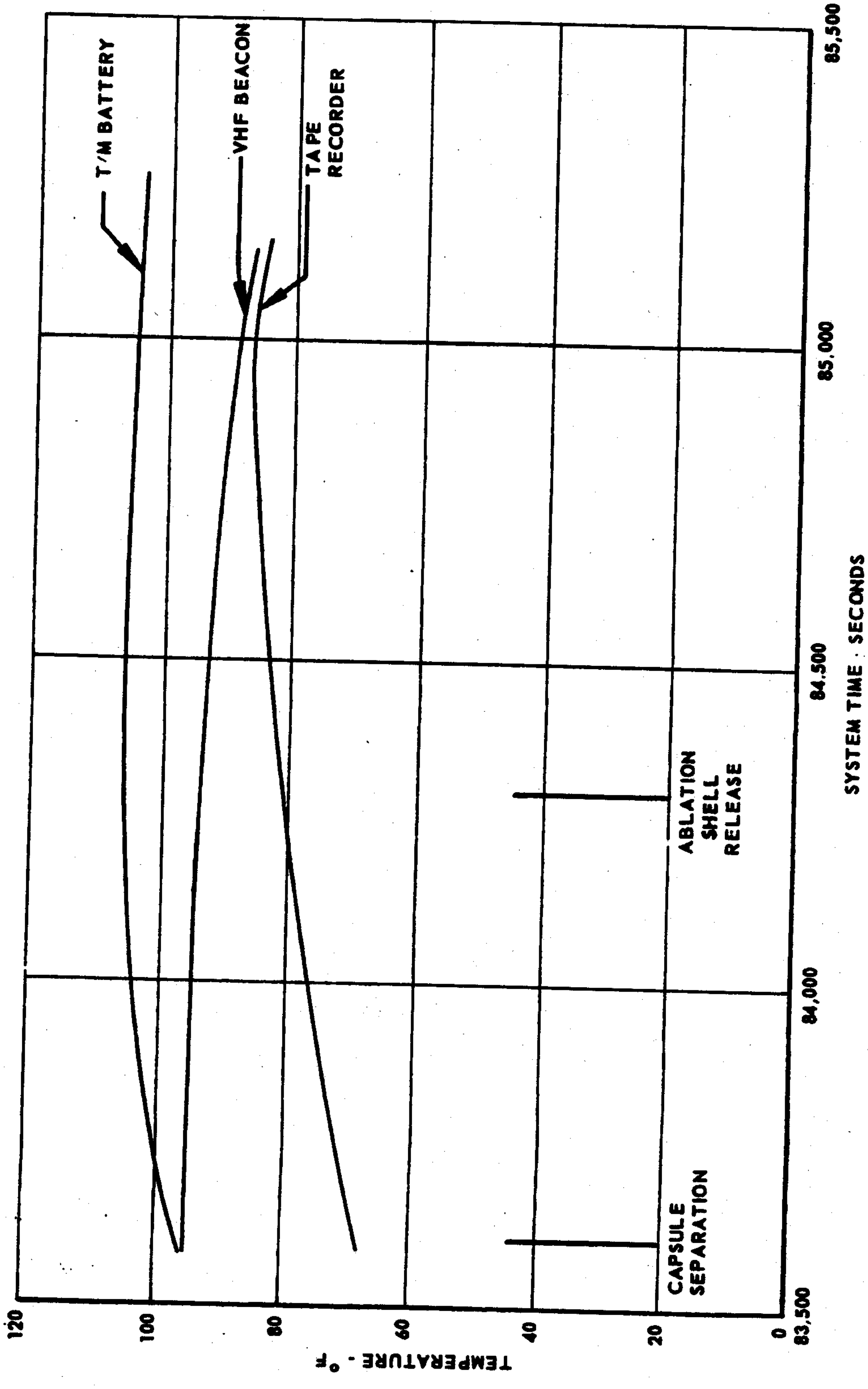

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Figure 26 Capsule Equipment Temperatures would not exceed 30°F for 25 minutes of continuous operation. It also indicates that interior component temperatures were unchanged by bucket transient temperature changes because of the high thermal resistance between the components and the bucket.

PARACHUTE DEPLOYMENT

Although no instrumentation specifically intended to measure parachute performance was installed, some data were obtained from pressure transducers in the recovery capsule. Capsule internal and external pressures were plotted (after parachute deployment) as a function of time as shown in Figure 27. Making use of a standard atmosphere table, the altitude as a function of time was calculated. Differentiation yielded the descent rate versus altitude and time (Fig. 28). The descent rate data were approximately as predicted, as was the altitude of parachute deployment.

The 5g switch closed at System Time 84168. The telemetry data shows the deceleration at this point to be 4.2g's. However, the data are noisy, and the zero level is uncertain. It should be noted that the trajectory simulation shows exactly 5g's at this time.

The mechanical timer switch which initiates the parachute deployment sequence closed at System Time 84296, exactly on time according to the specification value of 128 seconds after the 5g switch closure. From the trajectory simulation, the altitude was computed to be 50,000 feet.

<u>Parachute Impact Point.</u> Figure 29 summarizes the impact points and dispersion areas. The dispersion area with the nominal impact point at 24° N latitude and 158° 54.4' W longitude was for pre-launch. After launch the orbital period and regression rate were established, moving the dispersion area farther west.

The H-timer was adjusted several times during the flight to provide an impact point at 24° N latitude. After Pass 16, tracking data were obtained

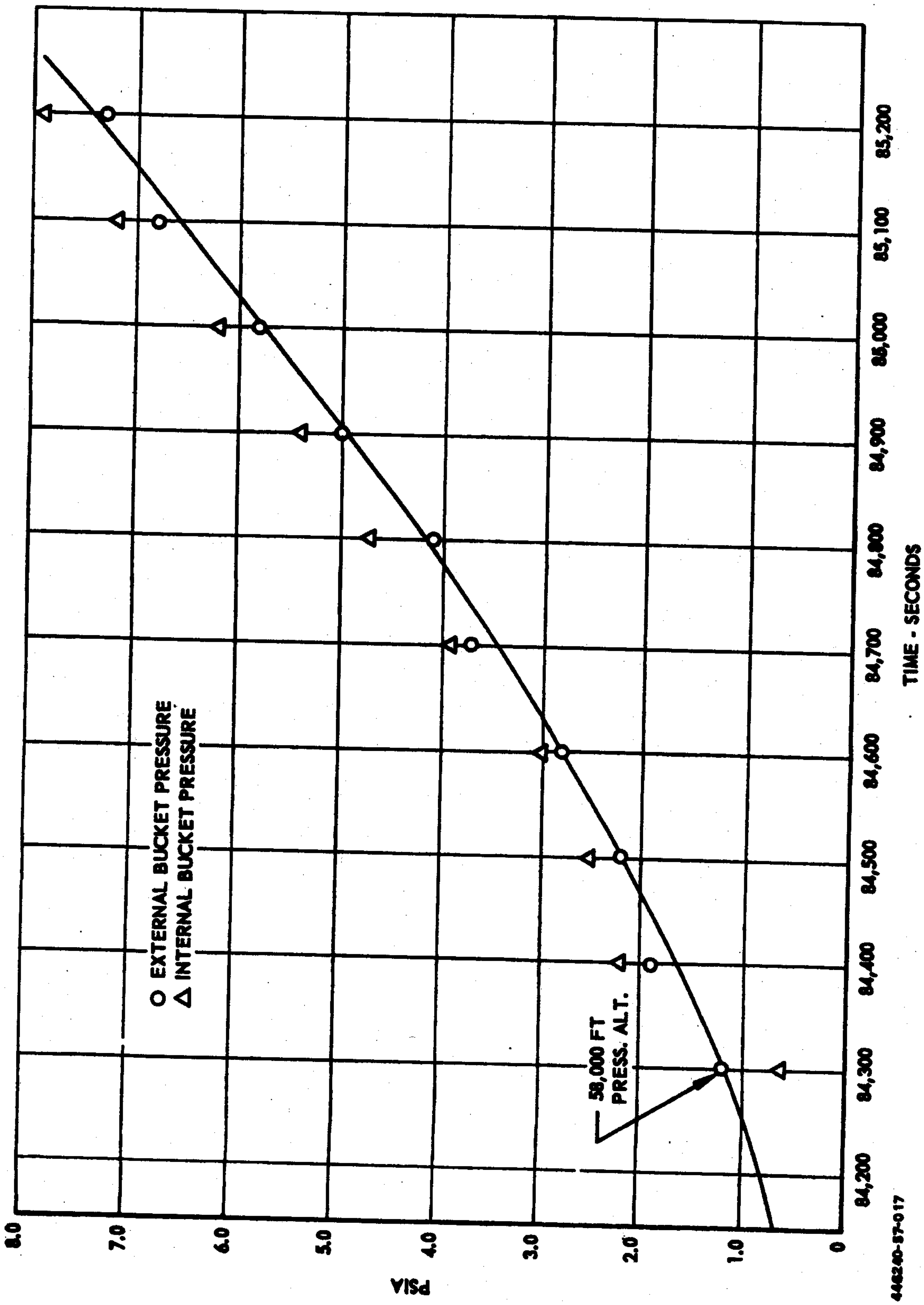

Figure 27 Capsule Pressures During Parachute Descent

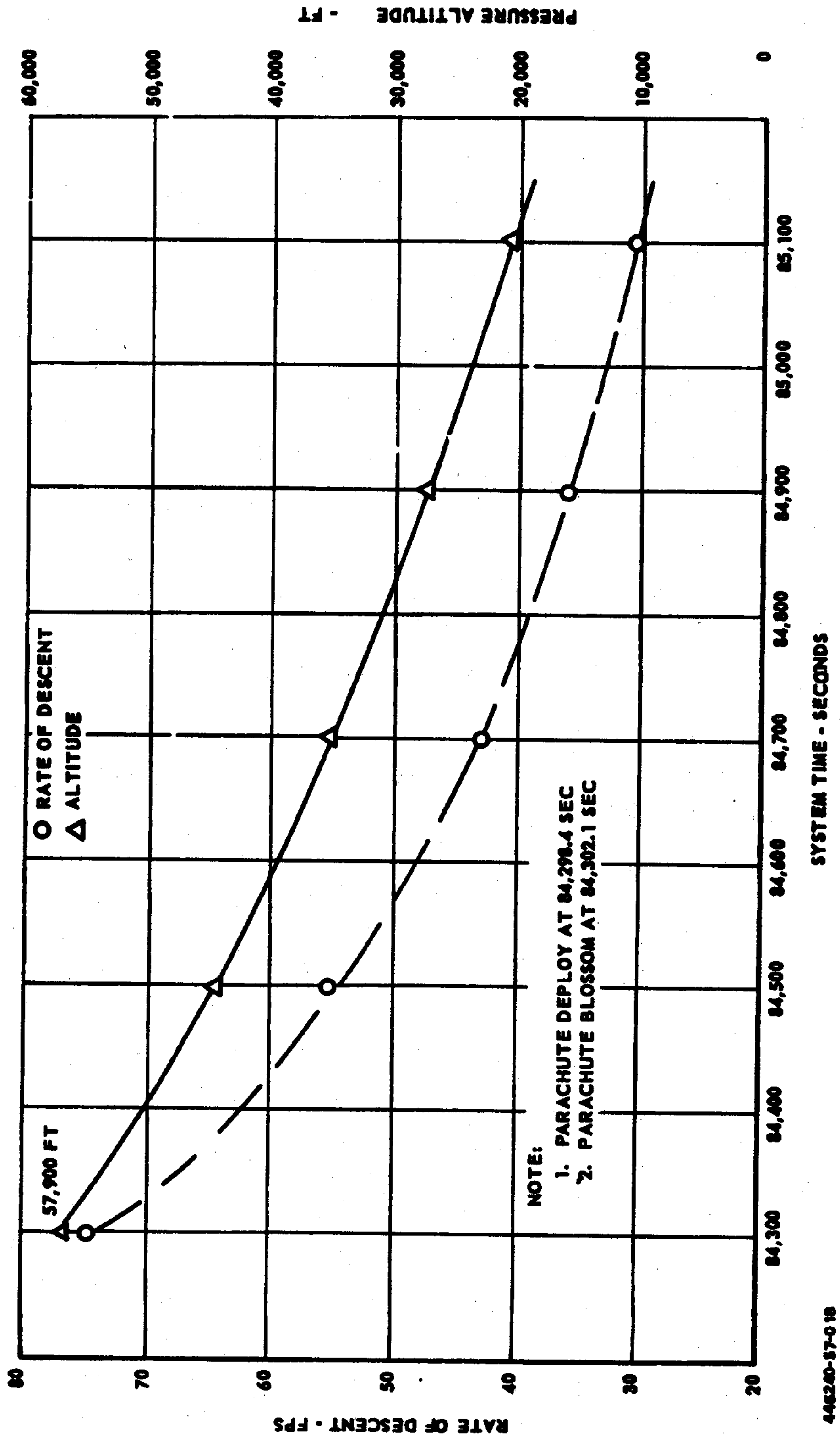

Figure 28 Parachute Rate of Descent

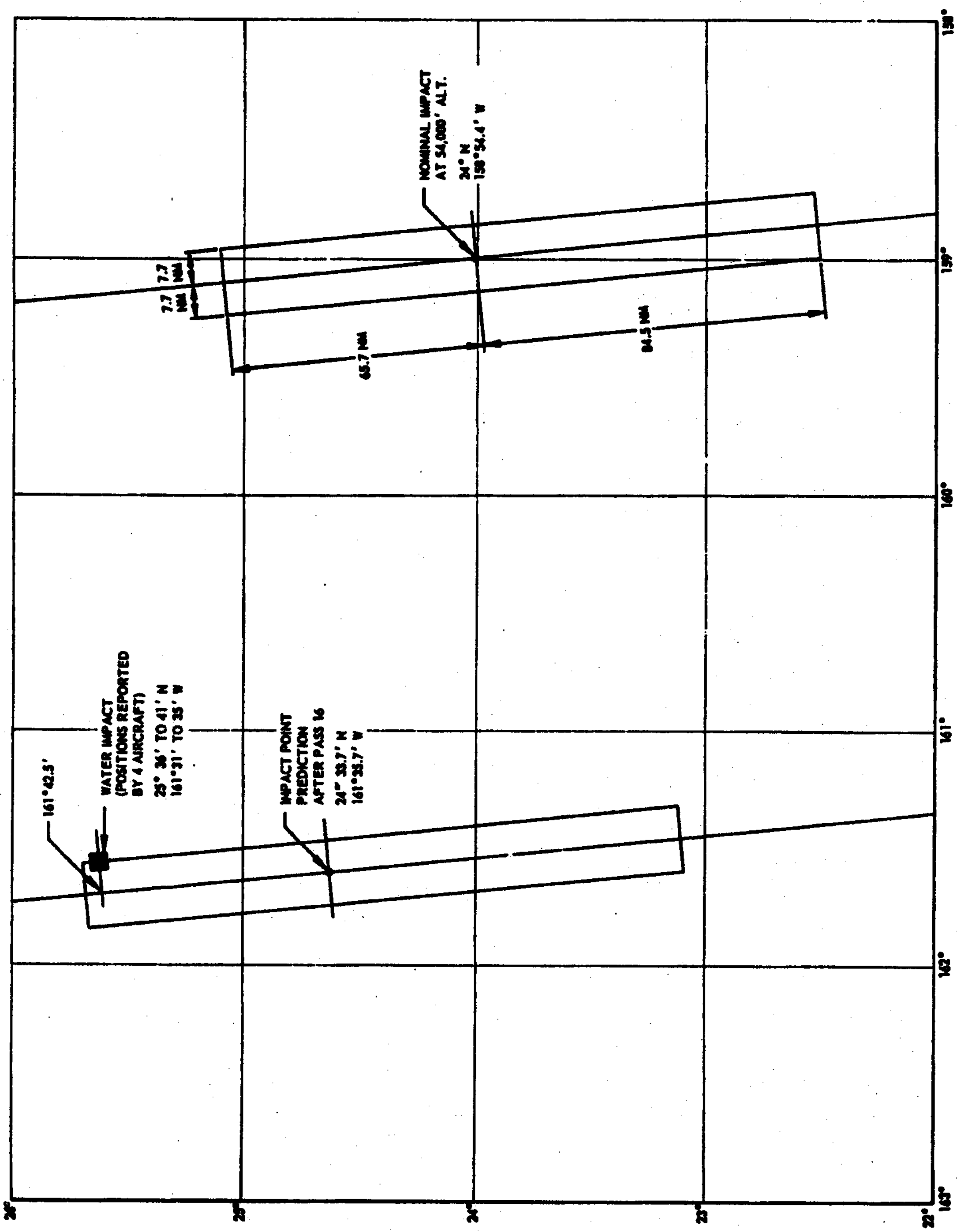

Figure 29 Capsule Impact Points and Dispersion Areas

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and orbit elements were refined. Thereafter, the H-timer could no longer be adjusted. Refinement of these data yielded an impact prediction of 24°33..7'N latitude and 161°35..7' W longitude. Actual water impact occurred at 25°36' to 41' N latitude and 161°31' to 35' W. This point was just inside the northeastern corner of the dispersion box. The time of chute descent from 50,000 feet was approximately 25 minutes. The winds in the recovery area were as follows:

Altitude, ftx 1000	Wind Speed, Knots	Wind From, deg
50	55	260
45	65	260
40	65	260
35	50	270
30	32	250
25	30	250
20	25	230
15	16	200
10	10	200
5	5	060

Normally, these wind speeds would have shifted the impact point east of the predicted. Factors which could have possible caused impact north of the predicted point are being studied.

SECTION 9
CAPSULE TRACKING AND RECOVERY FORCE EVALUATION

PRE-RECOVERY PROCEDURES

The recovery operation was initiated and conducted in a routine manner during pre-recovery phases. All necessary briefings were conducted, and a full Recovery Force was available at the time of the Discoverer XIII launch.

At the time of aircraft deployment from Hickam AFB, one C-119 aircraft aborted its mission due to an oil leak, and one JC-54 could not participate due to a fuel leak. Both aborts were compensated fro in a routine manner by redeployment of the Recovery Force as specified by planning directives.

Changes in predicted impact location after Passes 1 and 2 through Pass 16 were small enough to allow all Force components to deploy properly prior to ETPD. Minor equipment discrepancies were reported prior to ETPD by airborne units, but all malfunctions were satisfactorily corrected prior to ETPD.

CAPSULE RE-ENTRY TRACKING

The flight objective of "To adequately track the re-entering capsule for computed impact point prediction" was attained by the combined tracking of the Agena vehicle prior to separation, tracking of the capsule S-Band beacon, tracking of the telemetry and VHF beacon transmitters, and by radar tracking of the chaff cloud and reflective parachute.

The S-Band Beacon Tracking

The capsule S-band beacon was turned on by the D-timer shortly before capsule separation. The KTS VERLORT radar was actively tracking the Agena vehicle and interrogating the Agena beacon in Code 1 at this time. Prior to separation, the KTS radar was switched to Code 5 interrogation and began active tracking of the capsule beacon. Several data points were received from the capsule beacon prior to separation, four data points were received during the retro phase of the flight, and 68 additional data points were received before KTS lost contact with the beacon.

A total of 34 invalid data points were obtained, indicating that radar tracking was at least 53 percent effective. If only the re-entry points are considered, and the last six are discarded because of low elevation angles, then radar tracking can be considered as producing 59 percent usable data at ranges up to 728 nautical miles.

The radar data were used by the Palo Alto computer facility on two different types of computing programs for predicting the impact point. As the actual time of retrorocket firing was not immediately known, the first calculations were based on a nominal firing time. While the points computed by the two methods agreed favorably with each other, they were 75 nautical miles from the actual impact point. Later computations were made using the correct retrorocket firing time, and the errors were measurably less. Other computations were made by combining the HTS TLM-18 tracking data with the radar data and the error was again decreased. Final computations were made by selecting only the best quality radar data and the predicted impact point was approximately 15 miles from actual water impact. The computed impact points were of no value to the Recovery Force in this operation, however, if a correct retrorocket firing time is known, the computations can be made in 15 to 25 minutes.

HTS did not acquire the capsule S-band beacon. That station's VERLORT radar searched for the capsule beacon in Code 5 interrogation from System Time 83965 to 84140. The radar was then switched to Code 1 interrogation and tracked the satellite at System Time 84156. Assuming that the thrust cone which contained the beacon had maintained the same re-entry path which the capsule followed, the thrust cone and beacon would have been located 552 nautical miles from Hawaii at the time the radar stopped searching for the capsule beacon. The capsule was at an elevation of 220,000 feet above the earth's surface at this time, and the elevation angle from HTS was -0.89 degree. The extreme range and unfavorable elevation angle would have prevented HTS from acquiring the capsule beacon if it was transmitting at this time.

Telemetry Transmitter Tracking

The capsule's telemetry transmitter was received by KTS, the northern WV-2 aircraft, BSTS, HTS, and the Haiti Victory. All retro-phase events were observed by both KTS and the WV-2 aircraft, and the first report of contact near the recovery area was from BSTS. BSTS reported contact at Systems Time of 84200, HTS at 84201, and the Haiti Victory acquired a strong signal at 84280. HTS conducted antenna lobing tests immediately after acquisition, and the signal was strong enough to provide usable data at approximately 30 seconds after acquisition.

The HTS TLM-18 tracking data proved to be highly useful in later re-entry computations, however, the BSTS aximuth information was found to be in error by approximately 8 degrees. At the time HTS acquired the signal, the slant range was 360 nautical miles, the capsule was 135,000 feet above the earth's surface, and the elevation angle from HTS was 0.5 degree. When HTS acquired strong signals 30 seconds later, the slant range was 324 nautical miles, the capsule was at an altitude of 102,000 feet, and HTS's elevation angle was +0.26 degree. Insufficient information exists for accurate calculation of a re-entry radio blackout region for this recovery operation. One factor which may have prevented the ground stations from acquiring the signal sooner is the possibility of poor capsule antenna orientation. A projection of telemetry data indicates that the capsule was at a zero spin rate approximately 100 seconds prior to acquisition by the ground stations and, if the antenna was at an unfavorable angle at this time, little energy would be radiated toward the ground stations.

VHF Beacon Tracking

Signals from the VHF beacon were received by KTS, HTS, BSTS, the Haiti Victory, and by all C-119/C-130 aircraft of the Recovery Force. However, HTS successfully tracked the beacon for over 1,500 seconds. Class A contacts were reported by the Haiti Victory and by six of the RC-119 aircraft, some of which were approximately 200 nautical miles from the capsule. Contact was not made by one RC-119 which was approximately 250 nautical miles from the capsule. All stations reported that the frequency of the beacon was approximately 1 megacycle above nominal while the capsule was in the air. The frequency of the beacon was found to have shifted upward an additional six megacycles after the capsule entered the water. Tracking of the VHF beacon was highly successful.

Chaff Cloud and Parachute Tracking

The chaff cloud and the parachute were successfully tracked by the SPS-8A radar aboard the Haiti Victory. This radar, operating at a frequency of approximately 3500 megacycles, acquired the chaff cloud first and observed the parachute a short time later. This tracking was accomplished at a range of approximately 100 nautical miles, and the two targets were separately distinguished. The chaff cloud was tracked for a total of approximately 45 minutes, and the parachute was tracked from shortly after deployment until it descended below the radar horizon.

The RC-121 Command aircraft (No. 1, Figure 5) was approximately 130 nautical miles from the point of parachute deployment but was unable to positively identify the target by radar. The effectiveness of the aircraft radar was seriously hampered by the heavy clouds at altitudes up to 24,000 feet. This aircraft remained on station and received radar information in the form of azimuth, elevation, and range from the Haiti Victory. This information was plotted on charts and used to direct other elements of the Recovery Force. The radar information was later proven to be accurate to within two miles of the actual water impact point.

CAPSULE TELEMETRY DATA ACQUISITION

The only surface stations to acquire the capsule telemetry were KTS, HTS, BSTS, and Haiti Victory. (KTS performance is discussed under re-entry). No other surface stations and no airborne units acquired the capsule telemetry due to the northerly impact of the capsule. The JC-54 No. 1 aircraft acquired a signal on a frequency of 223.2 MC, which was recorded, but it was an extraneous signal. Christmas Island reported one capsule beacon acquisition, which was probably an extraneous signal. The Dalton Victory recorded a signal which was subsequently proven to be the Agena telemetry. HTS and Barking Sands tracked and recorded the capsule transmissions on a triangulation basis for 520 seconds. The stabilized bearing of HTS (after capsule parachute deployment) was in a direct line with the descending capsule. The Barking Sands data, however, was 8 degrees in error. After loss of signal by Barking Sands, HTS continued to track the descending capsule until 85790 System Time. The Haiti Victory tracked and recorded capsule transmissions during the recovery phase. The bearing information from the ship appears to be accurate despite the limitations of its azimuth indication system. The WV-2 aircraft obtained a DF bearing that was almost directly in line with the point of final impact.

OPERATION OF RECOVERY FORCE AIRCRAFT

The chaff was not radar acquired by the searching RC-121 aircraft. After initial acquisition of the capsule's beacon by the C-119 aircraft, RC-121 No. 1 observed an occasional, poor-quality radar return in the impact area. This could have been return from the metallized parachute since the combination of the extended distance of the aircraft from the parachute and the small reflective area of the parachute would produce a poor radar target. The return was not of sufficient strength to warrant recording.

The capsule beacon operated well. It was recorded by all C-119 aircraft, the C-130 aircraft, one Victory ship, HTS, and Barking Sands. Because of the negative chaff reports, the beacon was the primary means of vectoring to the impacted capsule. No problems were encountered, and the C-119 counterpart (FLR-2 equipment) of the capsule VHF beacon was sufficiently accurate to bring the aircraft into the proximity of the capsule. Then, by maneuvering, the aircraft were able to home directly to the capsule.

C-119 No. 1 experienced a saturated signal upon initial contact. Reports indicate that reducing the receiver gain failed to alleviate the condition. Because of this, and because of an RC-121 possible target, the aircraft was vectored to the possible target, which proved to be a towering cumulus cloud. The C-119 was then able to obtain a bearing on the beacon signal and home on it -- too late for an aerial recovery.

At acquisition (and saturation), the C-119 was 24 nautical miles from the final impact point. The errors involved were twofold: (1) The C-119 did not report its acquisition and saturation signal, and (2) In error, the RC-121, knowing the bearings of all the other force components, sent C-119 No. 1 to the nebulous target 90 degrees from all other reported bearings. Had the status of the C-119 signal been known, the RC-121 would have been less likely to send the C-119 to the west, since the C-119 was probably nearly under the descending capsule.

Capsule beacon bearings were recorded from distances of 600 nautical miles (Class A bearings from 500 nautical miles while the capsule was in the air) and from 60 nautical miles while in the water. The flashing lights operated satisfactorily and were seen from 1/2 nautical mile and 300 feet altitude while the capsule was in the water. The impacted capsule and parachute were sighted from 7 1/2 nautical miles and 1,000 feet altitude.

One of the two RADARCs dropped at the point of impact resulted in Class A beacon bearing. Several smoke bombs were also dropped in the area as markers.

RECOVERY AIRCRAFT COMMUNICATIONS

Communications during the operation were generally good. The single-sideband installations in the RC-121 aircraft were not at their optimum level of operation, although they were workable. Operator inexperience was probably the cause for this. The sets were turned off for most of the operation; thus, the capability could not be thoroughly checked. Some extraneous communications were noted during the early stages of the operation between the RC-121 and C-119 aircraft. Since most of the RC-121 crews were relatively or completely new for this operation, it is presumed that their unfamiliarity with procedures caused the circuit overloads. With increased operator knowledge and familiarity with the recovery operation, these problems should diminish.

PAYLOAD RECOVERY

The 11 August recovery of the Discoverer XIII Agena 1057 recoverable capsule was the first successful recovery of a Discoverer Agena payload from orbit. The recovery was basically successful in all aspects, with the exception of intended aerial recovery. However, water retrieval was satisfactorily accomplished.

OPERATION OF SURFACE RECOVERY UNITS

The Dalton Victory was not called upon as a recovery unit because of its remote position with respect to the impact point. The Haiti Victory, the recovering ship, headed for the impact point immediately upon capsule signal acquisition. Because of the distance from the ship to the capsule, the two helicopters aboard were sent to retrieve the capsule from the ocean. Capsule retrieval and return to the ship were routinely accomplished.

WEATHER CONDITIONS DURING RECOVERY

Data obtained from commercial aircraft passing through the recovery area prior to Force deployment indicated that weather in the area might be worse than predicted. During recovery, weather in the northern area was generally as forecast except for the middle layer of clouds. Weather in that area consisted of low, scattered clouds from 2,000 to 4,000 feet, middle-layer clouds broken to overcast from 10,000 to 14,000 feet, and high, broken clouds from 35,000 to 40,000 feet. Visibility in the area was 10 to 15 nautical miles, rain showers were reported, and cumulus buildup to 22,000 feet was encountered on the western edge of the area. This limited somewhat the effectiveness of the C-119 and RC-121 aircraft. No inversion layers were reported in the area by the RC-121 aircraft. Cloud buildup produced return on the RC-121 radar system, which made searching for capsule chaff difficult because of scope clutter and because of the similarities between cloud and chaff radar return. The C-119 aircraft were not seriously handicapped by the weather, although it did reduce their altitude visibility. Flying under the clouds required too low an altitude (1,500 feet in some instances).

Weather in the southern area was excellent as was forecast. Wind conditions have been described in the paragraph discussing parachute deployment.

OPERATION OF HAWAII CONTROL CENTER

Operation of the HCC was normal, and control of the Force was exercised at all times. The Center was occasionally burdened by the excessive number of personnel required for its operation. This is due mainly to the increased complexity of the diagnostic recovery configuration and should be alleviated when normal operations are resumed and some of the special tasks imposed upon the HCC are eliminated.

Codes used for the operation were in some cases dropped in favor of clear text messages between the HCC and STC. This is a compromise which will undoubtedly be eliminated during future operations.

Debriefings were generally accomplished satisfactorily, although some were delayed by conflicts with other briefing. Others were delayed by expected conflicts caused by news conferences being conducted at the same time as the technical debriefings.

Only limited information on capsule condition was obtained. This was due to the immediate departure of the capsule's courier from Hawaii after the capsule's arrival from the Haiti Victory. Immediate technical inspection of the capsule, as required by Discoverer planning documents was, therefore, not accomplished.

SECTION 10
GROUND SYSTEMS EVALUATION

Ground system elements satisfactorily accomplished prelaunch, launch, ascent, orbit, and recovery operational functions. Tracking and telemetry data obtained by the tracking stations during the operation were of good quality for on-line evaluation, orbital computations, and post-flight analysis.

SATELLITE TEST CENTER

System operations were well conducted by the STC. Direction of launch, orbit, and recovery operations by the System Test Director was efficient.

The voice communication and 60 wpm lines were intermittent between the STC and KTS (outages at several random points) during the countdown and through the remainder of the day. A list of malfunctions appears in Appendix Table A. 7.

Minor coordination problems concerning the allotment of the teletype communication channels from KTS to the PACC during recovery operations were quickly resolved, and no serious loss of time or information resulted. All re-entry and recovery events were adequately reported to the System Test Director over the telephone and 60 wpm lines.

Communication procedures and the use of code words for security reasons did not seriously degrade information flow from KTS, HTS, HCC, and the STC as has been reported following previous operations.

SYNCHRONOUS OPERATIONS ANALYSIS

The Synchronous Operations Analysis (SOA) area in the STC and PACC was manned at T-1 hours. Times of important launch events were converted to System Time and visually displayed for the Test Director. After the orbital injection parameters and first pass KTS acquisition information were received, the Pass 1 timer commands were prepared and sent to the Test Director. KTS successfully transmitted the four STEP commands, as determined by the SOA. The SOA verified the various ETPD predictions as generated by the PACC. The proper recovery pass position of the northerly WV-2 aircraft was issued after Pass 2. Orbital timer drift was determined to be negligible.

The SOA recommended that an alternate acquisition message be issued on Pass 15. This required that a reset command be given 62 seconds before reset latitude was reached. Issuance of the final pre-recovery pass ETPD prediction was authorized by the SOA after the final orbital timer adjustment had been made on Pass 16. The SOA utilized KTS, HTS, and BSTS angle tracking data to generate the last two ETPD predictions. Sightings by the Haiti Victory and C-119 and WV-2 aircraft were employed to determine the final prediction. These predictions were relayed to the HCC. Overall performance of the SOA was highly satisfactory.

PALO ALTO COMPUTER CENTER

The computer facility at Palo Alto was successfully utilized during prelaunch, orbit, and re-entry operations. Readiness tests were conducted and all systems were reported as being ready.

Launch data was received from MTS and VTS, with the MTS data used to predict acquisition times for Pass 1. Based on launch data, the period was predicted to be 92.3 minutes. After Pass 1, this was revised to 94.1 minutes. (This error is attributed to a temperature inversion which affected the radar data.)

All predictions and acquisition messages were available at least 50 minutes prior to station acquisition, an improvement over previous operations.

The re-entry trajectory and impact area were predicted accurately and the data were used to deploy effectively the Recovery Force. The time for retro ignition had to be assumed as nominal due to lack of an immediate precise time. The re-entry data from KTS was used to predict the impact point. The data from HTS could not be used due to extremely low elevation angle of the orbiting Agena. The computer predicted the impact point at 50,000 feet altitude, which was only 49 minutes of latitude from where the capsule was recovered from the water.

HUMAN FACTORS

Personnel performance was monitored by human factor engineers at VTS, KTS, and at the STC. No problems of note were reported.

TRACKING STATIONS

Tracking station performance was excellent. Specifically, all pre-recovery commands were successfully transmitted, received, and verified; no difficulty was encountered in commanding the Agena; see Appendix Tables A. 8 and A. 9. VERLORT and TLM-18 tracking data were of high quality, a result of a stable satellite attitude and properly operating radar beacon and telemetry transmitter. The quality of the space position data generated by the tracking station network is indicated in Appendix Table A. 10.

Launch and orbit telemetry coverage was satisfactory for evaluation of Thor and Agena performance. Usable data on launch was received from liftoff until T + 784 seconds. Figure 30 shows VERLORT and telemetry coverage during launch and ascent. Orbital contacts, acquisition and fade times, and duration of tracking for each station on all passes through Pass 32 are summarized in the Orbital Contact Summary, Appendix Table A. 11.

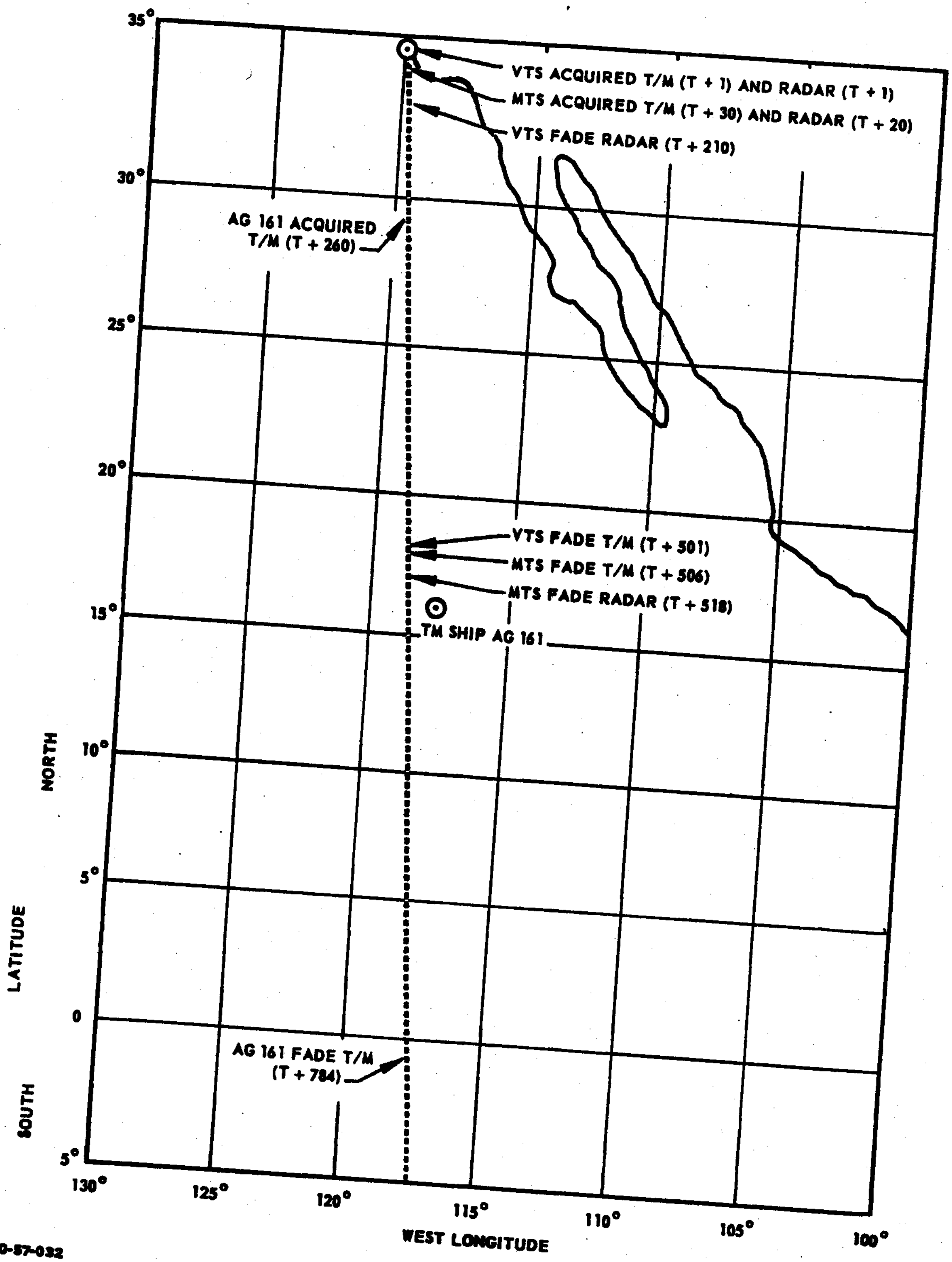

Figure 30 ***VERLORT*** *Radar and Telemetry Coverage, Launch and Ascent Phases*

Contact with the capsule S-Band beacon was achieved by KTS only. Recovery telemetry data was successfully received and recorded by KTS, HTS and BSTS, with supplementary coverage provided by the WV-2 aircraft stationed under the capsule separation point. Capsule telemetry signal strength was strong, as opposed to previous operations. Tracking station coverage of the capsule transmitters is shown on Figure 31. A uni-helix antenna and ground station facilities at LMSD Sunnyvale made near real-time evaluation of vehicle functions possible during launch and Pass 15. Telemetry data was also monitored at stations located at Holloman AFB, Van Nuys, Calif. and New Boston, New Hampshire.

Vandenberg Tracking Station

Tracking station operations were successfully carried out by VTS during launch and subsequent orbit operations. Active VERLORT radar contact was maintained until T + 166 seconds, when the radar became passive as planned. The VERLORT then tracked on MTS return until T + 516 seconds, when fade occurred at an elevation of 0.079 degree and an azimuth of 179.7 degrees. A synchronization problem between the VTS VERLORT radar and range safety radar resulted in 50 percent "beacon countdown" prior to launch, as shown in Figure 32. The "beacon countdown" resulted in re-cycling of the terminal countdown until synchronization was achieved. Countdown was observed at regular intervals throughout the duration of track, starting at T + 120, as shown in Figure 32. Telemetry tracking and data acquisition was successfully carried out by both the TLM-18 and the Tri-Helix antennas. Orbital contact was achieved on Passes 1, 8, 9, 15, 16 and 30. For Pass 15, VTS had been designated by the STC to actively track. However, VTS had difficulty in obtaining radar lock; the beacon return indicated that it was in the wrong range gate. Since VTS was having difficulty, STC directed MTS to go active and VTS to go passive. Records show that VTS was locked on for approximately 60 seconds before being directed to go passive. MTS obtained angle lock but was one range sweep off at the time of acquisition due to the acquisition programmer tape being

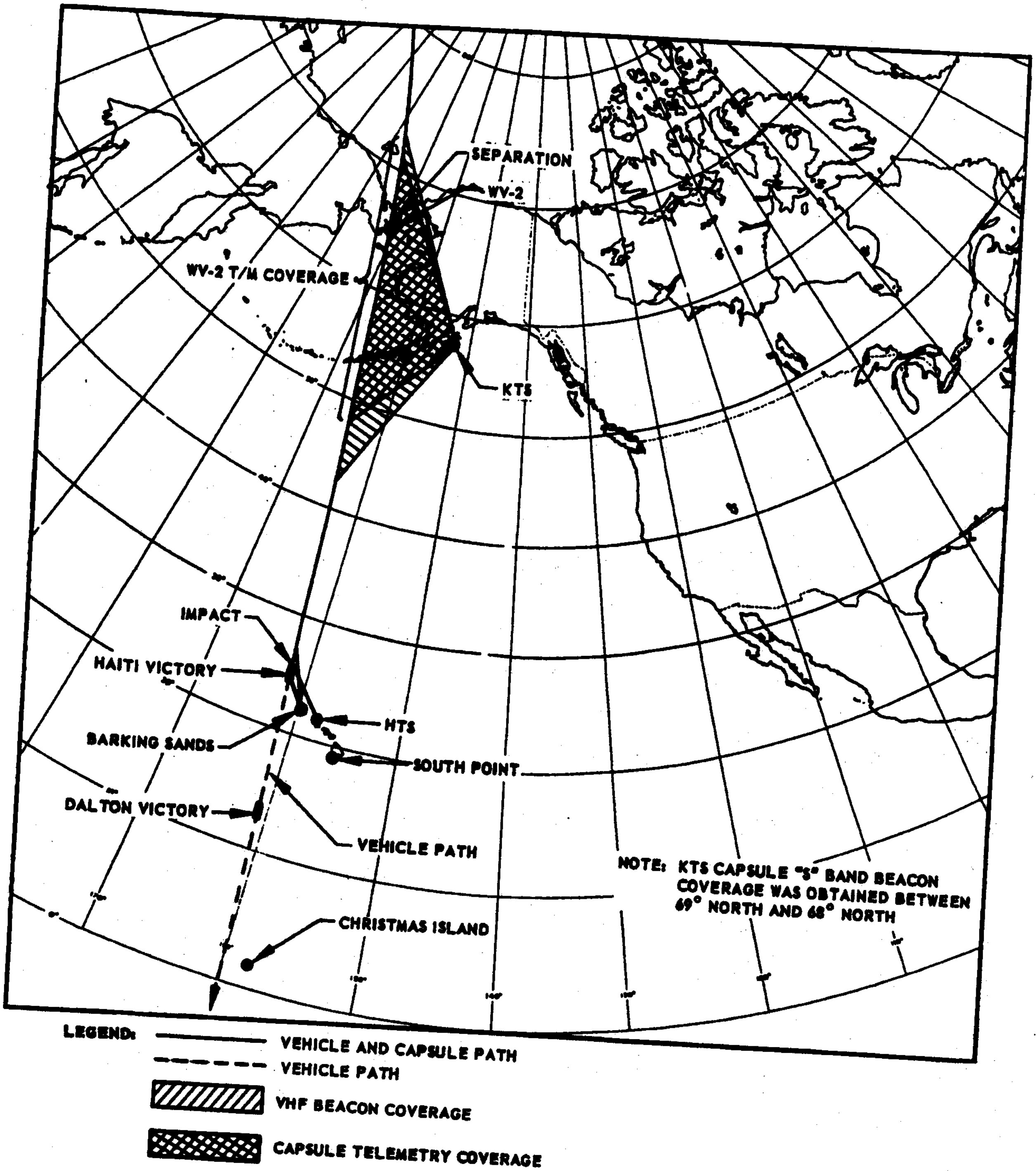

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Figure 31 Tracking Station Coverage

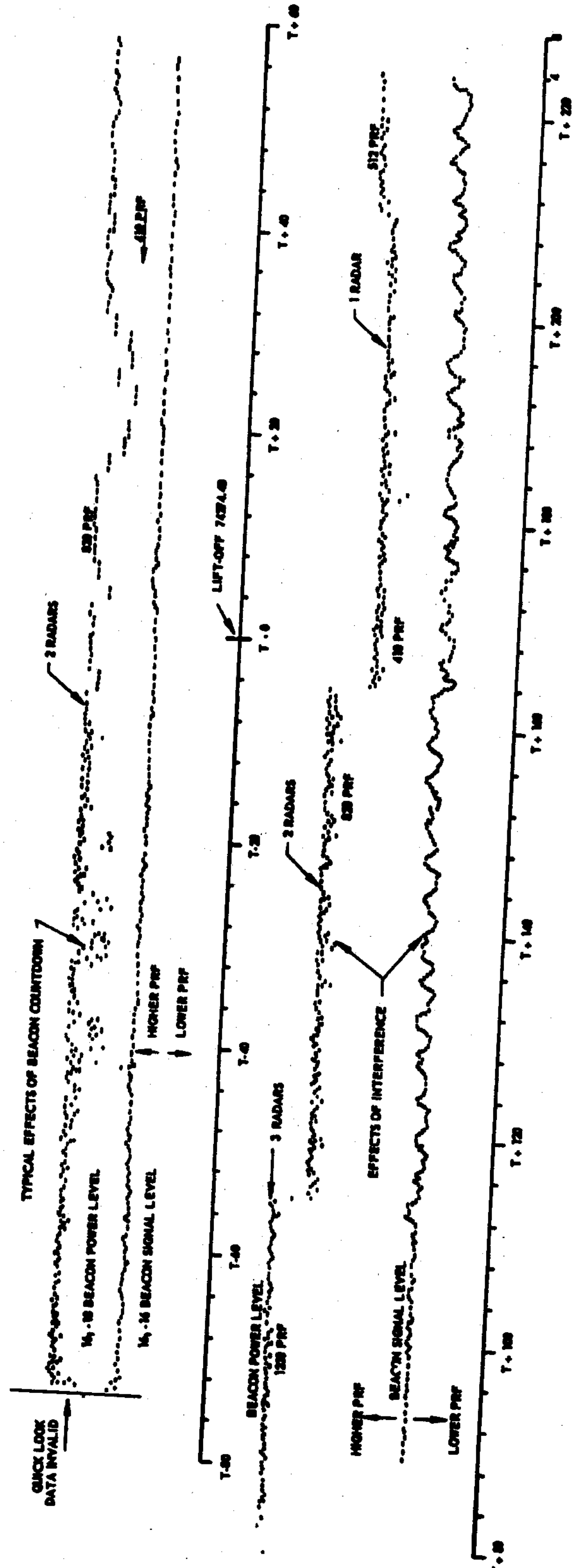

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Figure 32 ***Effects of Synchronization and Interference on Radar Beacon During Launch***

slightly in error. Proper lock-on was not obtained until a short time before the beacon was turned off. Radar track was unsatisfactory for these stations during Pass 15. Out of 123 points of VTS TLM-18 data transmitted to PACC, 55 points were useable for updating the ephemeris.

Point Mugu Tracking Station

Performance of station equipment was satisfactory at MTS during launch and subsequent orbital passes. Radar beacon returns were acquired 20 seconds after liftoff, automatic track was achieved at T + 41 seconds, and contact maintained until T + 518 seconds.

Commands 5 and 6 were properly computed and transmitted for durations of 50 and 13 seconds respectively. No radar interference occurred during the track.

Orbital tracking was also maintained on Passes 8, 9, 15, 16, but the station had difficulty obtaining active radar lock-on during Pass 15 and did not obtain solid lock-on until a few seconds before the plates were turned off.

No radar acquisition was achieved on Pass 16 due to the satellite's low elevation angle.

Downrange Telemetry Ship

Performance of the downrange AG-161 telemetry ship was satisfactory during launch operations. Telemetry contact was achieved at T + 260 and sustained until T + 784. The ship provided positive verification of successful Agena reorientation (yaw-around) and +3.55 deg/min pitch rate.

Kodiak Tracking Station

Performance of KTS during orbit and recovery operations was superior. KTS verified that the Agena had achieved orbital status by acquiring the CWAT 87.8 minutes after launch. Orbital contact was obtained during all scheduled passes (Passes 1, 2, 9, 10, 16, 17, 24, 25, 31 and 32). All equipment functioned normally except for the ART, (Automatic Range Tracking) unit which was replaced after Pass 2 due to "jitter" in range.

Tracking was satisfactorily accomplished on all scheduled passes, although CWAT signal strength was reported low on several passes.

On Pass 17, KTS VERLORT radar interrupted the satellite's S-band beacon for approximately 70 seconds to 83630 System time, changed their pulse code spacing from one to five, acquired the capsule's S-band beacon approximately 12 seconds later and tracked it for approximately 235 seconds before signal fade. KTS acquired the capsule's telemetry signal for 352 seconds before fade. A time history of raw polar data (azimuth, elevation, and range) generated by KTS as the station tracked the capsule S-band beacon is shown in Figure 33.

Post-recovery passes tracked were utilized as command exercises. Tracking was terminated after Pass 32 to prepare for Discoverer XIV operations. For the first time, Agena telemetry data were transmitted from KTS to LMSD Sunnyvale by telephone line. Data from two commutated Agena channels were transmitted after Pass 2, and data for the same channels plus capsule Channels 18 (commutated) and 13 (continuous) were sent after Pass 17. Transmitted data were of generally good quality, although coded time was somewhat noisier than expected. Within two hours after KTS acquired the vehicle on Pass 17, reduced capsule telemetry data were delivered to LMSD test evaluation personnel in Sunnyvale. This method will be utilized on subsequent operations.

Hawaii Tracking Station

The performance of HTS was satisfactory. During the recovery pass, HTS made contact with the capsule in telemetry and VHF beacon transmitters, but no contact was made with the capsule's S-band beacon. Total duration of contact with the capsule telemetry was 589 seconds; with the beacon it

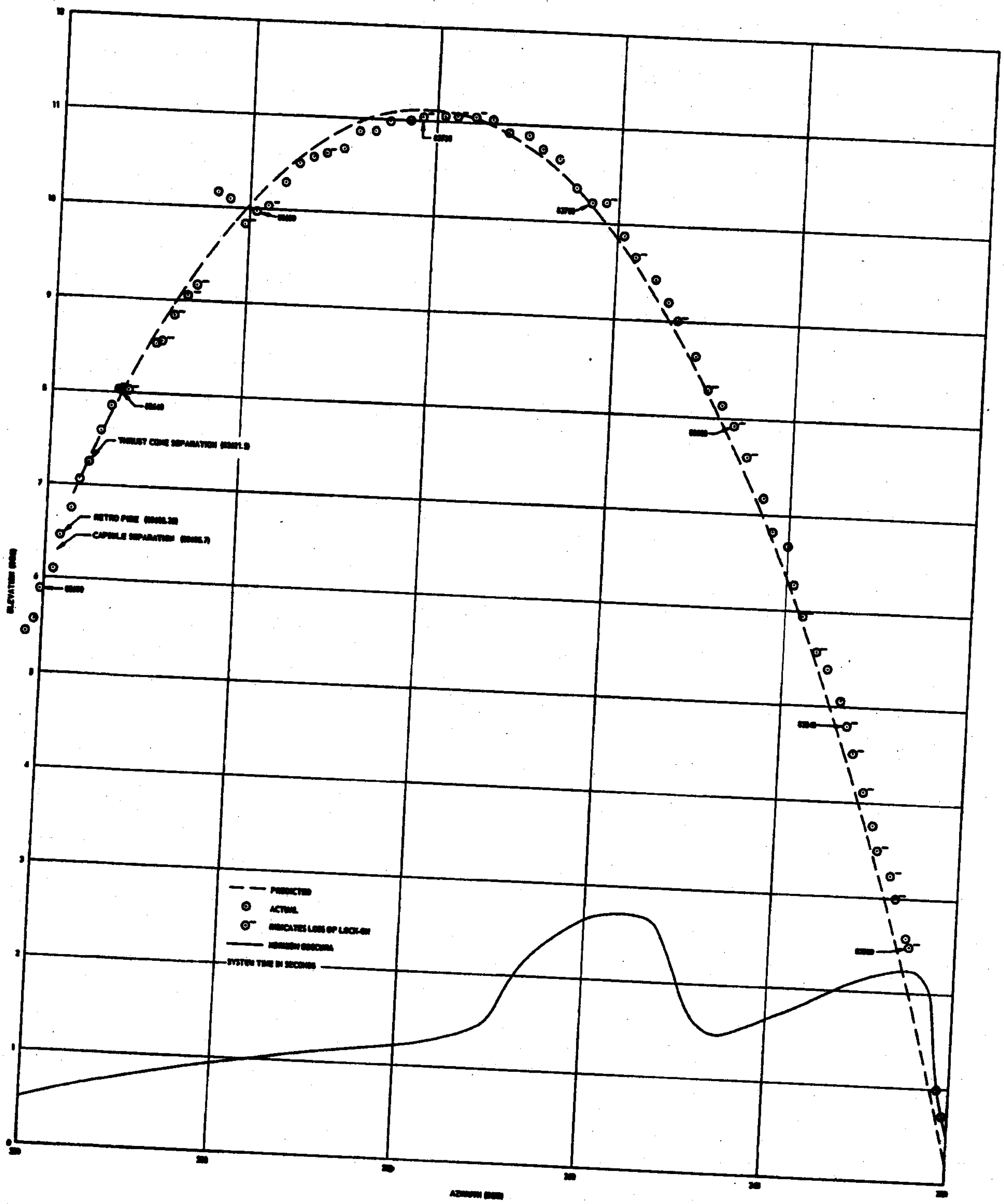

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Figure 33 Azimuth vs Elevation at Time of Capsule Separation, KTS, Pass 17

was 559 seconds. Maximum elevation angle of the TLM-18 antenna was approximately 1 degree. The raw capsule-tracking data from the HTS TLM-18 is shown in Figure 34. Vehicle tracking was effected on Passes 1, 2, 9, 10, 17, and 32.

USS Joe E. Mann

The recovery telemetry ship was stationed at 7° N latitude, 160° 50' W longitude for the recovery pass. Orbital contact with the Agena satellite was made on Passes 1, 9, and 10. No contact was accomplished with capsule transmitters on Pass 17 because the ship was stationed far south of the actual recovery area.

Barking Sands Tracking Station

The recently activated tracking station at Barking Sands (BSTS), Kauai Island, Hawaii, was utilized to track capsule signals during the recovery pass. Capsule telemetry was acquired and sustained for 520 seconds. A post-recovery evaluation of tracking data shows that the accuracy of BSTS azimuth bearings was in error by approximately 8 degrees. (A study is being conducted to determine the error's source.)

South Point and Christmas Island Tracking Stations

No acquisition of capsule telemetry was reported from either South Point or Christmas Island stations, although all equipment was operational. Post-flight evaluation of the re-entry trajectory shows that the capsule did not appear above the tangent plane of either station.

New Boston Tracking Station

Orbital contact was obtained for the first time by the newly activated LMSD Station at New Boston, New Hampshire. Passes 6, 7 and 29 were tracked,

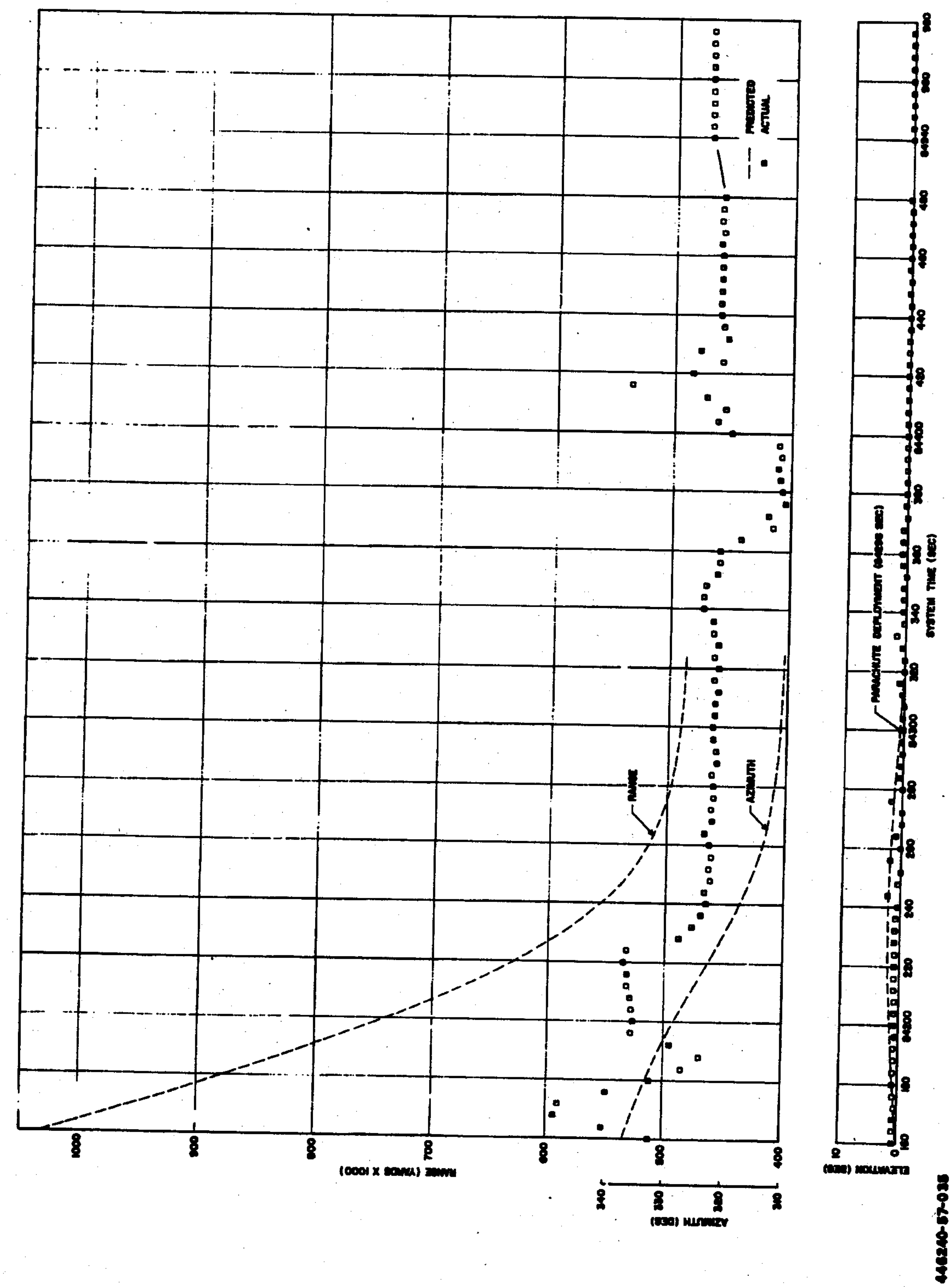

Figure 34 HTS TLM-18 Capsule Track

using the CW acquisition transmitter signal; no contact was made with telemetry or radar because they were not programmed to turn on by the orbital timer during these passes.

WV-2 Telemetry Aircraft

An aircraft equipped for telemetry reception (WV-2) was deployed in the vicinity of HTS to receive and record capsule telemetry data. The WV-2 was on station during Pass 17 when satellite and capsule telemetry signals strength records were made for 645 seconds. Performance of the system in receiving the telemetry signals is illustrated in Figure 35, where the signal strengths, recorded on a six-pen recorder, are given.

GROUND SUPPORT EQUIPMENT

Blockhouse

Equipment at the blockhouse functioned satisfactorily during countdown and launch.

Launch Area

No serious Agena GSE problems occurred at the pad. During Phase I of the terminal countdown, a malfunction light on the Douglas Launch Monitor Console lit, and personnel were sent to the DAC pad electric trailer to trace the faulty circuit. A power supply circuit breaker was reset and no further trouble was encountered.

Pad Damage

Blast and flame damage at liftoff was confined to the usually expendable equipment as air conditioning ducts, hydraulic flex lines, and electrical wiring.

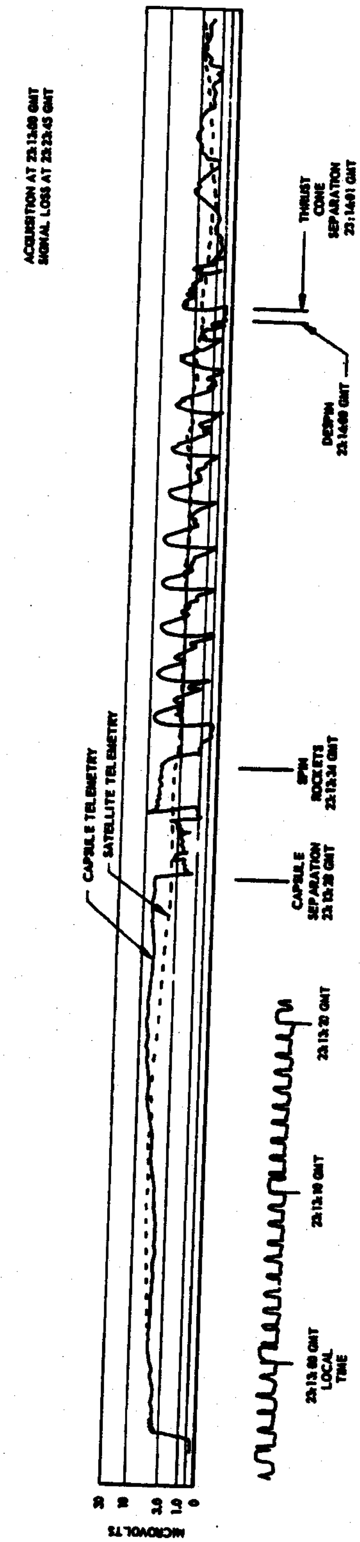

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Figure 35 WV-2 Signal Strength Records, Pass 17

SECTION 11
OPERATIONS SUPPORT EVALUATION

Adequate support was provided by the following participating agencies:

- 6594th Test Wing
- 1st Missile Division
- Alaskan Air Command
- Space Track
- Lookout Mountain Laboratories
- Pacific Missile Range
- Flight Test Working Group, VAFB
- Douglas Aircraft Company
- LMSD Data Services
- LMSD Palo Alto Computer Center
- 6594th Recovery Control Group

Ascent, orbit, and recovery data were received on time, with the exception of the 30 hour shipment from VAFB. The C-47 dispatched by 6594th Test Wing was held at VAFB by weather conditions and the shipment arrived in Sunnyvale 15 hours late.

For the first time, part of the Pass 17 data from KTS was transmitted by telephone line, permitting early evaluation of re-entry events.

A receiving station was newly activated by LMSD Data Services in Sunnyvale to provide early launch and orbit data.

No photographic data of the Recovery operation were received by the authorized agency. Such coverage is valuable for engineering analysis purposes.

APPENDIX

Table A. 1

AGENA 1057 WEIGHT STATEMENT

	PREDICTED Sub-totals (lb)	PREDICTED Totals (lb)	ACTUAL Sub-totals (lb)	ACTUAL Totals (lb)
Agena Weight Empty		1943		1944
Add				
Oxidizer	4801		4801	
Fuel	1870		1868	
Gross Weight-Thor Payload		8614		8613
Less				
Adapter and Attachments	149		149	
Retro Rockets	16		16	
Destruct System	7		7	
Separation Weight		8442		8441
Less				
Horizon Scanner Fairing	2		2	
Control Gas Expended During Coast	3		1	
Ullage Rockets and Attachments	38		38	
Engine Ignition Weight		8399		8400
Less				
Starting Charge	2		2	
Nozzle Closure	3		3	
Oxidizer Pre-flow	5		5	
Impulse Oxidizer	2		2	
Impulse Fuel	1		1	
Thrust Attainment Weight (90% P_c)		8386		8387
Less				
Impulse Oxidizer	4720		4702	
Impulse Fuel	1816		1810	
Control Gas Expended During Boost	2		1	
Burnout Weight		1848		1874
Less				
Vented Residual Propellants	127		149	
Vented Helium	5		5	
Weight Empty on Orbit (With Control Gas)		1716		1720
Less				
Attitude Control Gas	32		35	
Weight Empty on Orbit (Gas Expended)		1684		1685

Table A. 2

CENTERS OF GRAVITY AND MOMENTS OF INERTIA

Condition	C.G. Location - inches X	Y	Z	M.I. - Slug Ft^2 I_{xx}	I_{yy}	I_{zz}
Liftoff	0	+0.01	797.0	808,776	808,776	3,285
Booster Burnout	+0.09	+0.12	646.6	381,908	381,908	2,079
Separation	-0.05	+0.04	361.3	2,184	2,199	130
Engine Ignition	-0.04	+0.04	360.8	2,099	2,112	126
Engine Burnout	-0.16	+0.20	354.7	1,715	1,729	127
On Orbit - No Gas	+0.15	+0.24	349.5	1,558	1,570	123

Table A. 3

CAPSULE ACQUISITION INFORMATION

Recovery Force Component	Time Acq. (GMT)	Time Fade or Visual Contact	Magnetic Bearing Initial	Magnetic Bearing Fade	Class of Bearing*	Frequency	Signal
C-119 No. 1	2324:25 2342 2353	2352:10 0012 (Visual)	- 070° 070°	- 070° 070°	A A	238 238 238	Beacon Beacon Beacon
C-119 No. 2	2324:15 0000:00	2352:00 0007:00 (Visual)	355° Orbiting	005° 150°	A A	237 241	Beacon Beacon
C-119 No. 3	2323:45 2352:30	2352:00 0005:30 (Visual)	340° 352°	352° 343°	A A	236 242	Beacon Beacon
C-119 No. 4	2324:33 2355:00	2352:00 0010:00 (Visual)	340° 338°	340° 340°	A A	236.5 236.5	Beacon Beacon
C-119 No. 5	2326:00 2350:00	2348:00 0055:00 (Visual)	350° 355°	357° 355°	A A	235.75 236 (RADARC)	Beacon
C-119 No. 6	2324:00 2331:30	2352:00 0158:00 (Visual)	- 315°	- 357°	C B to A	235.8 235.8	Beacon
C-119 No. 7	2328:30	2346:15	340°	350°	A	235.5	Beacon
C-119 No. 8	2325:15	2325:30	342°	342°	C	235.7	Beacon
C-130 No. 9	30 second duration		North				Beacon
Haiti Victory	2320:15	2348:30	000° to 000°	to 015° **	A		Beacon Agena TM
BSTS	2321	2332:00	345° **	340°**	A		Beacon Agena TM
WV-2	2348	0120 (Visual)	020°	-	A		Beacon

* A-Strong, reliable; B-Usable; C-Doubtful, unreliable
** True headings

Table A. 4

SUMMARY OF CRITICAL DATA

Event	Prelaunch Predicted	Actual
Liftoff Weight (lb)	117,538	117,260
Thor Payload Weight (lb)	8,614	8,613
Agena Dry (lb)	1,943	1,944
Agena Oxidizer (lb)	4,801	4,801
Agena Fuel (lb)	1,870	1,868
Launch Azimuth (deg)	172	174
Thor Roll Program (deg)	46.5	44.1
Thor Main Engine Cutoff		
Time (sec)	164.5	163.0
Altitude (nm)	44.40	47.0
Velocity (Inertial) (ft/sec)	13,613	13,588
Flight Path Angle (Inertial) (deg)	20.22	22.06
Range (nm)	82.16	79.8
Thor Vernier Engine Cutoff		
Time (sec)	173.5	172.47
D-Timer Hold:		
Start (sec)	221.0	221.31
Stop (sec)	258.78	272.91
Command 5:		
Start (sec)	223.0	223.64
Stop (sec)	258.78	272.91
Command 6:		
Start (sec)	258.78	272.91
Stop (sec)	274.60	285.94
Start Separation:		
Weight	8,442	8,441
Time (sec)	181.0	181.41

Table A. 4 (Continued)

Event	Prelaunch Predicted	Actual
Agena 90% Thrust Attainment:		
Time (sec)(1)	288.23/302.1	302.45
Weight (lb)	8,386	8,387
Altitude (nm)	110.32	125.8
Velocity (inertial) (ft/sec)	12,722	12,501
Flight Path Angle (inertial) (deg)	8.33	8.5
Range (nm)	329.79	354.2
Orbital Boost:		
Burning Time (sec)(1)	121.93	118.97
Average Flow Rate (Total lb/sec)	53.44	54.73
Specific Impulse (sec)	277.5	280.0
Horizontal Velocity-to-be-gained(2) (inertial)(ft/sec)(90% Cp to 70% Cp)	13,366/13,515	13,450
Agena Burnout:		
Time (sec)(1)	410.21	421.42
Weight (lb)	1,870	1,874
Altitude (nm)	124	139.7
Velocity (inertial) (ft/sec)	25,900	25,786
Injection Angle (inertial) (deg)	0	+.18
Range (nm)	667.28	679.2
Longitude (Geodetic) (deg)	119.22W	119.58W
Latitude (Geodetic) (deg)	23.67N	23.56N
Initial Orbit Parameters:		
Eccentricity	.0323	.0326
Perigee Altitude (nm)	124	137
Perigee Longitude (Pass 0) (Geodetic)(deg)	119.2W	119.8W
Perigee Latitude (Pass 0) (Geodetic)(deg)	23.7N	23.4N
Apogee Altitude (nm)	361	379
Apogee Longitude (Pass 0) (Geodetic)(deg)	49.1W	48.4W
Apogee Latitude (Pass 0) (Geodetic)(deg)	22.9S	25.4S

Table A.4 (Continued)

Event	Prelaunch Predicted	Actual
Period (minutes)	93.50	94.1
Inclination (deg)	81.69	82.87
Empty Weight (with gas)(lb)[3]	1,716	1,720
Expected Lifetime (days)	25	84 (Calculated)
Average Regression Rate (17 passes)(deg/orbit)	23.49	23.65
Re-Entry:		
Retro Ignition Longitude (Geodetic)(deg)	168.05W	171.2W
Retro Ignition Latitude (Geodetic)(deg)	60.63N	65.2N
Impact Longitude (Geodetic)(deg)[4]	158.91W/161.58W	161.57W
Impact Latitude (Geodetic)(deg)[4]	24.00N/24.00N	25.6N
Re-Entry Pass		
T/M Ship Location (at launch):		
AG 161	16N 117.7W	On Station

DISTRIBUTION

Addressee	Quantity
Commander Air Force Ballistic Missile Division Attn: WDAT Air Force Unit Post Office Los Angeles 45, California	25
Air Force Plant Representative (SMAMA) Sunnyvale, California	1
6594th Test Wing (Satellite) (ARDC) Attn: TWRAT Satellite Test Center Bldg. 171, Plant 1 Sunnyvale, California	6
6594th Recovery Control Group 6594th Test Wing (Satellite) (ARDC) APO 953, San Francisco, California	1
6596th Instrumentation Squadron 6594th Test Wing (Satellite) (ARDC) Vandenberg AFB, California	1
6594th Launch Squadron (ARDC) 6594th Test Wing (Satellite) Vandenberg AFB, California	1
AFBMD Field Office Attn: Lt. Col. Heisler Vandenberg AFB, California	1
Commander Pacific Missile Range Attn: DCOS-AF Col. S. G. Curtis USN Missile Test Center Pt. Mugu, California	1
D. McCallum Douglas Aircraft Company Space Systems (Systems Test) 3000 Ocean Park Blvd. Santa Monica, California	2
LMSD Organizations	$\frac{69}{108}$

Table A. 5
EQUIPMENT TEMPERATURES

Component	Temperature at Launch T = 0 (°F)	Maximum Temperatures For T = 0 to T = 760 seconds (°F)		Temperature Rise During Ascent for T = 0 to T = 760 seconds (°F)		Temperature in Orbit (°F)		
		Maximum Temperature During Ascent	Maximum Allowable Operating Temp.	Flight Data	Due to Power Dissipation Only	Pass 2	Pass 9	Pass 17
Beacon Transponder E-74	60	78	145	18	18	48 to 52	30	30
Battery Case C-9	60	85(2)	100	25	2(3)	61	48	35
Horizon Scanner(1) D-82	116	128	200	12	5	129	115	110 to 90
2000 CPS Inverter SD-80	69	105(2)	140	36	19	81	60	53
R-F Amplifier SD-81	62	105(2)	165	43	44	33 to 37	17 to 20	12 to 22
Telemetry Transmitter E-71	67	105(2)	165	38	30	45 to 49	22 to 25	20 to 30
Retrorocket Motor L-30	71	78	100	7	0	77	52	40

(1) *The horizon scanner sensor is located on the motor case. During operation of the scanner, the motor case is approximately 60°F above the ambient temperature.*

(2) *Based upon Telemetry Ship data which is approximately 10°F higher than VTS data.*

(3) *Bulk average temperature rise for the whole battery, including cells.*

Note: *The internal roll gyro was instrumented but no calibration was available to reduce the sensors' output to temperature values.*

Table A.6

POWER SUPPLY VOLTAGES AND TEMPERATURES

FUNCTION	TIME FROM LIFTOFF, SECONDS								PASS		
	T/M at Liftoff	100	200	300	400	500	600	700	2	9	17
400 CPS 3ø Inverter ø AB	115	155	115	115	115	115	115	115	115		113
ø BC	115	115	115	115	115	115	115	115.5	115	114	115
2000 CPS Inverter	115	115	115	115	115	115	115	115	114.9		112
+28.3v dc Regulator 1	+ 28.5	‚28.5	+28.5	+28.6	+28.5	+28.5	+28.6	+28.6	+28.6	+28.6	+28.6
-28.3v dc Power Supply	-28	-28	-28	-28	-28	-27.9	-28	-28	-28.1	-28.1	-28.2
Unregulated +28V Battery Bus	+27	+27	+27	+25.6	+25.5	+25.5	+25.5	+25.5	+23.3	+23	+22.5
+28V Battery Case Temperature	60°	60°	65°	71°	73°	75°	75°	74°	61°	48°	37°
Hydraulic Battery	+29*	+29*	+29*	+23**	+23.9**	+28.9	+29	+29	+29	+28.2	28

* Values obtained from Performance Analysis

** Hydraulic Motor Operating
400 through 700 seconds from Ship T/M

Table A.7

COMMUNICATION MALFUNCTIONS

Date	PDT	
10 August	0650 - 0730	NBTS voice line noisy
10 August	0812 - 0840	KTS 60 WPM TTY running open (out at Anchorage)
10 August	0810 - 0819	VCC Hot line connection dead
10 August	0812 - 1055	KTS voice line dead (All voice communication between U.S. and Alaska lost at 0812)
10 August	0828 - 1232	WV-2 No. 8 aircraft single sideband inoperative
10 August	0955 - 1044	VTS 100 WPM garbled
10 August	1044 - throughout launch	VTS Doppler coder out
10 August	1055 - 1245	KTS voice line weak but clear. Operable after 1245
10 August	1055 - 1235	NBTS 60 WPM TTY garbled between San Jose and Oakland
10 August	1405 - 1430	STC plot board TV camera out of synch
10 August	2220 - 2250	KTS experiencing cross-talk on voice line
11 August	1335 - 1430	NBTS voice line out East to West (reception acceptable West to East), accepted for Pass 16
11 August	1500 - 1530	NBTS voice line out East to West
11 August	2315 - 2327	KTS 60 WPM TTY had "hits on line"
12 August	1235 -	PACC's 60 WPM TTY running open
12 August	2012 - 2015	KTS 60 WPM TTY running open
15 August	1020 - 1115	KTS voice line out

Note: New Boston (NBTS) was not in operational station but was in checkout stage

Table A. 8

ORBITAL TIMER EVENTS

Event	System Time (Seconds)		Resultant Period	Observing Station
	Computed (ACQ)	Observed (TWX)		
Orbital Timer Start	74453		D-5611	
B, T/M Plates Off	75187		D-5611	
PASS 1				
B, T/M Plates on and Reset Enable	79493		D-5611	
Two Step Commands		74852	I-5632	KTS
Reset Monitor On	79727	79720	I-5632	KTS
Reset Command		79799	I-5632	KTS
Two Step Commands		79909	I-5632	KTS
Reset Disable and B, T/M Plates Off	80545		D-5653	
PASS 2				
B, T/M Plates On and Reset Enable	85261		D-5653	
Reset Monitor On	85452	85441	D-5653	KTS
Reset Command		85441	D-5653	KTS
1 Step Command		Unknown	D-5643	HTS
Reset Disable and B, T/M Plates Off	86193		D-5643	
PASS 8				
B, T/M Plates On and Reset Enable	31297		D-5643	
Reset Monitor On	31532	31539	D-5643	VTS
Reset Disable and B, T/M Plates Off	31798		D-5643	
PASS 9				
B, T/M Plates On and Reset Enable	36939		D-5643	
Reset Command		37170	D-5643	VTS

Table A. 8 (Continued)

	System Time (Seconds)		Resultant Period	Observing Station
	Computed (ACQ)	Observed (TWX)		
Reset Monitor On	37170	37170	D-5643	VTS
Reset Disable and B, T/M Plates Off	37774		D-5643	
PASS 10				
B, T/M Plates On and Reset Enable	42411		D-5643	
Reset Monitor On	42646	42644	D-5643	HTS
Reset Command		42644	D-5643	HTS
Reset Disable and B, T/M Plates Off	43356		D-5643	
PASS 15				
B, T/M Plates On and Reset Enable	72164		D-5643	
Reset Command		72337	D-5643	KTS
Reset Monitor On	72337	72337	D-5643	KTS
Reset Disable and B, T/M Plates Off	72882		D-5643	
PASS 16				
B, T/M Plates On and Reset Enable	77744		D-5643	
Reset Monitor On	77979	77975	D-5643	KTS
Reset Command		77979	D-5643	KTS
Reset Disable and B, T/M Plates Off	78524		D-5643	
PASS 17				
B, T/M Plates On and Reset Enable	83386		D-5643	
Reset Monitor On	83621	83616	D-5643	KTS
Reset Disable and B, T/M Plates Off	84372		D-5643	

NOTE: ***Computed times are based on the nominal timer period, preflight calibrations, and observed switching operations.***

Table A. 9

ORBITAL COMMAND SUMMARY

(Pre-Recovery)

Station	Inc/Dec		Step		Reset		Payload		Command 5		Command 6		Total per Station	
COMMAND	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.
KTS	2	2	4	4	4	4	1	1	0	0	0	0	11	11
VTS	0	0	0	0	1	1	0	0	0	0	0	0	1	1
MTS	0	0	0	0	0	0	0	0	1	1	1	1	2	2
HTS	0	0	1	1	1	1	0	0	0	0	0	0	2	2
Total per Command	2	2	5	5	6	6	1	1	1	1	1	1	16	16

(Post-Recovery)

Station	Inc/Dec		Step		Reset		Payload		Command 5		Command 6		Total per Station	
COMMAND	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.	Sent	Ver.
KTS	0	0	0	0	3	2	0	0	2	2	2	2	7	6
VTS	0	0	24	24	0	0	0	0	0	0	0	0	24	24
MTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HTS	2	0	24	0	0	0	0	0	0	0	0	0	26	0
Total per Command	2	0	48	24	3	2	0	0	2	2	2	2	57	30

Table A.10

TRACKING STATION POSITIONAL DATA QUALITY

Pass	Station	Data Source	Points	Usable Points	Points Used in Fit	Deviation (n.m.)	Percent Usable Data
1	KTS	Mod II	113	78	57	2.27	73.1
2	KTS	Mod II	86	23	19	1.38	82.6
2	HTS	Mod II	147	58	44	0.88	75.9
8	VTS	Mod II	72	72	65	1.19	90.3
9	VTS	Mod II	100	75	73	1.22	97.3
9	KTS	Mod II	145	89	69	1.34	77.5
10	HTS	Mod II	291	125	85	1.33	68.0
10	KTS	Mod II	91	82	52	1.30	63.4
15	VTS	TLM-18	123	75	55	1.51	73.3
16	KTS	Mod II	134	85	79	0.63	92.9
17	KTS	Mod II	97	33	25	-	75.8

Definitions

Total Points: *All azimuth, elevation, range, and time data words generated by the tracking stations.*

Usable Points: *Total points after rejection of data words below 6 and above 85 degrees, when radar was not locked on, or obviously bad points.*

Points Used in Fit: *Usable data points remaining after rejection routines have reduced maximum deviation of data from best fit curve to less than 1.5 nautical miles.*

Deviation: *The maximum deviation remaining after rejection routine is completed.*

Table A. 11
ORBITAL CONTACT SUMMARY
(System Time - sec)

Pass	Station	CW ACQ. TRANSMITTER Acquire	Fade	Duration	TELEMETER Acquire	Fade	Duration	RADAR Acquire	Fade	Duration
Launch	MTS	74304	74780	476	74304	74780	476	74292	74294	498
Launch	AG 161		unknown		74534	75058	524		No Radar	
Launch	VTS	74275	74775	500	74275	74775	500	74275	74484	209
1	KTS	79540	80092	552	79540	80089	549	79552	79970	418
1	HTS	80180	80426	246	80153	80464	311	80243	80399	156
1	VTS	80162	80411	249	80162	80441	249		NA	
1	Joe E. Mann	80424	80696	272	80424	80554	130		Normal	
2	KTS	85272	85652	380	85263	85650	414	85365	85687	322
2	HTS	85787	86279	492	85765	86190	425	85790	86190	400
6	NBTS	20081	20795	714		NA			NA	
7	VTS	25436	25440	4		NA			NA	
7	NBTS	25815	26444	629		NA			NA	
8	MTS	31203	31917	714	31312	31802	490	31312	31802	490
8	VTS	31203	31970	767		NA		31521	31804	283
9	MTS	36952	37540	588	36945	37540	595	37036	37550	514
9	Xmas	36413	37006	593	36947	37006	59		No Radar	
9	Joe E. Mann	36550	37084	534	36946	37084	138		No Radar	
9	VTS	36908	37597	689	36947	37595	648	36923	37360	437
9	KTS	37263	37900	637	37261	37770	509	37290	37770	480
9	HTS	36413	37006	593	36674	37323	649		NA	
10	Joe E. Mann	42056	42910	854	42439	48890	451		No Radar	
10	HTS	42240	43090	850	42415	43098	683	42412	42964	552
10	KTS	42889	43605	716	42889	43353	464	43021	43353	332
11	KTS	48729	49263	534		NA			NA	
15	KTS	72147	72482	335	72178	72482	304	72227	72458	231
15	VTS	72541	73021	480	72541	72880	339	72675	72705	30
15	MTS	72579	73029	450	72579	72876	297		NA	
16	KTS	77786	78312	526	77787	78322	535	77809	78322	513
16	MTS	78407	78493	86	78407	78487	80		NA	
16	VTS	78330	78675	345	78330	78520	190	78407	78518	111
17	KTS	83488	83955	467	83488	83955	467	83570	83630	70
17	HTS	84014	84552	538	84014	84552	538	84156	84369	213
24	KTS	35541	36120	579	35541	35978	437	35568	35973	405
25	KTS	41108	41824	716	41114	41552	437	41145	41549	404
26	KTS	46907	47482	575	46910	47472	562	46956	47430	474
29	NBTS	65157	65428	271		NA			NA	
31	VTS	70791	71199	408	70963	71206	243	70994	71184	190
31	KTS	76012	76520	508		NA			NA	
32	HTS	82237	82768	531	82228	82404	176		NA	
32	KTS	81713	82195	482	81789	82047	258	81853	No Look on	

Pass	Station	VHF (GE) CAPSULE BEACON Acquire	Fade	Duration	CAPSULE TELEMETRY Acquire	Fade	Duration	CAPSULE RADAR Acquire	Fade	Duration
17	KTS	83488	83955	467	83527	83879	352	83642	83877	235
17	HTS	84231	85790	1559	84201	85790	1589		NA	
17	WV-2		Unknown		83580	84225	645		No Radar	
17	Bark		Unknown		84200	84720	520		No Radar	

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