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DISCOVERER XIII

(Agena 1057/Thor 231)

SYSTEM TEST EVALUATION
AND
PERFORMANCE ANALYSIS REPORT

(35-Day Report)

Contract [redacted]

Prepared by

SYSTEMS INTEGRATION, 62-44

STC TECHNICAL OPERATIONS AND EVALUATION, 61-44

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APPROVED:

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SATELLITE SYSTEMS MANAGER

APPROVED:

[redacted] MANA[redacted]

SATELLITE [redacted] TEMS EN[redacted]

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LOCKHEED AIRCRAFT CORPORATION

SECRET

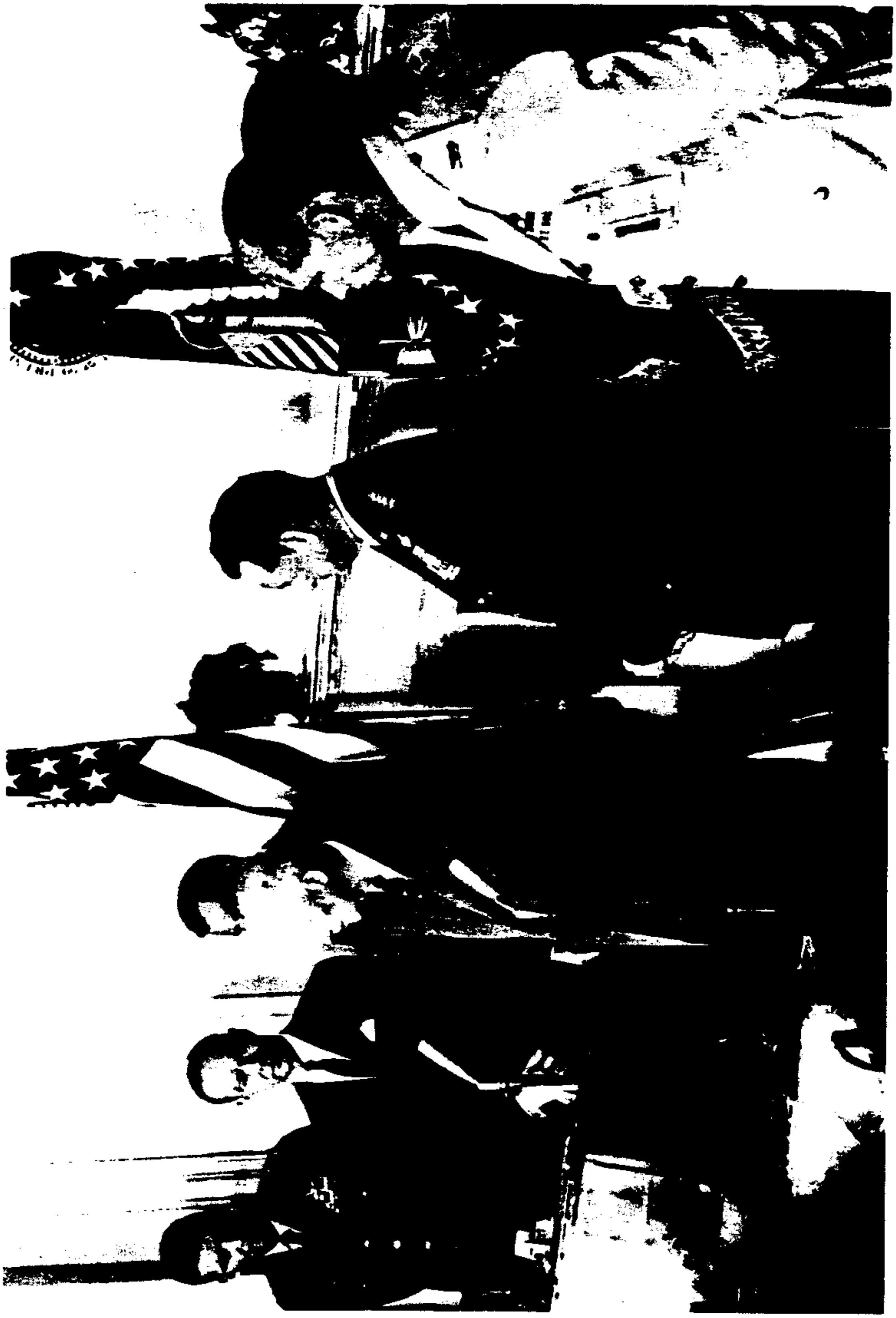
MISSILES and SPACE DIVISION

[redacted]

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 [redacted] in accordance with Paragraph 1. 4. 1 of [redacted] Discoverer Program.

[redacted]



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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*

[redacted]

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.

[redacted]

CONTENTS

[redacted]

CONTENTS (Continued)

ILLUSTRATIONS

[redacted]

ILLUSTRATIONS (Continued)

 [redacted]

TABLES

[redacted]

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
[redacted]	[redacted]
HATS	High Altitude Temperature Simulator
[redacted]	[redacted]
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
[redacted]	[redacted]
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

[redacted]

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
[redacted]	[redacted]

[redacted]

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 3 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 [redacted] 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.

[redacted]

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 gimbolling 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 i[redacted] 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.

Notice of Page Substitution

Test Description

For the purposes of electronic archiving, this page is a substitute for an unscannable page.

[redacted]

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

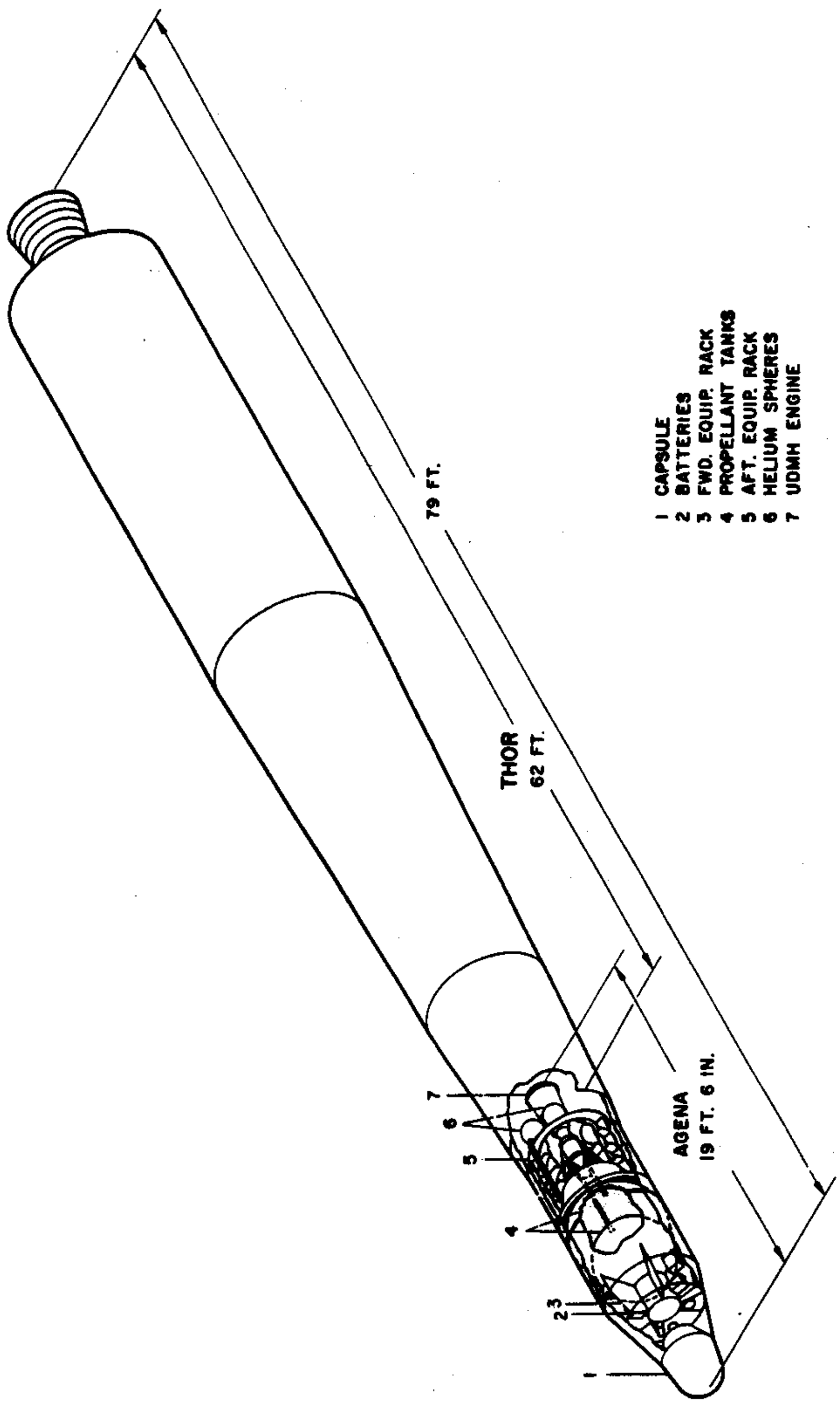

Figure 1 Agena 1057/Thor 231 Configuration

[redacted]

[redacted]

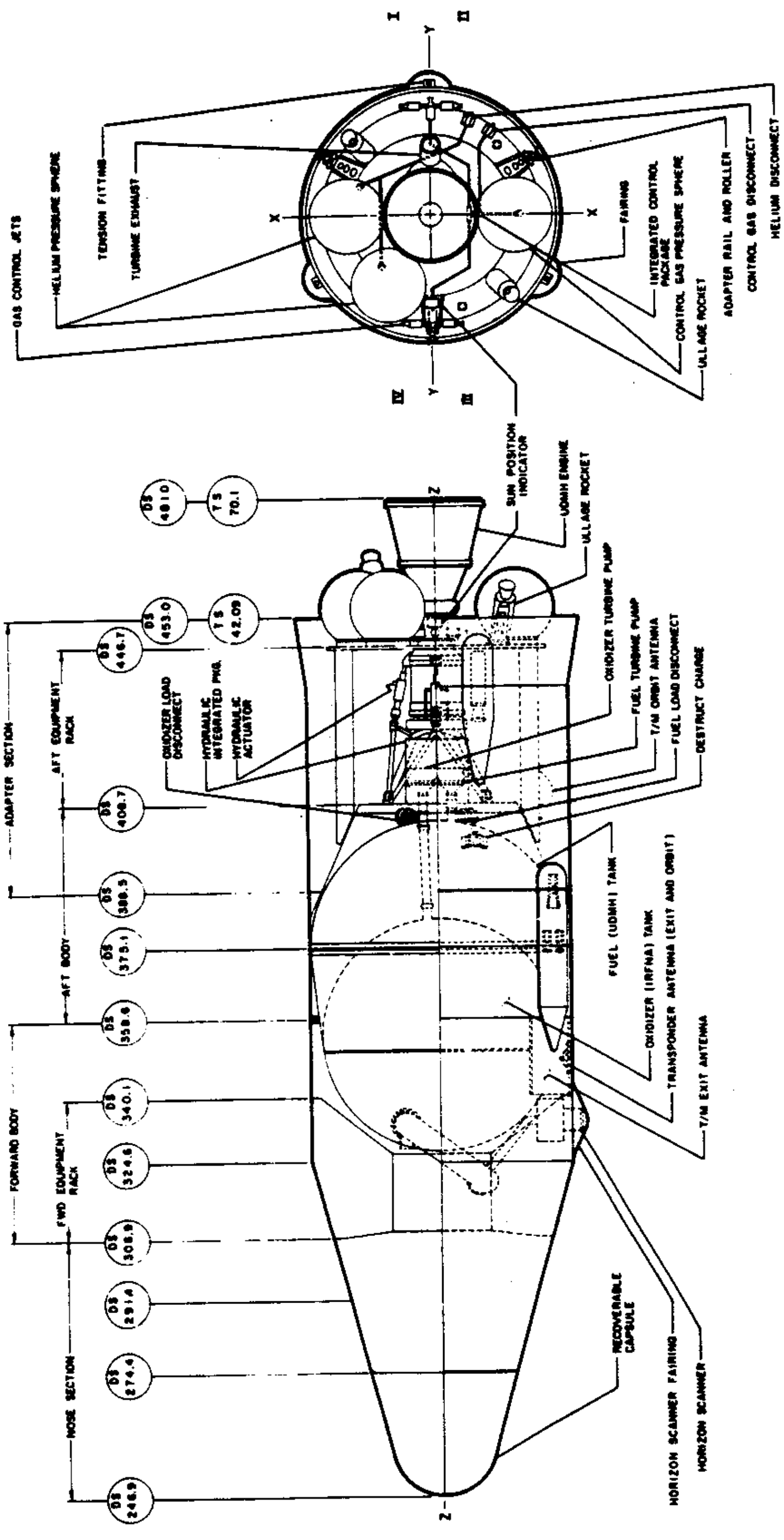

Figure 2 Agena Inboard Profile

[redacted]

[redacted]

Figure 3 Discoverer XIII Diagnostic Payload Undergoing Postflight Inspection at LMSD

[redacted]

[redacted]

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.

[redacted]

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 [redacted] 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 [redacted] 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 [redacted] participated in tracking operations to check out equipment and to train personnel.

[redacted]

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 [redacted] That station's Doppler coder remained inoperative throughout the launch. [redacted] 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 [redacted] 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 Start Time (min)	Time Scheduled Duration (min)	Actual Countdown Time Start Time PDT	Actual Countdown Time Start Time (min)	Actual Countdown Time 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***			1317	T-12	6
Hold 4****			1333	T-2	3
Liftoff	T-0		1337:54		

[redacted]

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 [redacted] initial orbit elements were calculated and a new acquisition message generated and sent to [redacted] for Pass 1. Acquisitions messages were also sent to the other tracking stations [redacted] and [redacted] for use during Pass 1.

Pass 1

Pass 1 acquisition of the Agena's CWAT by [redacted] was made 88 seconds later than predicted by the PACC. [redacted] 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 [redacted] 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
[redacted] T/M Fade	---	500.0
[redacted] T/M Fade	---	476.0
Remove -40°/minute Yaw Rate	701.6	701.9
T/M Ship Fade	---	784.0

[redacted]

Table 4
TRAJECTORY AND INITIAL ORBITAL PARAMETERS

Trajectory

Event	Time (sec)		Altitude (n.m.)		Range (n.m.)		Inertial Velocity (ft/sec)	
	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	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

[redacted] 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 [redacted] and [redacted] to be weak.

Pass 2

[redacted] and [redacted] tracked the vehicle on all equipment during this pass. [redacted] 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 [redacted] 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 [redacted] reported the reset monitor ON at 31539, [redacted] 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, [redacted] and [redacted] [redacted] reported 20 percent countdown on the S-band beacon, which was usual for this time of night.

Pass 9

The [redacted] 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. [redacted] acquired at 36947, [redacted] 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 [redacted] 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

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

Pass 14

[redacted] 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

[redacted] 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 [redacted] and [redacted] had difficulty in obtaining continuous radar lock-on. [redacted] 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

[redacted] 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).

[redacted] nd [redacted] acquired the vehicle on all parameters and experienced no trouble in tracking on this pass. [redacted] bserved telemeter OFF 4 seconds earlier than expected, based on reset on the timer. All parameters were normal.

Pass 17

[redacted] cquired 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. [redacted] acquired the satellite and verified all recovery events. Successful tracking was achieved by [redacted] f the capsule's S-band beacon and the telemetry.

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

Post-Recovery Orbits

Passes 24, 25, and 26 were tracked by [redacted] nd used for command exercises. Contact was gained by [redacted] on Pass 29, [redacted] and [redacted] on Pass 31, and [redacted] and [redacted] 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	[redacted]
16	92	
16	93	
16	93	
17	107	[redacted]
17	108	
17	109	
18	120	
19	138	

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 [redacted] 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

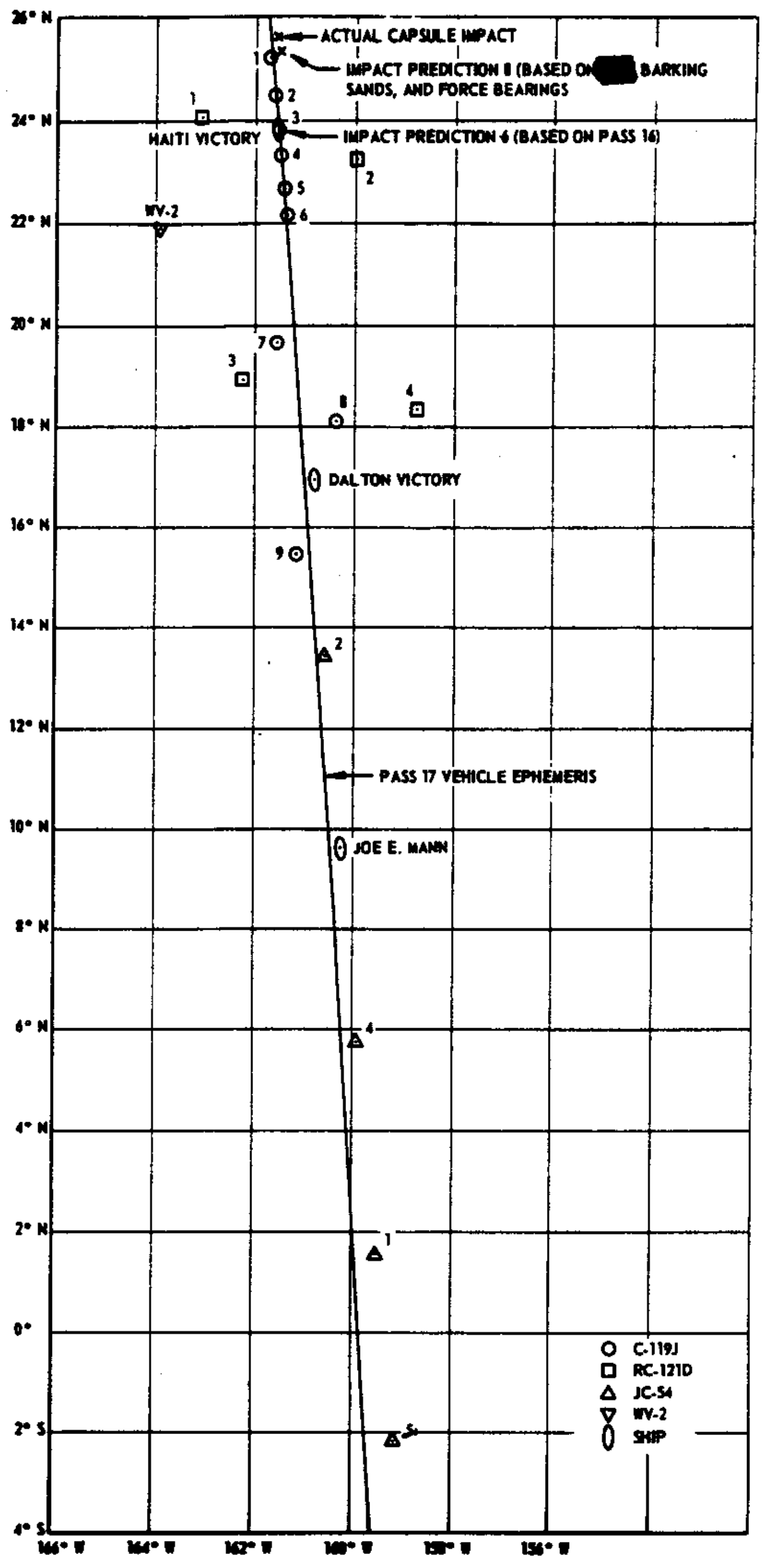

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Figure 5 Recovery Force Deployment at ETPD

[redacted]

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 [redacted] 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.

Notice of Page Substitution

Test Evaluation

For the purposes of electronic archiving, this page is a substitute for an unscannable page.

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 [redacted] 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		

	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		

	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

[redacted]

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 [redacted] 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 [redacted]

Usable telemetry data during the recovery phase were obtained by [redacted] at 84220 seconds, System Time, or approximately 106,000 feet capsule altitude. Analysis of capsule signal strength records from [redacted] 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 [redacted] but it was sufficient to yield good telemeter records from 0.5 until 299 seconds after capsule ejection. [redacted] 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 [redacted] Data were not obtained after this time.

THOR INSTRUMENTATION

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

[redacted]

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.

[redacted]

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 [redacted] 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

[redacted] 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 [redacted] and Telemetry ship data. Telemeter ship launch data from Channel 15 indicated approximately 10°F higher temperatures than [redacted] for the same components (10°F is within overall system accuracy). These