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FOREWORD

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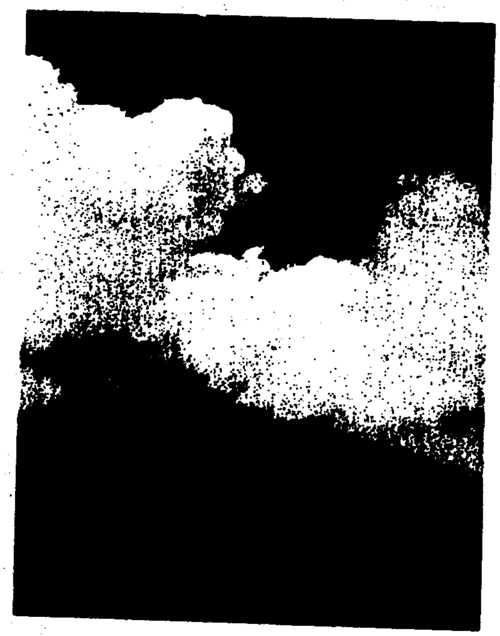

SPACE

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HEADQUARTERS
AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)
UNITED STATES AIR FORCE
Air Force Unit Post Office, Los Angeles 45, California

WDLPM-4

30 April 1960

FOREWORD

Activities summarized in this report include the major space systems, projects and studies for which the Air Force Ballistic Missile Division is wholly or partially responsible. Each space system and project is introduced by a concise history of the administration, concept and objectives, making possible a more meaningful evaluation of the monthly progress information. The program description information is revised monthly as necessary to reflect major technical and administrative changes.

This month's report includes detailed follow-up information on the accomplishments of DISCOVERER XI, TRANSIT 1B, TIROS and ABLE-4 THOR (PIONEER V satellite). Information is current as of the printing deadline for this report (15 May).

The development of the Able-Star stage, as authorized by ARPA, has been completed. Also completed recently is the AGENA modification program authorized by ARPA.

O. J. RITLAND
Maj. Gen., USAF
Commander

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CON

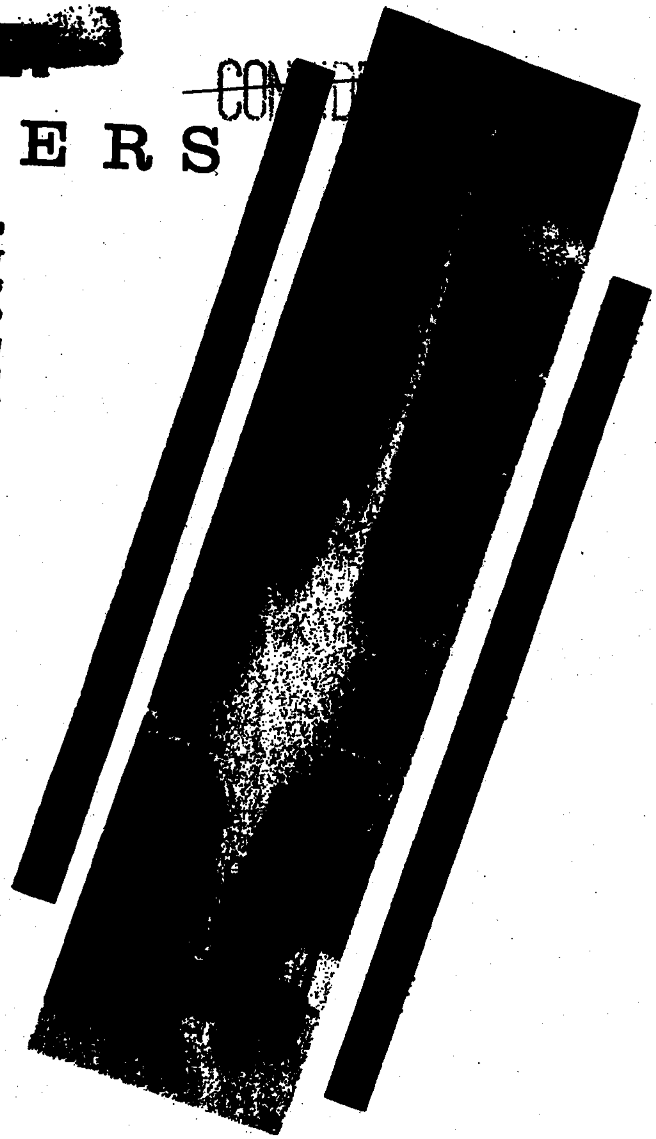
Space Program

BOOSTERS

Planning time schedules for the accomplishment of Space Program missions is based largely, at present, on the availability of booster vehicles. IRBM, ICBM, and upper stage development programs must be closely monitored. As modifications are incorporated into these programs: reducing weight, increasing thrust, lengthening burning periods, using improved fuels; in short, any change which improves overall performance, the use of the vehicle must be re-evaluated in terms of use as a satellite or space probe booster. As breakthroughs are achieved which advance the state-of-the-art in propulsion, guidance, re-entry; in more durable materials and more reliable components, new doors are opened through which additional space capabilities are made possible.

Because of the wide variety of space research missions which must be accomplished the problem of accommodating a maximum number of experiments within a given payload becomes very complex. Among other factors, solving this problem involves the selection of the most effective booster combination, the maximum use of booster subsystems, and the maximum use of existing ground tracking and support facilities and equipment.

Because of its signal success in providing the nation with an operational THOR IRBM and ATLAS ICBM within an unbelievably short period of time, as well as for its advanced work in TITAN and MINUTEMAN programs, AFBMD possesses a distinct advantage in evaluating booster capability in terms of specific space payloads or missions. The following pages are devoted to a brief presentation of the various boosters currently being used to support AFBMD space programs. Performance charts are given which make possible a comparison of several booster combinations now in use. Specific performance figures for each vehicle are given in the table of specifications. All data shown is nominal, with individual qualifications indicated where necessary.



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THOR

Prime contractor:
Douglas Aircraft Co.

Engine manufacturer:
Rocketdyne Div., North American Aviation

Height 64 feet 10 inches (without re-entry vehicle)

Weight (no residual propellants)
SM-75 106,546 pounds
DM-21 108,395 pounds

Engine
SM-75 MB-3 Block I
DM-21 MB-3 Block II

Fuel RJ-1
Oxidizer LOX

Guidance — removed on space booster flights

Used as first stage for:
DISCOVERER
ABLE-3 and -4
TRANSIT
COURIER
TIROS

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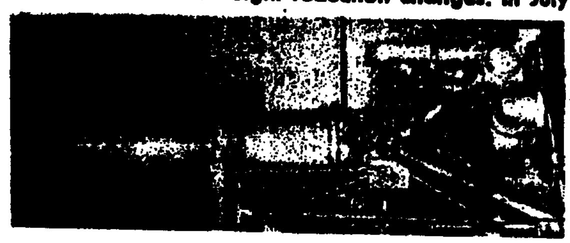
Early in 1958, the decision to accelerate the national space effort was made effectively possible only because of the availability of the THOR IRBM. THOR No. 127 was diverted from the R&D flight test program for use as the ABLE-1 space probe first stage. With top national priority assigned to the space research effort, THOR No. 163 was used to boost the DISCOVERER I into orbit on 28 February 1959. Since then, the THOR has become a reliable operational IRBM and highly reliable also as a booster for space vehicles. During 1959 all THOR boosted space flights achieved completely successful first stage performance. THOR performance has been increased through weight reduction modifications and use of RJ-1 (instead of RP-1) fuel. In April 1960 a modified THOR, designated DM-21, will be available, incorporating a shortened guidance compartment and additional weight reduction changes. In July 1960 THOR thrust will be increased to 167,000 pounds through installation of the MB-3-Block II engine. The first DM-21 vehicle will be used to boost DISCOVERER XVII.



ATLAS

Prime contractor:
Convair

Engine manufacturer:
Rocketdyne Div., North American Aviation

Height 69 feet

Diameter 10 feet

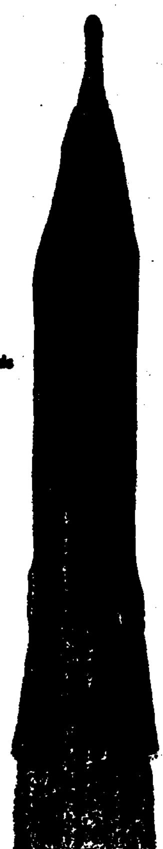
Weight 261,206 pounds

Engine
Series D ATLAS MA-2

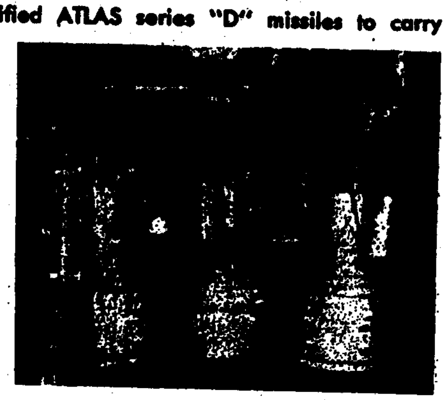
Fuel JP-4
Oxidizer LOX

Guidance — Radio-inertial
General Electric (radar)
Burroughs Corp. (computer)

Used as first stage for:
SAMOS
MIDAS
COMMUNICATIONS SATELLITE
ABLE-4
PROJECT MERCURY



The ATLAS ICBM, providing over twice the thrust of the THOR, will be used as the first stage booster for the three Advanced Military Satellite Programs and for Project Mercury man-in-space. The first ATLAS boosted space flight was launched from the Atlantic Missile Range on 18 December 1958. Designated Project Score, this vehicle (ATLAS 10B) successfully placed a communications payload satellite into orbit around the earth. In November 1959 the ABLE-4 space probe did not attain orbit; however, the ATLAS first stage performance was entirely successful. The first flight test vehicle in Project Mercury was launched on 7 September with all objectives essentially achieved and excellent ATLAS booster performance realized. Future flights will use modified ATLAS series "D" missiles to carry increased payload weights. Project Mercury boosters are being modified also to include abort-sensing and other pilot safety features. The success of the first three ATLAS boosted space flights, plus the increased performance and reliability being demonstrated in the ATLAS R&D flight test program, lend confidence in this booster as a means of realizing advanced space objectives.



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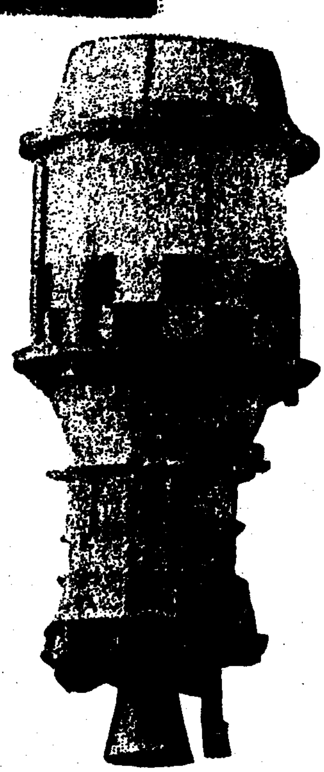
AGENA

Although originally designed as the basic satellite vehicle for the Advanced Military Satellite Programs, flight testing of the AGENA was accelerated when the DISCOVERER program was created, using the THOR/AGENA combination. Because of its availability, the Bell Aircraft LR81-Ba-3 rocket engine was selected for AGENA propulsion, and later modified to use unsymmetrical di-methyl hydrazine instead of JP-4 fuel. Subsequent modifications resulted in the AGENA "B" configuration, in which propellant tank capacity was doubled and the engine modified to provide single restart and extended burn capabilities. The increased performance of this design greatly enhanced the potential of the THOR/AGENA combination. An optical inertial system for guidance and orbital attitude control was developed to meet the critical orbital eccentricity and attitude requirements for the programs involved. Gas jets and reaction wheels are used to control attitude. Payloads may be installed on the forward equipment rack or distributed throughout the vehicle. The flight test program also has been used to develop a recovery capability for a payload capsule which is ejected from the orbiting satellite.



Prime contractor:
Lockheed Missile and Space Division

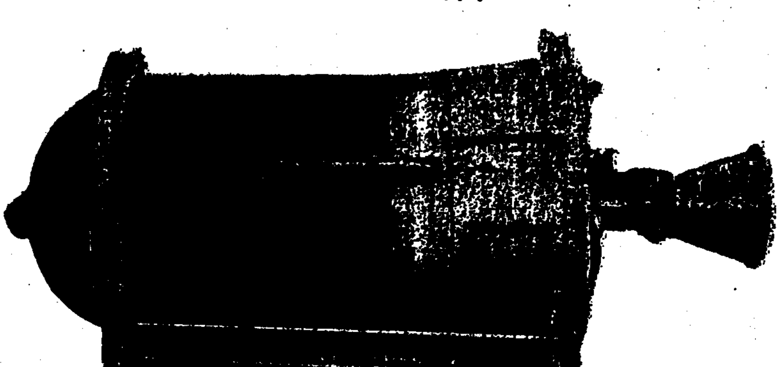
Engine manufacturer:
Bell Aircraft Corp.

Length	
"A" version	14 feet
"B" version	19.5 feet*
	21 feet**
Diameter	60 inches
Weight	
"A" version	7,987 pounds
"B" version	14,800 pounds
Engine	
"A" version	YLR81-Ba-5
"B" version	XLR81-Ba-7*
	XLR81-Ba-9**
Fuel	UDMH
Oxidizer	IRFNA
Guidance	optical-inertial

Used as second stage for:
DISCOVERER (XVII & subs)
SAMOS (flight 4 and subs)
MIDAS (flight 3 and subs)

ABLE-STAR Vehicle

The ABLE-STAR upper stage vehicle contains an AJ10-104 propulsion system which is an advanced version of earlier Aerojet-General systems. In addition to providing increased performance capability, the system includes automatic starting, restarting, shutdown, ground control, coast period pitch and yaw control, and ground monitoring systems. Propellants are fed to the thrust chamber by a high pressure helium gas system. The thrust chamber is gimballed by electrical signals to provide pitch and yaw control during powered flight. Roll control during powered flight is achieved by expelling nitrogen through a system of nozzles in response to electrical signals. Roll control during coast periods uses a parallel circuit at lower thrust. Attitude control for coast periods up to one-half hour provided in the current design can be extended by increasing the nitrogen supply.



Contractor:
Aerojet-General

Height	14 feet 3 inches
Diameter	4 feet 7 inches
Weight	9772 pounds
Engine	AJ10-104

with Restart Capability
Nozzle Expansion Ratio—40.1

Fuel
Unsymmetrical Dimethyl Hydrazine

Oxidizer
Inhibited Red Fuming Nitric Acid

Guidance
STL Advanced Guidance System
Burroughs J-1 Computer

Used as second stage for:
TRANSIT 1B, 2A, 2B
COURIER 1A, 1B

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ABLE Vehicle

The ABLE upper-stage vehicle has been flight tested successfully as the second stage on THOR re-entry vehicle tests, ABLE Projects and TRANSIT 1A. The vehicle uses AJ10-42 or AJ10-101 propulsion systems (improved versions of systems used originally on the Vanguard Program), guidance systems, and electronic and instrumentation equipment. The ABLE vehicles are guided during second stage engine burning. Vehicles using the AJ10-101 system are spun with the third stage and payload prior to second stage engine burnout to provide spin stabilization of the unguided third stage and payload. On flight vehicles using the AJ10-42 propulsion system, only the third stage and payload are spun prior to second stage separation by a spin table bearing system located at the second to third stage separation plane. Only minor differences exist between the two propulsion systems.

Contractor:
Aerojet-General Corp.

Height	18 feet 7 inches
Diameter	4 feet 8 inches

Weight

AJ10-42	4622 pounds
AJ10-101	4178 pounds

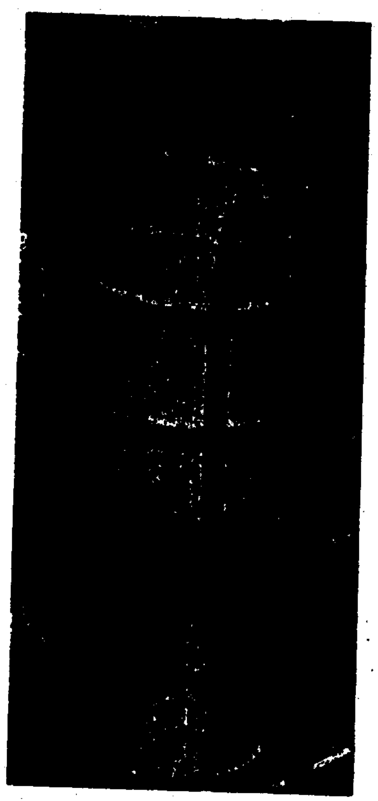
Fuel
Unsymmetrical Dimethyl Hydrazine

Oxidizer
Inhibited White Fuming Nitric Acid

Guidance
AJ10-42
Radio-Inertial (BTL)
AJ10-101
Advanced Guid. Syst. (STL)
Computer (Burroughs J-1)

Used as second stage for:
AJ10-42 — TRANSIT 1A, TIROS
AJ10-101 — ABLE 3 and 4

Development of the Allegany Ballistics Laboratory X-248 engine for the Vanguard Program was accelerated when it was selected as the third stage for Project ABLE-1. The unit represented the most advanced solid propellant engine of its size available at the time. Since the engine had not been qualification or flight tested, test firings were conducted in a vacuum chamber simulating approximately 100,000 feet altitude. Design modifications involving the igniter, nozzle, and internal insulation were found to be required. The modified engine performed with complete satisfaction on the successful flight of ABLE-1 and subsequently on ABLE-3 and ABLE-4 THOR.



ABL 248 Vehicle

Contractor:
Allegany Ballistic Laboratory

Height	4 feet 10 inches
Diameter	1 foot 6 inches
Weight	515 pounds
Fuel	Solid

Used as third stage on:
ABLE 3 and 4
TRANSIT 1A, TIROS

[redacted]

Specifications....

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THOR / ATLAS — FIRST STAGE

THOR	A SM-75	B DM-21
Weight—dry	7,746	6,510
Fuel	30,500	33,695
Oxidizer	68,300	68,190
TOTAL WEIGHT	106,546	108,395
Thrust-lbs., S.L.	152,000	167,000
Spec. Imp.-sec.	246.42	248.3
Burn Time—sec.	163.59	148.0

ATLAS	C Series D
Weight—wet	15,100
Fuel	74,900
Oxidizer	172,300
TOTAL WEIGHT	262,300
Thrust-lbs., S.L.	
Boost	356,000
Sustainer	82,100
Spec. Imp.-sec.	
Boost	286
Sustainer	310

FIRST STAGE

NOTES

① *Payload weight not included. Does include controls, guidance, APU and residual propellants.*

② *Does not include THOR adapter (225 lbs.) or ATLAS adapter (315 lbs.).*

③ *Single restart capability.*

④ *Dual burn operation.*

⑤ *Allegany Ballistic Laboratory.*

AGENA — SECOND STAGE

AGENA	D "A"	E "B"	F "B"
Engine Model	YLR81-Ba-5	XLR81-Ba-7③	XLR81-Ba-9④
①Weight—inert	1,155	1,370	1,400
Impulse propellants	6,550	13,100	13,100
Pyrotechnics	67	108	108
②TOTAL WEIGHT	7,772	14,578	14,608
Separation Weight	7,746	14,552	14,582
Thrust-lbs., vac.	15,000	15,000	15,000
Spec. Imp.-sec., vac.	277	277	290
Burn Time—sec.	120	240③	240④

SECOND STAGE

AEROJET-GENERAL — SECOND STAGE / ⑤ABL 248 — THIRD STAGE

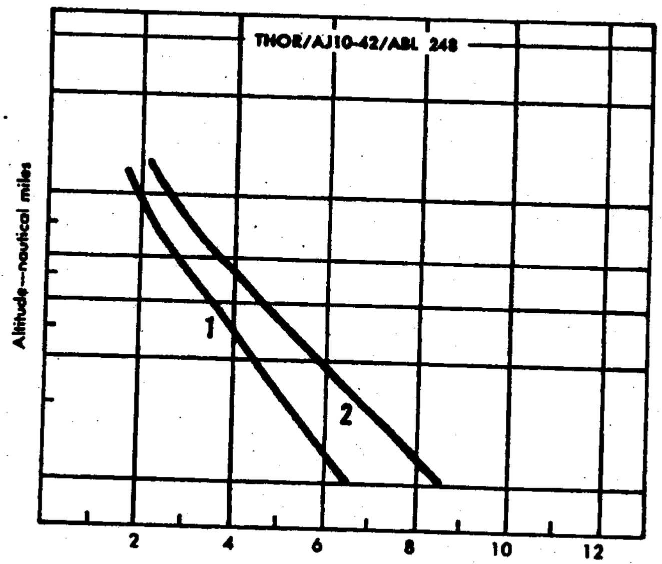
AEROJET-GENERAL	G AJ 10-42	H AJ 10-101	J AJ10-104 ABLE-STAR	⑤ABL 248 K
Weight—wet	1,247.1	847.9	1,297	59.5
Fuel	875.1	869.0	2,247	455.5
Oxidizer	2,499.6	2,461.0	6,227	(solid)
TOTAL WEIGHT	4,621.8	4,177.9	9,771	515
Burnout Weight	1,308.6	944.1	1,419	50.5
Thrust-lbs., vac.	7,670	7,720	7,900	3,100
Spec. Imp.-sec., vac	267	267	278	250.5

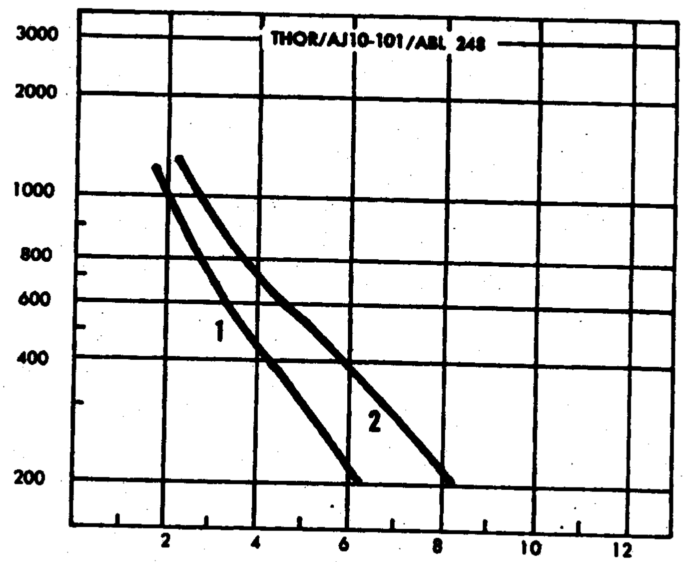
SECOND STAGE — THIRD STAGE

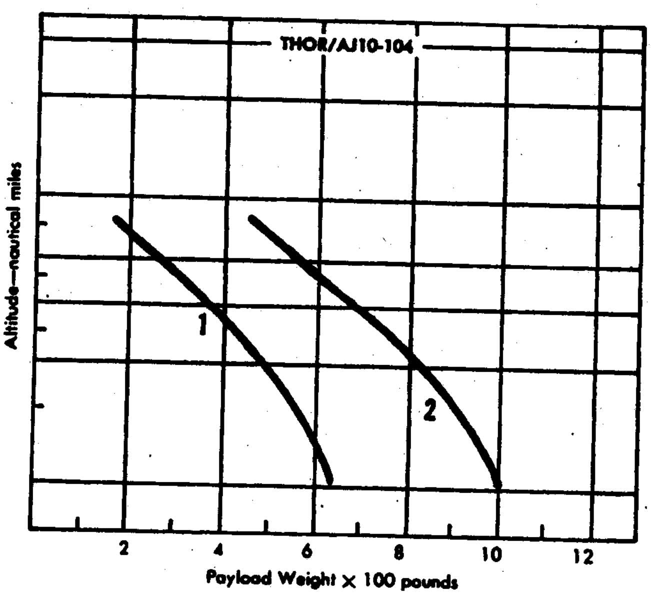
Program Vehicle Combinations

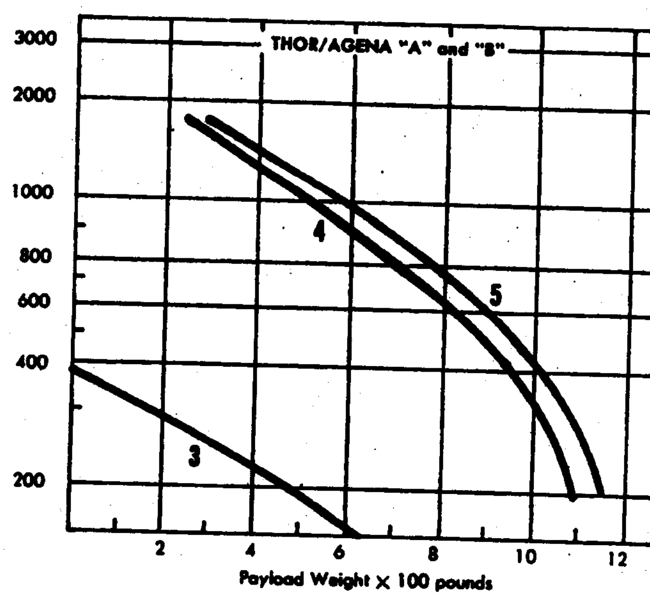
DISCOVERER (1 thru 16)......A-D
DISCOVERER (16 thru 21).....A-E
DISCOVERER (21 thru 29).....B-F
COMM. SATELLITE ....C-E
COMM. SATELLITE ....C-F
MIDAS (1 and 2).............C-D
MIDAS (3 and subs)...........C-F
SAMOS (1 thru 3).............C-D
SAMOS (4 and subs)..........C-F
ABLE-3 ....A-H-K
ABLE-4 ....C-H-K
ABLE-4 ....A-H-K
TRANSIT IA ....A-G-K
TRANSIT IB, 2A, 2B ....A-J
COURIER ....A-J
TIROS ....A-G-K

Performance Graphs — THOR BOOSTED









1. Polar—AMR or VAFB
2. AMR—90 degrees
3. VAFB—AGENA "A"
4. VAFB—AGENA "B" (XLR81-Ba-7)
5. VAFB—AGENA "B" (XLR81-Ba-9)

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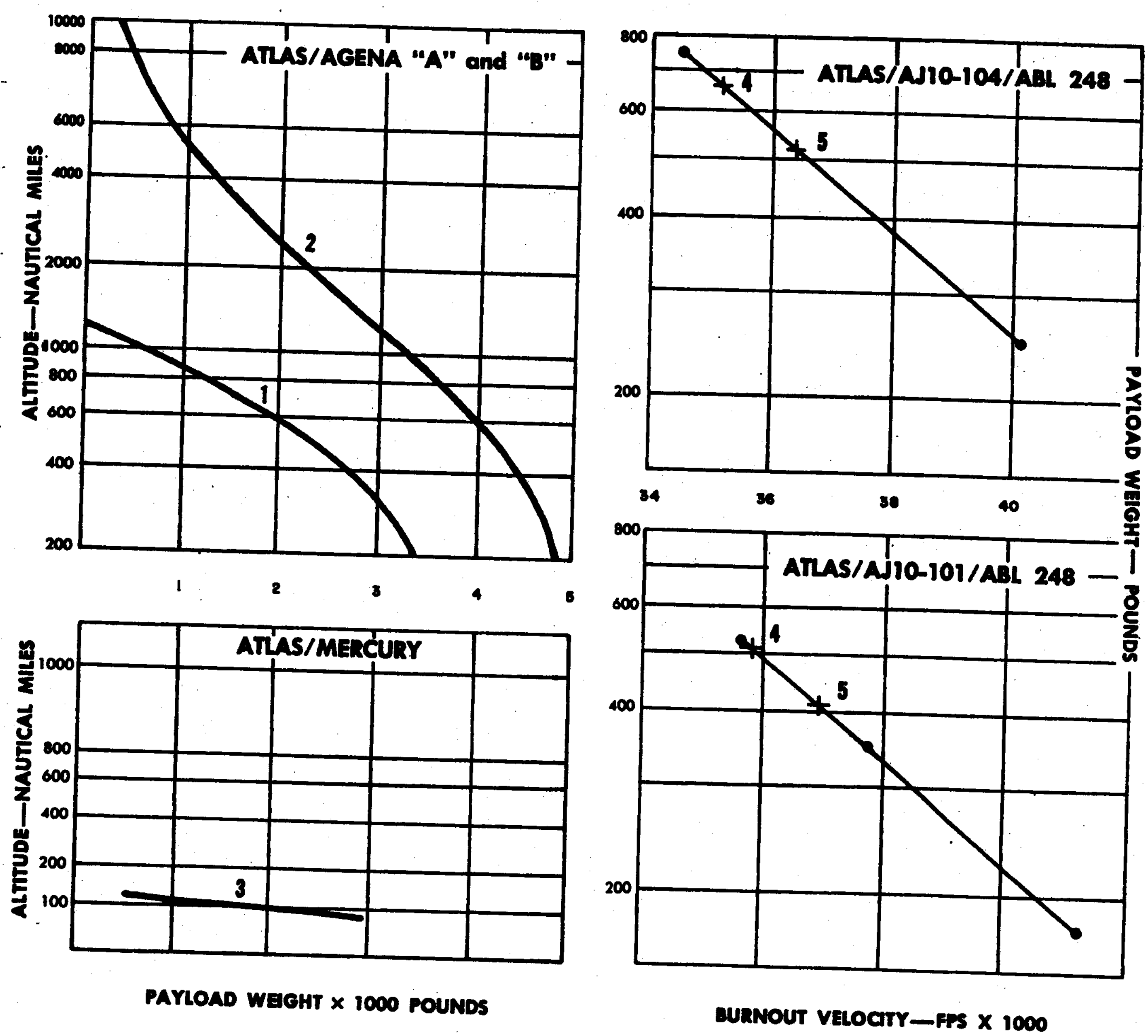
Performance Graphs — ATLAS BOOSTED



1. AGENA "A"— Polar Orbit
2. AGENA "B"— Polar Orbit
3. AMR—90 degrees

4. Lunar Probe
5. Venus Probe

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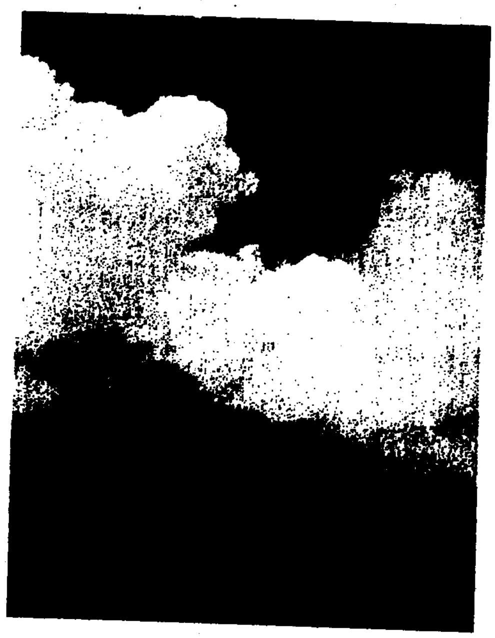
SPACE



systems

DISCOVERER

SAMOS

MIDAS

COMMUNICATIONS
SATELLITE

SPACE SYSTEMS

The DISCOVERER Program consists of the design, development and flight testing of 29 two-stage vehicles, using the THOR IRBM as the first stage booster and the AGENA as the second stage, satellite vehicle. The program was established early in 1958 under direction of the Advanced Research Project's Agency, with technical management assigned to AFBMD. On 14 November 1959, program responsibility was transferred from ARPA to the Air Force by the Secretary of Defense. Prime contractor for the program is Lockheed Missile and Space Division. The DISCOVERER Program will perform space research in support of the advanced military reconnaissance satellite programs.

PROGRAM OBJECTIVES

(a) Flight test of the satellite vehicle airframe, propulsion, guidance and control systems, auxiliary power supply, and telemetry, tracking and command equipment.

(b) Attaining satellite stabilization in orbit.

(c) Obtaining satellite internal thermal environment data.

(d) Testing of techniques for recovery of a capsule ejected from the orbiting satellite.

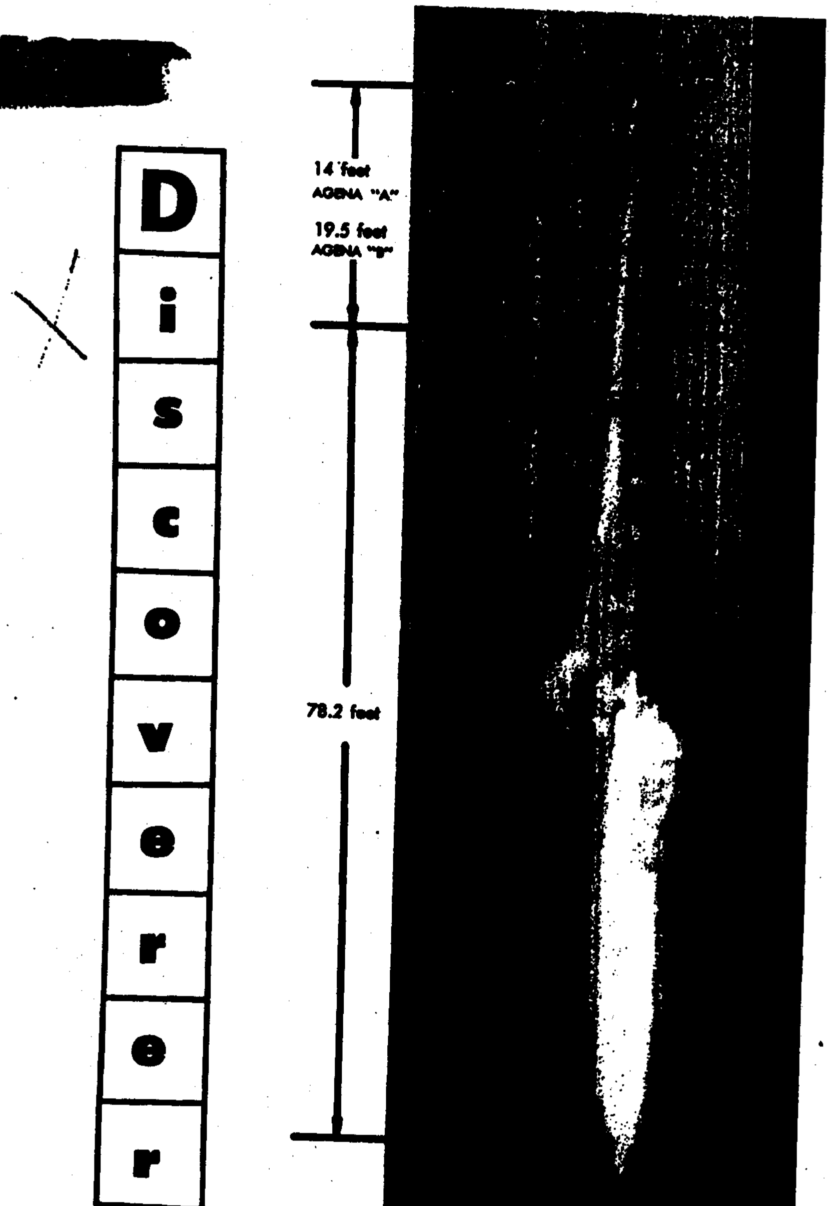
(e) Testing of ground support equipment and development of personnel proficiency.

(f) Conducting bio-medical experiments with mice and small primates, including injection into orbit, re-entry and recovery.

PROGRAM SUMMARY

Early launches confirmed vehicle flight and satellite orbit capabilities, developed system reliability, and established ground support, tracking and data acquisition requirements. Later in the program, biomedical and advanced engineering payloads will be flight tested to obtain support data for more advanced space systems programs. DISCOVERER vehicles are launched from Vandenberg Air Force Base, with overall operational control exercised by the Satellite Test Center, Palo Alto, California.

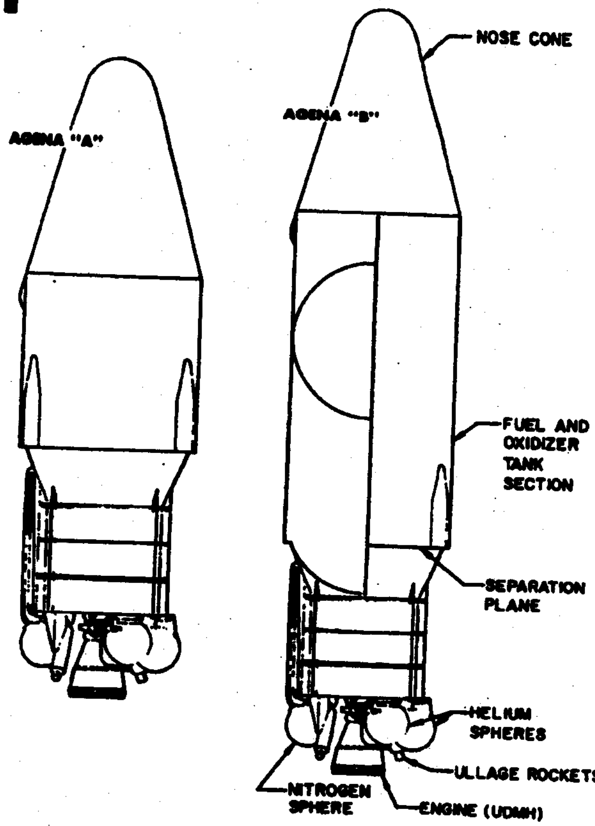
Tracking and command functions are performed by the stations listed in the Table on page A-4. A history of DISCOVERER flight to date is given on page A-5.



SECOND STAGE	AGENA "A"	AGENA "B"	
Weight—			
Inert	1,262	1,328	1,346
Payload equipment	497	887	915
Orbital	1,759	2,215	2,216
Impulse propellants	6,525	12,950	12,950
Other	378	511	511
TOTAL WEIGHT	8,662	15,676	15,722
Engine Model	YLR81-Ba-5	XLR81-Ba-7	XLR81-Ba-9
Thrust-lbs., vac.	15,600	15,600	16,000
Spec. Imp.-sec., vac.	277	277	290
Burn time-sec.	120	240	240

THOR BOOSTER	DM-18	DM-21
Weight—Dry	6,950	5,950
Fuel	33,750	33,750
Oxidizer (LOX)	68,300	68,300
GROSS WEIGHT (lbs.)	109,000	108,000
Engine	MB-3 Block 1	MB-3 Block 2
Thrust, lbs. (S.L.)	152,000	167,000
Spec. Imp., sec. (S.L.)	247.8	247.8
Burn Time, sec.	163	163

Telemetry ships are positioned as required by the specific mission of each flight. Figures 2 and 3 show a typical launch trajectory from Vandenberg Air Force Base, and figure 3 shows schematically a typical orbit. An additional objective of this program is the development of a controlled re-entry and recovery capability for the payload capsule (Figure 4). An impact area has been established near the Hawaiian Islands, and a recovery force activated. Techniques have been developed for aerial recovery by C-119 aircraft and for sea recovery by Navy surface vessels. The recovery phase of the program has provided advances in re-entry vehicle technology. This information will be used in support of more advanced projects, including the return of a manned satellite from orbit.



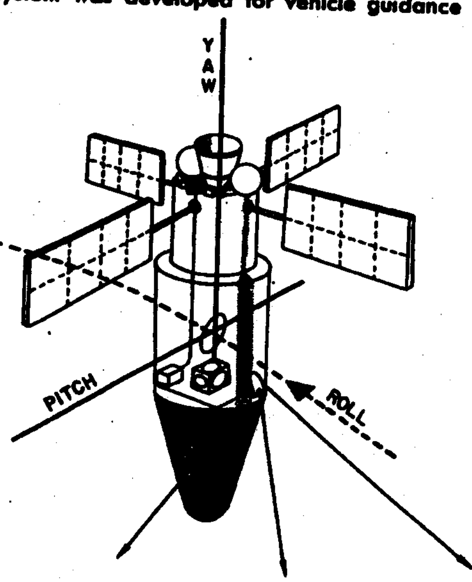
FLIGHT VEHICLE

The three versions of flight test vehicles used in the DISCOVERER Program are defined in the launch schedule shown on page A-5. Specifications for the two THOR configurations and three AGENA configurations used are given on page A-1.

AGENA VEHICLE DEVELOPMENT

The AGENA vehicle was originally designed by the Air Force as the basic satellite vehicle for Advanced Military Reconnaissance Satellite Systems Programs. Basic design was based on use of the ATLAS ICBM as the first stage. ATLAS trajectory characteristics and the stringent eccentricity requirements of the advanced programs led to the selection of a guidance system suited to achieving orbital injection in a horizontal attitude. As a result, an optical inertial system was developed for vehicle guidance and a gas jet system for orbital attitude control. An urgent need for attaining higher altitude orbits resulted in development of the AGENA "B" versions which included doubling the propellant capacity and addition of engine restart and extended burn capabilities. The YLR81-Ba-5 version of the LR81-Ba-5 engine, developed by Bell Aircraft for B-58 aircraft, is used on AGENA "A" vehicles.

Early AGENA "B" vehicles will use a later version of this engine (YLR81-Ba-7), redesigned to use unsymmetrical dimethyl hydrazine fuel instead of JP-4. The majority of AGENA "B" vehicles will use the XLR81-Ba-9 engine, incorporating a nozzle explansion ration of 45:1, and providing a further increase in performance capability.

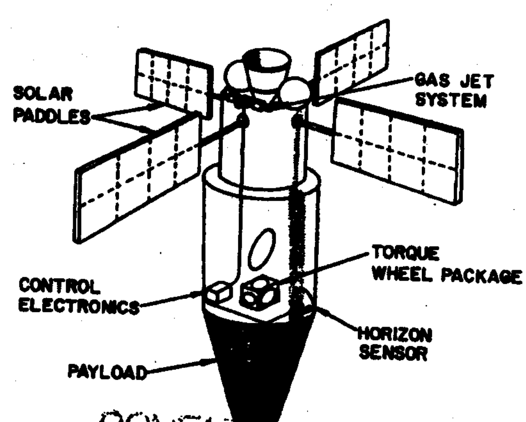


LINES OF SIGHT—HORIZON SENSING

PERFORMANCE CAPABILITIES

ALTITUDE
200–20,000 MILES

ATTITUDE
ROLL – 0.1 DEGREE
PITCH – 0.1 DEGREE
YAW – 1 DEGREE



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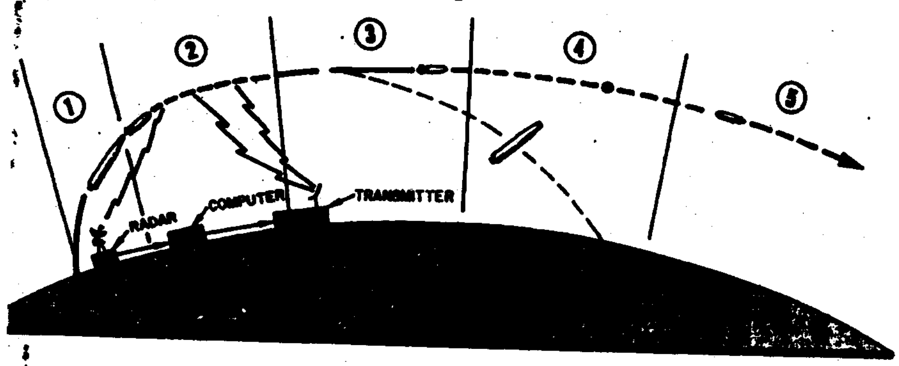
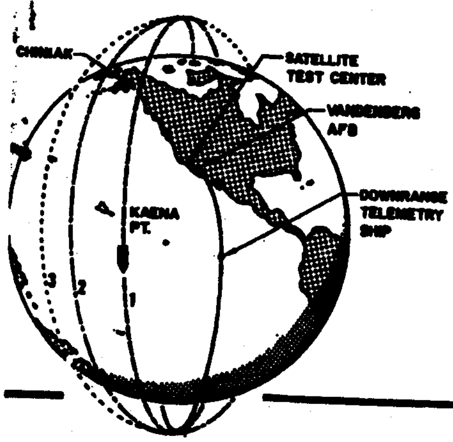
Powered Flight Trajectory



1. **First Stage Powered Flight**—2.5 minutes duration, 78 n.m. downrange, guided by programmed auto pilot.
2. **Coast Period**—2.4 minutes duration, to 380 n.m. downrange; guided and attitude controlled by inertial reference programmer, horizon scanner, gas reaction jets. Receives AGENA time to fire and velocity to be gained commands.
3. **Second Stage Powered Flight**—2 minutes duration, to 770 n.m. downrange. Guided and controlled by inertial reference programmer, horizon scanner, gas reaction jets (roll) gimballing engine, accelerometer.
4. **Vehicle Reorients to Nose Aft**—2 minutes duration, to 2,000 n.m. downrange. Guided and controlled by inertial reference programmer, horizon scanner and gas reaction jets.
5. **In-Orbit**—Guided and controlled (same as 4).

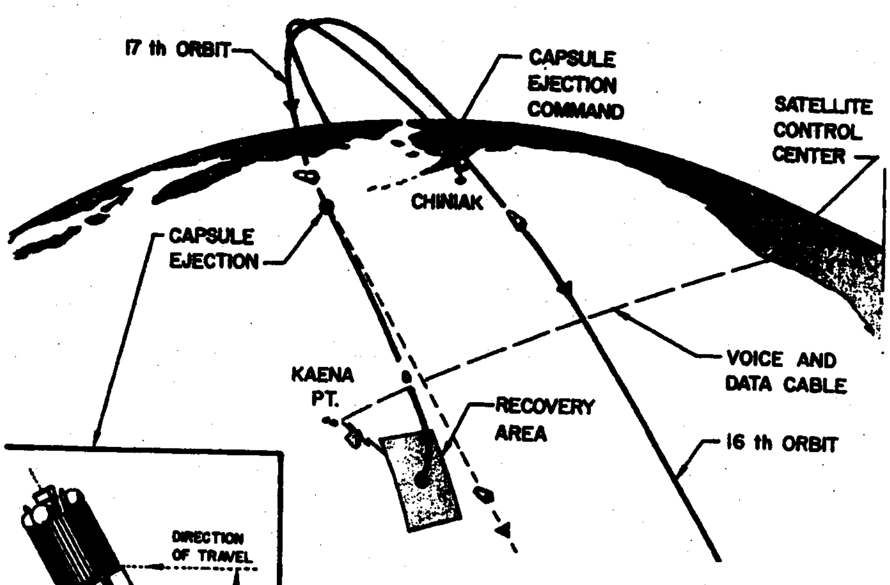


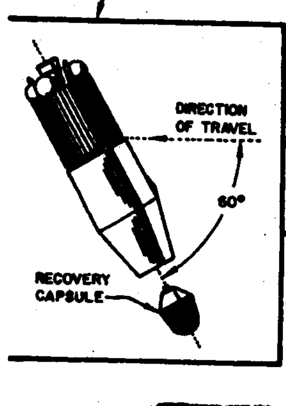
Orbital Trajectory

Schematic presentation of orbital trajectory following launch from Vandenberg Air Force Base. Functions performed by each station and a listing of equipment used by each station, is given on page A-4.

RECOVERY CAPABILITY

This objective was added to the program after the first launch achieved vehicle flight and orbit objectives successfully. It includes the orientation of the satellite vehicle to permit a recoverable capsule to be ejected from the nose section of the AGENA vehicle. Ejection is programmed to occur on command on the 17th orbit, for capsule impact within the predetermined recovery area south of Hawaii. Aircraft and surface vessels are deployed within the area as a recovery force.





CAPSULE RECOVERY SEQUENCE

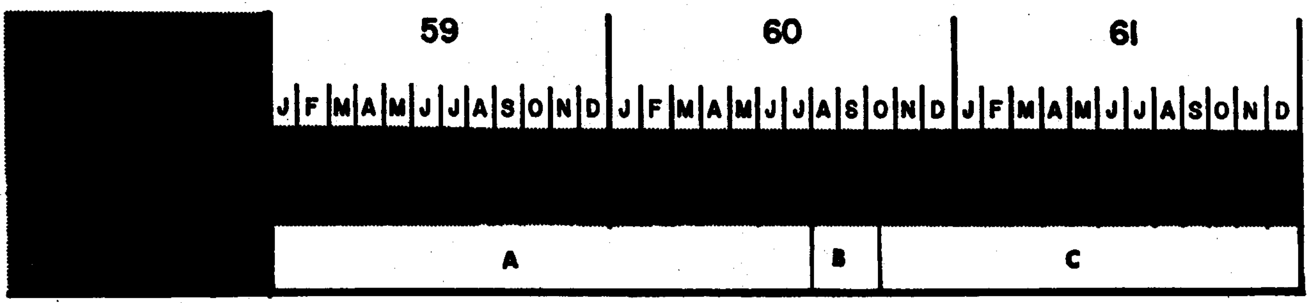
Capsule ejection command is sent to the satellite by the Chiniak, Alaska station on the 16th orbit. The vehicle reorients its position (see inset) to permit ejection to occur on a re-entry trajectory on the 17th orbit. The recovery capsule parachute is activated at about 50,000 feet, and the capsule beacon transmits a radio signal for tracking purposes. The recovery force is deployed in the recovery (impact) area.

Facility	Equipment	Flight Function
Satellite Test Center	A	Over-all control, convert tracking stations data to obtain a predicted orbit and generate subsequent ephemerides issue acquisition data to tracking stations for subsequent passes, predict recovery area.
Vandenberg AFB	BCDEFGHIJK	Launch, ascent and orbital tracking, telemetry reception, trajectory measurements including time to ignite second stage.
Point Mugu	BCDEFGHIJKL	Ascent tracking and telemetry data reception, transmits command to ignite and shut down AGENA (via guidance computer).
Telemetry Ship (Pvt. Joe E. Mann)	DF	Final stage ascent tracking and telemetry data reception.
Annette Island, Alaska (tracking station)		Activity at this station terminated 1 December 1959 due to fund limitations.
Cape Chiniak, Alaska (tracking station)	BDEFGHIJK	Orbital tracking and telemetry data reception, including first pass acquisition, recovery capsule ejection and impact prediction.
Kaena Point, Oahu, Hawaii (tracking station)	BCDEFGHIJK	Orbital tracking and telemetry data reception.
Hickam AFB Oahu, Hawaii		Over-all direction of capsule recovery operations.

***Equipment**

a. 2 UNIVAC 1103-A digital computers
b. VERLORT (Modified Mod II) radar
c. TLM-18 self-tracking telemetering antenna
d. Tri-helix antenna
e. Doppler range detection equipment
f. Telemetry tape recording equipment
g. Telemetry decommutators for real time data presentation
h. Plot boards for radar and TLM-18 tracking data
i. Conversion equipment for teletype transmission of radar, TLM-18 and doppler tracking data in binary format
j. Acquisition programmer for pre-acquisition direction of antennas
k. Ground command to satellite transmission equipment
l. Guidance computer

GROUND SUPPORT FACILITIES



A. THOR—SM-75 / AGENA "A"

B. THOR—DM-21 MB-3 Block 1 / AGENA "B" XLR81-Ba-7

C. THOR—DM-21 MB-3 Block 2 / AGENA "B" XLR81-Ba-9

Flight History

DISCOVERER No.	AGENA No.	THOR No.	Flight Date	Remarks
0	1019	160	21 January	*AGENA destroyed by malfunction on pad. THOR refurbished for use on flight XII.*
I	1022	163	28 Feb 1959	*Attained orbit successfully. Telemetry received for 514 seconds after lift-off.*
II	1018	170	13 April	*Attained orbit successfully. Recovery capsule ejected on 17th orbit was not recovered. All objectives except recovery successfully achieved.*
III	1020	174	3 June	*Launch, ascent, separation, coast and orbital boost successful. Failed to achieve orbit because of low performance of satellite engine.*
IV	1023	179	25 June	*Same as DISCOVERER III.*
V	1029	192	13 August	*All objectives successfully achieved except capsule recovery after ejection on 17th orbit.*
VI	1028	200	19 August	*Same as DISCOVERER V.*
VII	1051	206	7 November	*Attained orbit successfully. Lack of 400-cycle power prevented stabilization on orbit and recovery.*
VIII	1050	212	20 November	*Attained orbit successfully. Malfunction prevented AGENA engine shutdown at desired orbital velocity. Recovery capsule ejected but not recovered.*
IX	1052	218	4 February	*THOR shut down prematurely. Umbilical cord mast did not retract. Quick disconnect failed, causing loss of helium pressure.*
X	1054	223	19 February	*THOR destroyed at T plus 56 sec. by Range Safety Officer.*
XI	1055	234	15 April	*Attained orbit successfully. Recovery capsule ejected on 17th orbit was not recovered. All objectives except recovery successfully achieved.*

Monthly Progress—DISCOVERER Program

Flight Test Progress

- DISCOVERER XI was launched from Pad 5, Vandenberg Air Force Base, at 1230 hours, PST, on 15 April. No technical holds were encountered during the countdown. Terminal countdown time was only 12 minutes, 45 seconds. Significant events occurred as follows:

1. Liftoff was normal and boost trajectory was nominal.
2. Second stage separation occurred at T plus 186 seconds.
3. Trajectory during the coast period was slightly below normal dictating early AGENA engine ignition.
4. AGENA performance was very close to nominal.
5. Orbital status of the vehicle was indicated by ascent radar tracking.

- The resulting orbit has a perigee of 109.5 statute miles, an apogee of 380 statute miles, an eccentricity of .033 and an orbital period of 92.3 minutes.

- Acquisition was accomplished by every station on every pass. All fifteen commands were received and verified. The horizon scanner, inertial reference package, and gas jet control system functioned extremely well, resulting in excellent satellite attitude stabilization. The satellite power supply, including the two advanced design static inverters, performed efficienty. The main batteries lasted through the 26th orbit.

- DISCOVERER XI was the first orbiting AGENA to carry the dual-frequency doppler beacon (APL) used in the TRANSIT Program. This vehicle also carried four optical tracking lights which were visible at night as a seventh-magnitude star. These lights were photographed by cameras at a Smithsonian Astrophysical Observatory station providing the most precise satellite tracking data ever obtained. Both frequencies of the doppler beacon operated and were tracked during all passes. Sufficient data were received to determine the accuracy of the TRANSIT beacon and the DISCOVERER verlort radar stations by comparison with precise optical data.

- Telemetry data indicate that the recovery capsule was ejected on the 17th orbit as planned. A good track of the recovery capsule telemetry transmitter was obtained by the Kaena Point station, showing a high re-entry trajectory beyond the capability of the recovery forces. Analysis of all available data is being conducted to determine the cause of this high trajectory out of orbit.

- Four AGENA "B" vehicles have been added to the DISCOVERER Program. These additional vehicles bring the DISCOVERER/AGENA "B" total to sixteen.

Technical Progress

Second Stage Vehicles

Differences in DISCOVERER vehicle configurations are defined on page A-5.

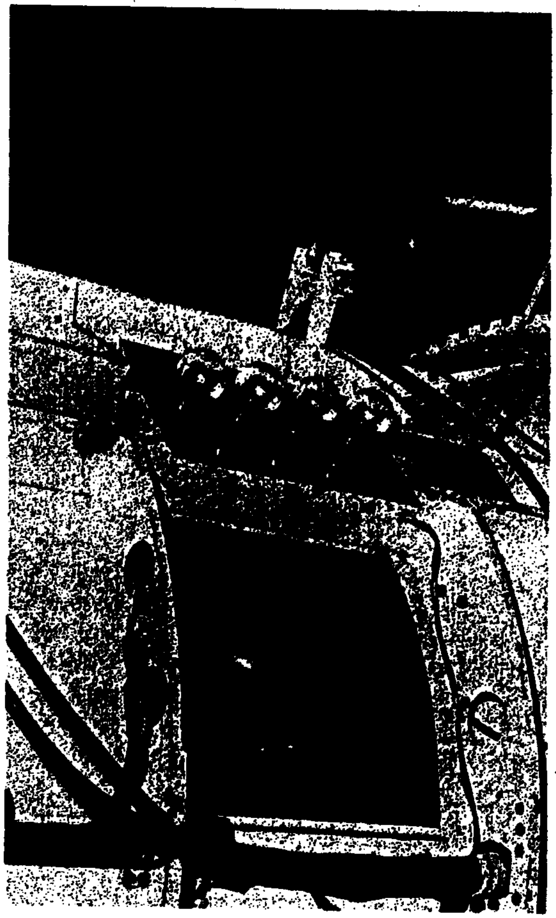


Figure 1. Optical tracking lights installed on aft equipment rack of DISCOVERER XI.

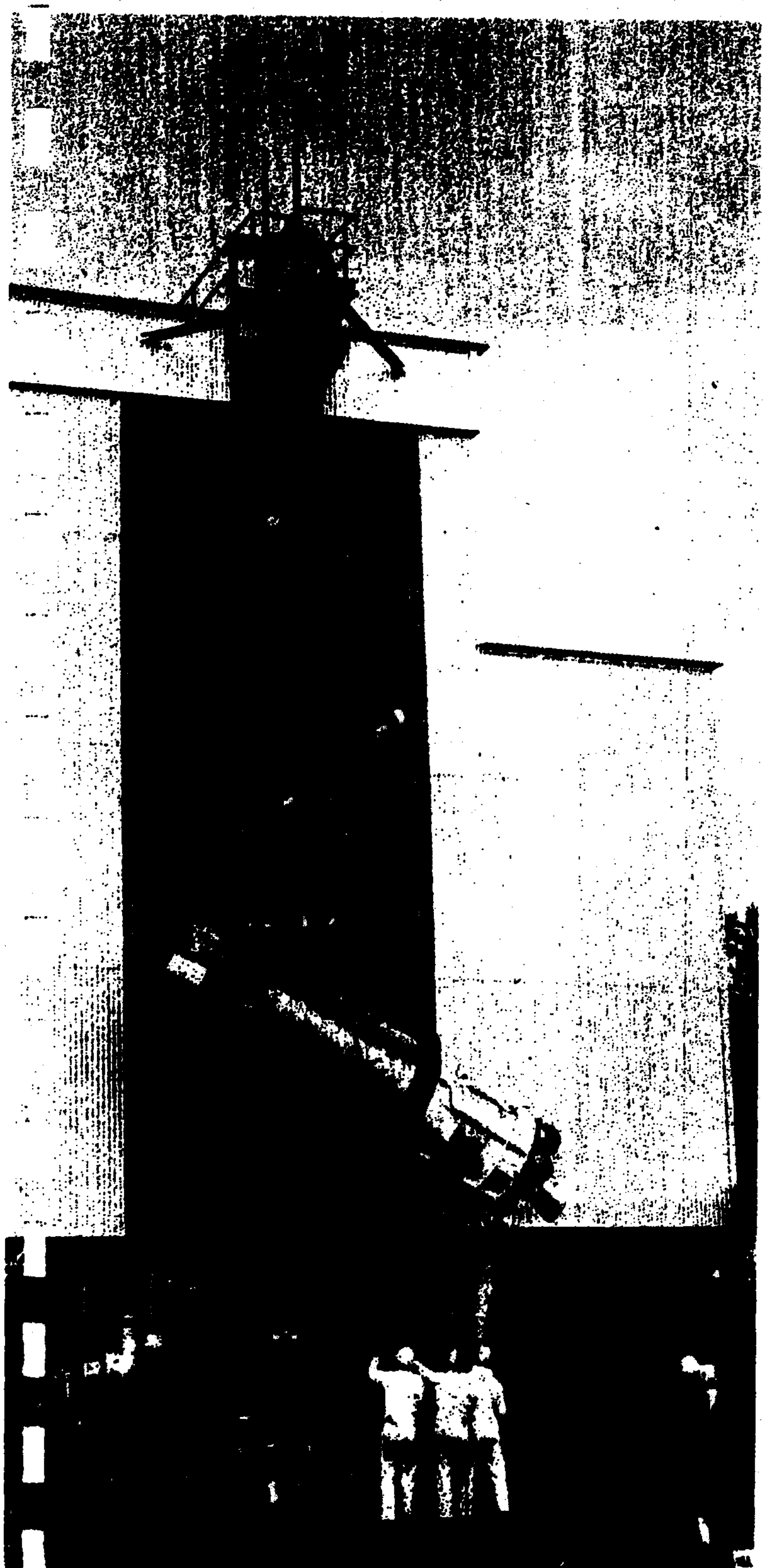


Figure 2. First DISCOVERER/AGENA "B" vehicle being installed in test stand 2 at Santa Cruz Test Base. This vehicle will be used on the DISCOVERED XVI flight.

- The AGENA "B" vehicles (XLR-81Ba-7 engine) for DISCOVERER flights XVI and XVIII underwent hot firing tests on 1 April and 19 April, respectively, at the Santa Cruz Test Base. The vehicle for flight XVI has been returned to the System Test Area for rework and a second system check prior to Air Force acceptance. Additional hot firing tests of this vehicle will not be required.

- Preliminary Flight Rating Tests (PFRT) of two XLR-81Ba-7 engines were completed during the month at the manufacturer's plant. The gas generator propellant valve malfunctioned during the tests and will be redesigned and retested.

- Testing of nozzle extensions for the XLR-81Ba-9 engine continued at Bell Aircraft and Arnold Engineering Development Center (AEDC). All tests of the 45:1 area ratio titanium nozzles have been successful. This nozzle has been released to production and will be used on flight vehicles. However, development of an uncooled nozzle which will provide a weight savings of five to ten pounds and simplify fabrication is continuing.

- Acceptance tests of the XLR-81Ba-9 engine at the engine contractor's facility revealed erosion of the thrust chamber throat. LMSD propulsion system representatives reviewed the problem with Bell Aircraft engineers and a program which provides for tighter control and acceptance testing of engine components is being established. A procedure for coating the thrust chamber with Zirconia is being instituted and injection modifications are being made which should reduce the amount of thrust chamber throat erosion.

- The Preliminary Flight Rating Test (PFRT) program for the XLR-81Ba-9 engine is scheduled to start 15 May using the existing thrust chambers. An additional PFRT program will be conducted to prove the realiability of the thrust chamber modifications prior to the first launch.

Antennas

- Type testing of the transistorized S-band beacon was accomplished during the month. The successful completion of these tests qualifies these weight saving beacons for use in the AGENA "B" vehicle. One of the beacons is undergoing compatibility tests at Vandenberg Air Force Base. The first flight beacon has been delivered to LMSD for installation in the AGENA "B" vehicle.

Biomedical Capsules

● Upon arrival at LMSD in May of the test capsule (USE-77), specialized biomedical environmental testing of flight components will begin. Vibration, centrifuge and impact tests designed to assure reliable flight operation will be conducted.

Ground Support Equipment

● Two new pieces of ground handling equipment for the AGENA "B" vehicle are now in use. The first is a ground handling dolly adaptable for either AGENA "A" or "B" configurations. The vehicle will be mounted in this stand during assembly and checkout. The other piece of equipment is the vehicle transporter. This trailer will be used to transport the AGENA "B" vehicle between LMSD, Santa Cruz Test Base and Vandenberg Air Force Base.

● An AGENA "B" facilities checkout vehicle for use at Vandenberg Air Force Base was completed during late April. This vehicle is capable of facilities checkout for the DISCOVERER, SAMOS and MIDAS programs.

Facilities

● The construction contract for the Vandenberg Air Force Base propellant storage and disposal facility has been awarded with completion scheduled for September.

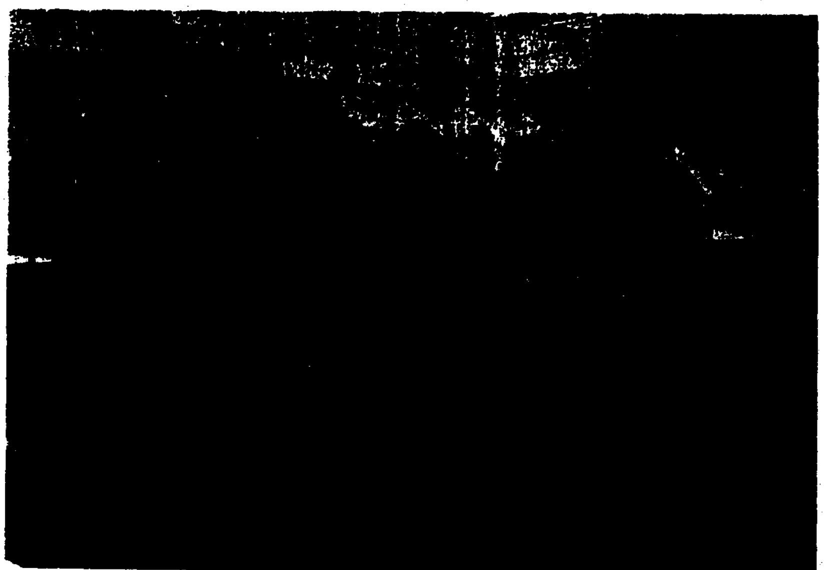
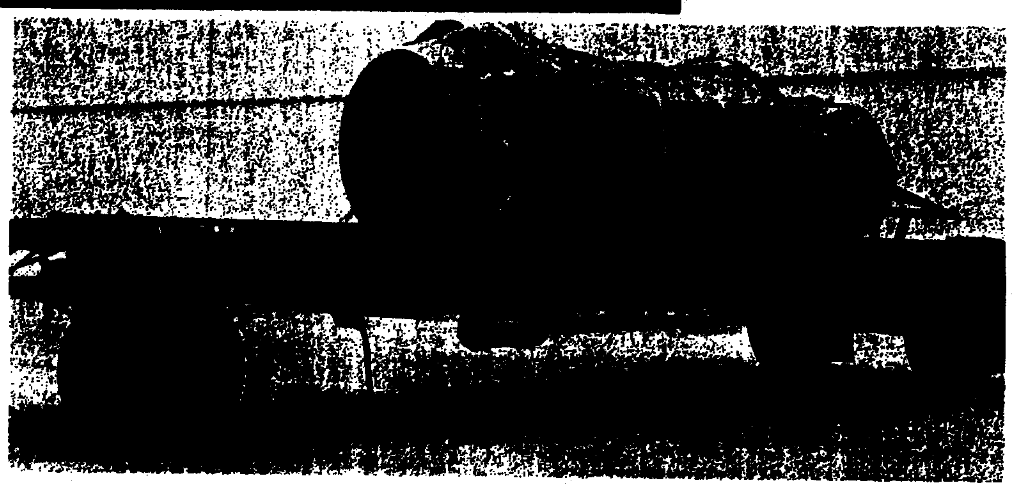


Figure 3. AGENA "B" vehicle mounted on new ground handling dolly in Systems Test Area (left). New transporter with AGENA "B" vehicle ready for delivery to Santa Cruz Test Base.



Samos

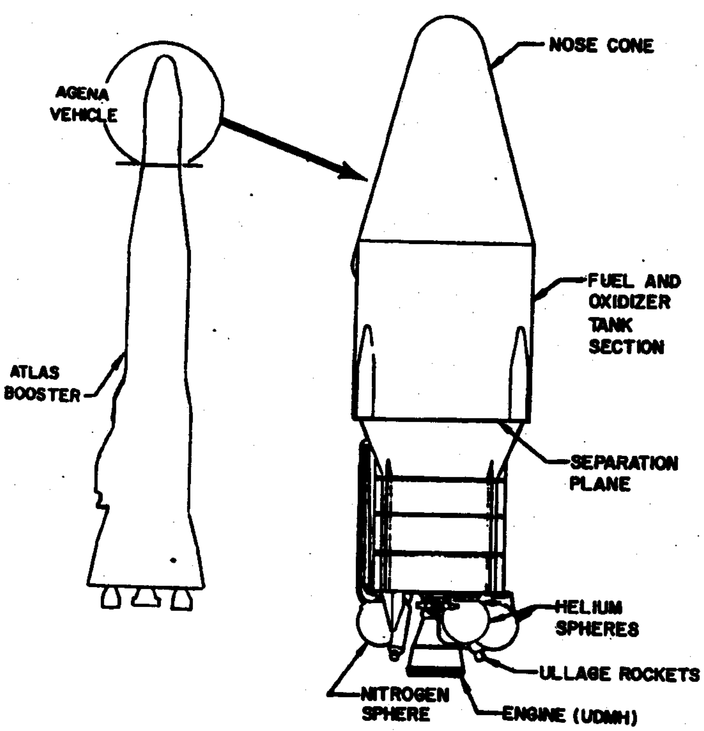
BOOSTER—ATLAS ICBM

Weight—Wet	15,100
Fuel, RP-1	74,900
Oxidizer (LOX)	172,300
GROSS WEIGHT (lbs.)	262,300
Engine—MA-2	
Thrust (lbs. vac.) Boost	356,000
Sustainer	82,100
Spec. Imp. (sec. vac.) Boost	286
Sustainer	310

SECOND STAGE	AGENA "A"	AGENA "B"
Weight—		
Inert	1,508	1,695
Payload equipment	2,605	3,058
Orbital	4,113	4,753
Impulse Propellants	6,492	12,950
Fuel (UDMH)		
Oxidizer (IRFNA)		
Other	606	718
GROSS WEIGHT (lbs.)	11,211	18,421
Engine	YLR81-Ba-5	XLR81-Ba-9
Thrust, lbs. (vac.)	15,600	16,000
Spec. Imp., sec. (vac.)	277	290
Burn Time, sec.	120	240

Figure 1.

Artists' concept of SAMOS satellite. Line drawing of complete flight vehicle (right) and detailed view of basic AGENA upper stage (left).



PROGRAM HISTORY

The SAMOS Program was included in Weapon System 117L when WS 117L was transferred to the Advanced Research Projects Agency early in 1958. ARPA separated WS 117L into the DISCOVERER, SAMOS and MIDAS programs with the SAMOS objectives based on a visual and ferret reconnaissance system. On 17 November 1959 responsibility for this program was transferred from ARPA to the Air Force by the Secretary of Defense.

PROGRAM MISSION

The primary mission of the SAMOS advanced reconnaissance system is to provide visual and electronic reconnaissance of the USSR and its allied nations. Efforts include development of hardware to permit:

a. Determination of characteristics of enemy electronic emissions.
b. Verification of known targets, detection of unknown targets.
c. Location and evaluation of defenses.
d. Evaluation of military and industrial strength.
e. Assessment of high-yield weapons damage.
f. Reconnoitering of troop movements.
g. Location of naval forces throughout the world.

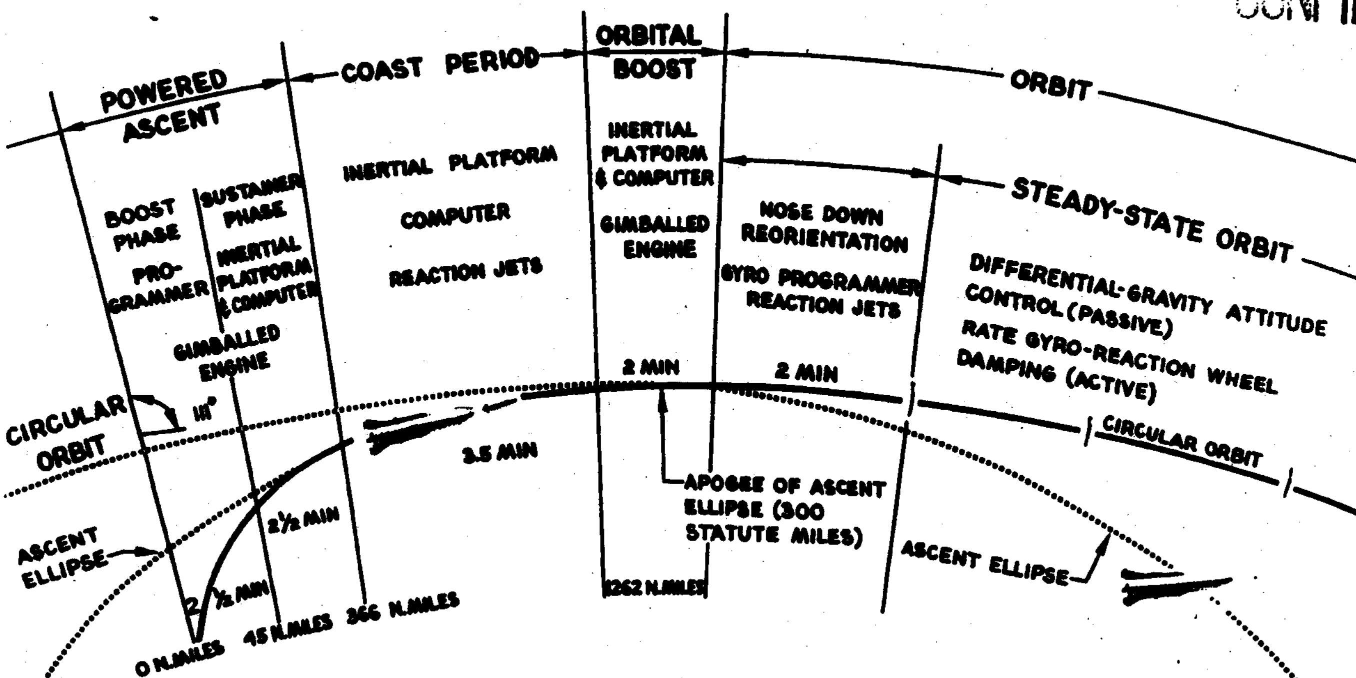


Figure 2. Typical SAMOS trajectory, launch- to-orbit.

Ferret Reconnaissance...

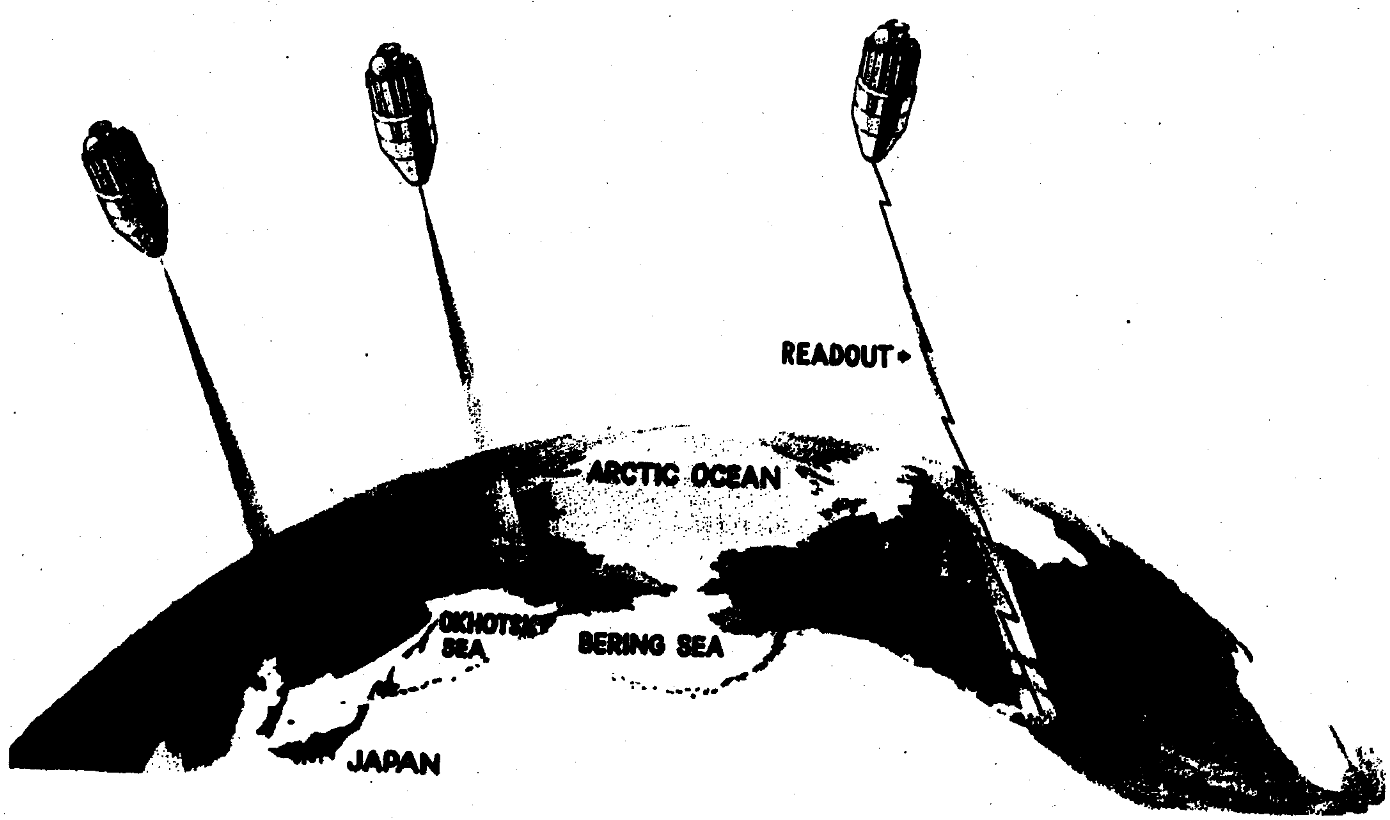


Figure 4. The Ferret reconnaissance system will gather data from electronic emissions over areas of interest.

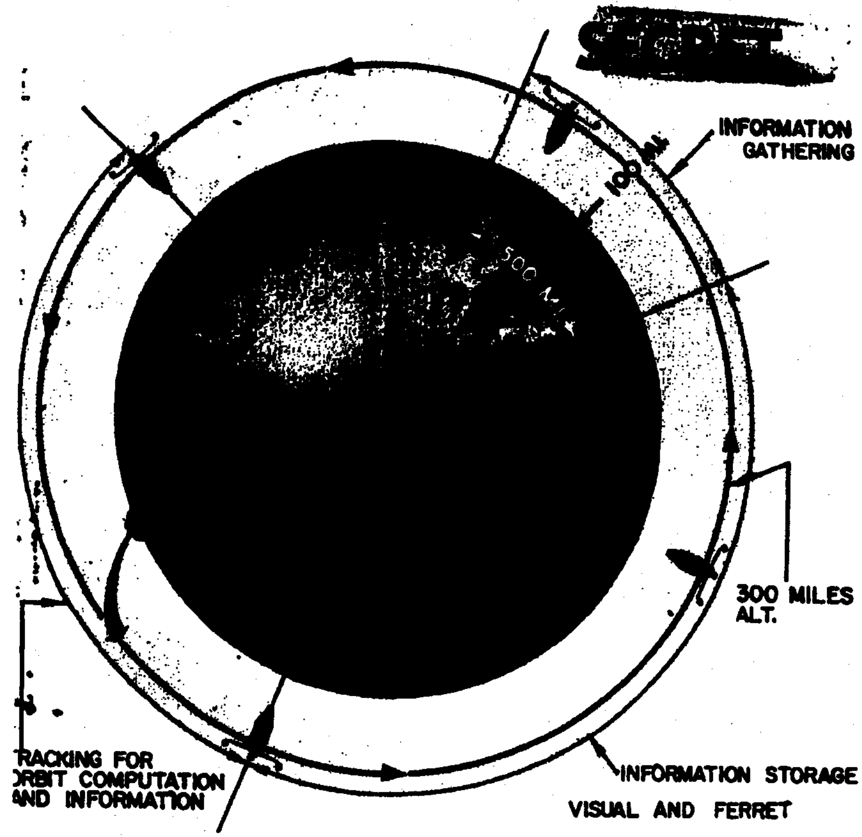


Figure 3.
Schematic of SAMOS system in operational orbit. When the satellite is over the area of interest the sensing equipment is turned on (Information gathering). When it leaves the area of interest the sensing equipment is turned off and the sensing data is processed (Information storage). When the vehicle comes within range of a ground receiving station, the data will be read-out upon command for processing and transmitted to using agencies. This process is continuously repeated during the useful lifetime of the vehicle.

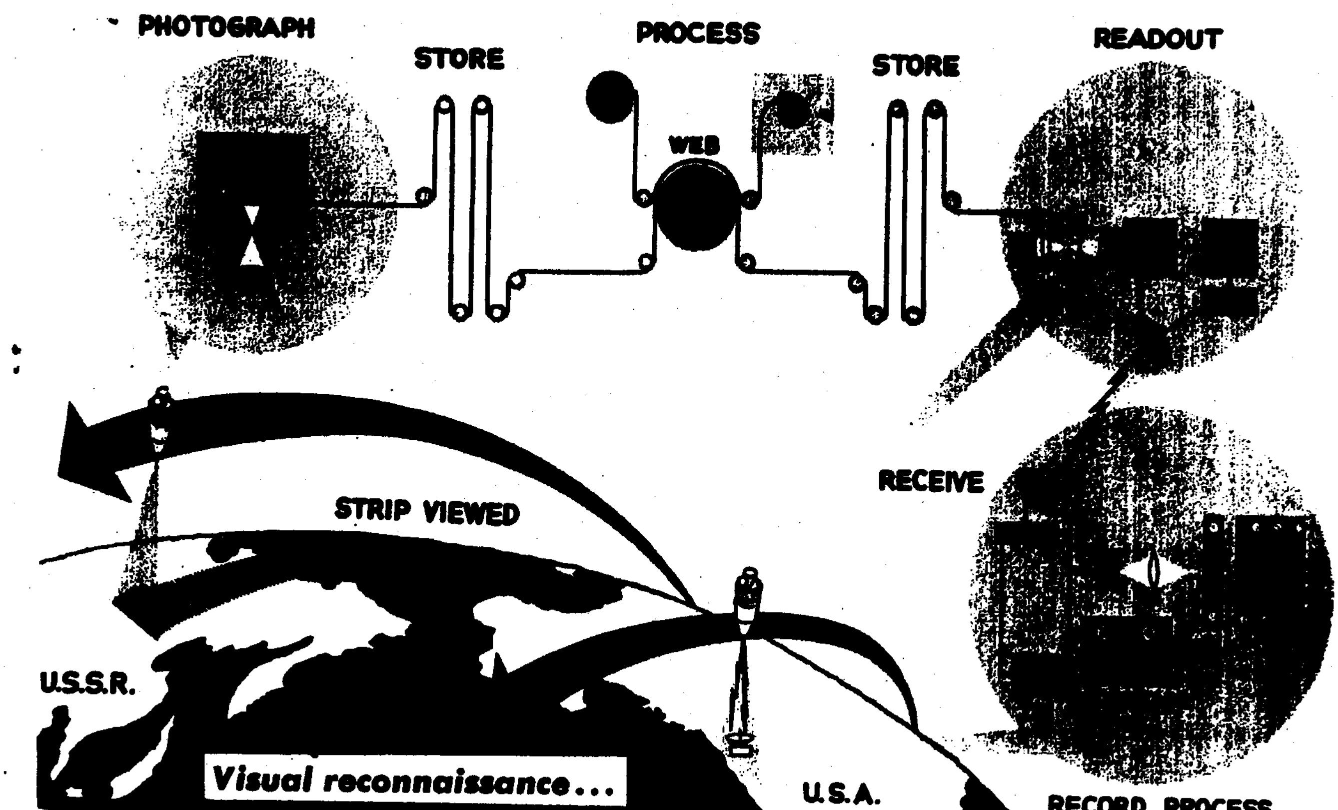


Figure 5.
The initial visual reconnaissance program will use conventional photo techniques with automatic film processing and TV-type electronic image readout to ground stations thru a data link. Ground electronics will reconvert the signal into photo image form, with a capability of resolving objects 20 feet in length.

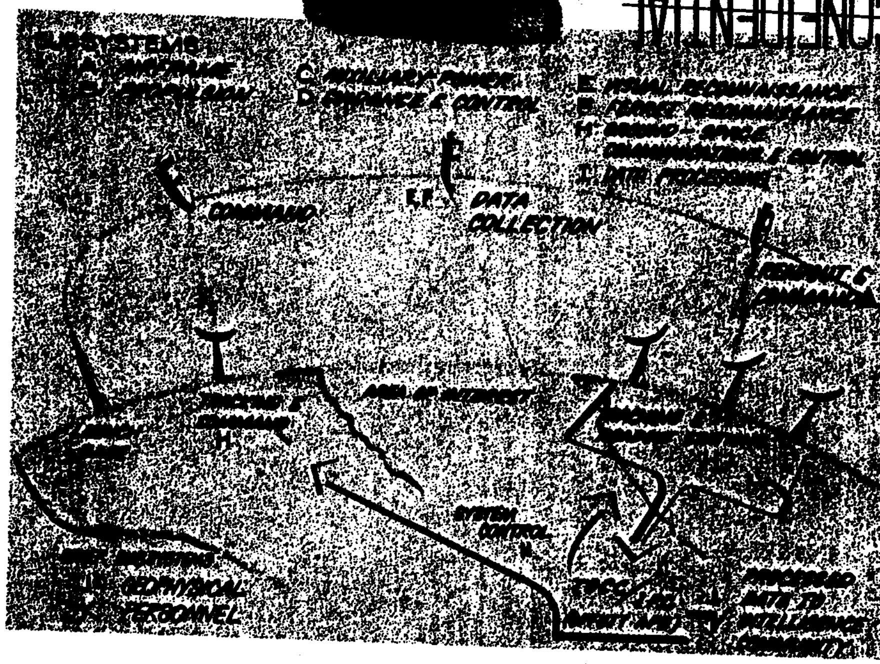


Figure 6. SAMOS concept, showing reception of commands and transmission of data between satellite and ground station; and subsystem functions (schematic).

For economical testing of components a dual-capability visual and ferret payload will be used during the early development phase. On later flights only a visual or ferret system payload will be carried. These payloads will be housed in the AGENA vehicle (Figure 1).

Data collected by the visual payloads will be electronically transmitted in the readout system and retrieved in the recovery system. Ferret data will be transmitted electronically. These systems are composed of the AGENA vehicle, ATLAS booster, launch facilities, tracking facilities, and a communications and data processing network. The recovery system will also include a re-entry capsule and a recovery force.

CONCEPT

ATLAS Series D missiles launched from VAFB will boost the AGENA vehicle into polar orbits. Injection into near-circular orbits (Figure 2) will be accomplished by the AGENA vehicle rocket engine. A self-contained guidance system using a horizon reference scanner will provide altitude stabilization. As the satellite travels in an orbit essentially fixed in space the earth rotates inside the orbit (Figure 3). Each successive orbit is displaced laterally approximately 23½ degrees at the equator, permitting one vehicle to observe the entire earth in a time period dependent upon the width of the area under surveillance. Early versions will have a useful life of approximately ten days. The readout systems will have a useful life of four months with a design objective in certain configurations of one year; recovery systems will have a useful life of fifteen to thirty days.

TECHNICAL DESCRIPTION

Visual Program—Payload camera, film processor and electronics readout equipment are being developed by Eastman Kodak Co. Cameras having a 36-inch focal length are being used. The payload equipment includes automatic film processing, film transport and take-up, electronic readout and temperature controls. The recoverable system will retain both the exposed film and the 66-inch local length camera.

Ferret Program—Ferret payloads are being developed on a progressively more advanced basis from R&D (F-1) to advanced systems (F-4). The F-2 all-digital, general coverage payload will use superheterodyne scanning receivers in conjunction with directional antennas, an analog to digital converter and tape recorders (for storage). A programmer will be used to control read-in over areas of interest and readout over tracking stations. The F-3 payload will use similar receivers with stop-scan capability and controllable antennas added. Recording of the actual signal intercepted (rather than the digital representation) will be possible with a bandwidth up to 6mc. A complex programmer will permit satellite search of a given area or frequency range.

Monthly Progress—SAMOS Program

Second Stage Vehicles

- The AGENA vehicle for the first SAMOS flight is undergoing system checks in the System Test Area. Late delivery of airborne communications equipment, vehicle wiring changes and problems encountered in completion of the systems checkout complex has caused a one-month delay. The wiring changes were completed on 6 April, the UHF narrow band transmitter was delivered on 14 April. The systems checkout complex is complete except for equipment to check out the UHF wide band transmitter. Completion of systems tests and shipment to Santa Cruz Test Base for hot firings is schedulel for mid-May.

- The second AGENA flight vehicle was delivered to the System Test Area on 11 April. Vehicle wiring changes caused a two-week delay in delivery.

- Final assembly of the third and last AGENA "A" vehicle is in progress. This vehicle will be delivered to the Systems Test Area on schedule.

- Design efforts for the first of seven AGENA "B" vehicles scheduled to carry the recoverable payload (E-5) are proceeding on schedule.

Visual Reconnaissance Systems

- Visual Reconnaissance System payloads are being developed in a minimum number of configurations to attain readout and recovery mission objectives. The design and purpose of each configuration is as follows:

  Readout:

  E-1—Component Test Payloads

  E-2—Steerable Reconnaissance Payloads (with 20-foot ground resolution)

  Recovery:

  E-5—High Resolution, Steerable, Recoverable Payload (with 5-foot ground resolution)

Payloads

- E-1 Payloads—Operational tests of the second E-1 payload were successfully completed and the payload was accepted at Eastman Kodak on 14 April. The tests were of 19 and 48 hours duration. The payload is being prepared for subsystem testing and installation in the vehicle. A thermal model of the E-1 payload also was delivered during the month. This model will be used for additional environmental testing. Modification and checkout of the third E-1 payload is continuing.

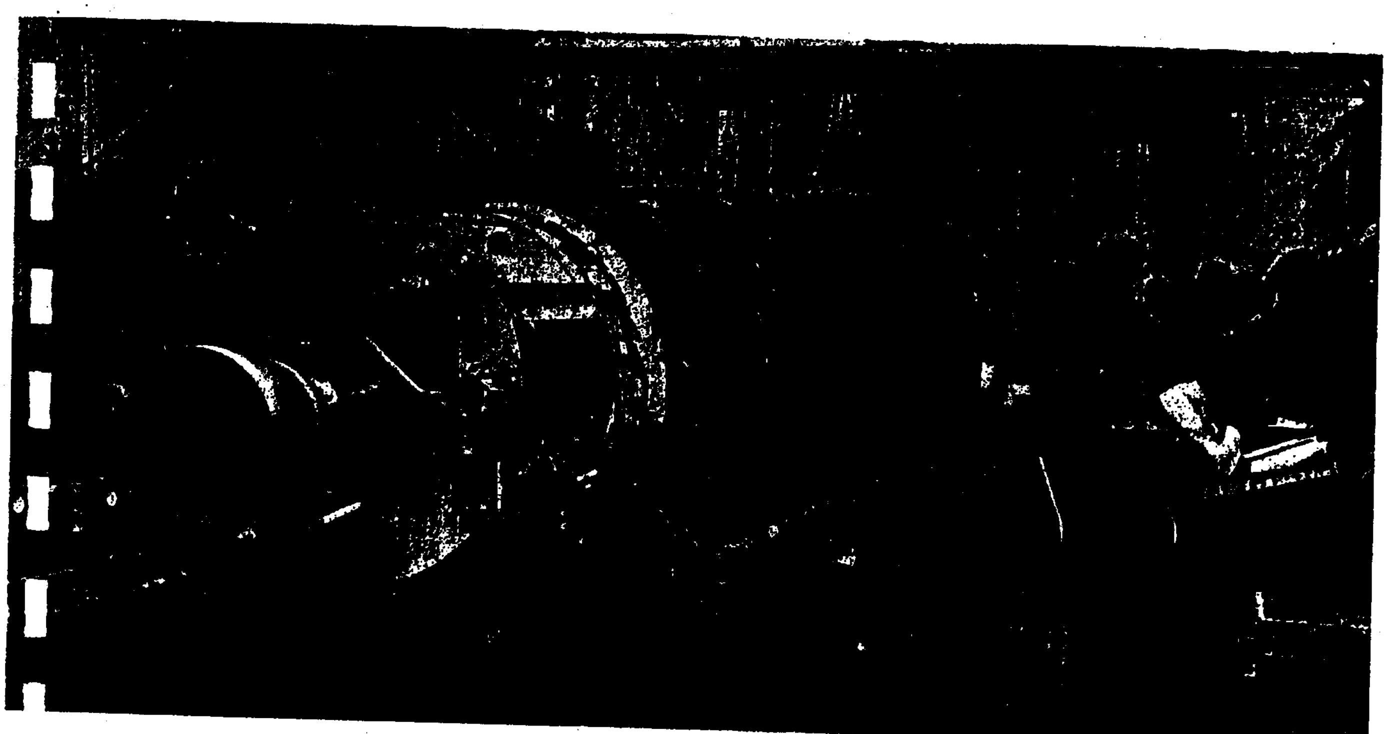


Figure 7. The first SAMOS/AGENA vehicle during checkout in the Systems Test Area. The E-1 and F-1 payloads are mounted on the forward handling fixture.

- E-5 Payloads—the basic design approach was established and preliminary interface problems involving the E-5 recovery payload were resolved during this report period.

Ground Support Equipment

- The vacuum test chamber for use in leak testing E-1 and E-2 payloads prior to launch and the E-1 test console was shipped to the Missile Assembly Building at Vandenberg Air Force Base during the first week in April. Installation and alignment of the E-1 collimator and checkout of the E-1/E-2 ground reconstruction electronics equipment at the Missile Assembly Building are nearing completion. Delivery of the operating console and the ground reconstruction electronics equipment with repeater kinescope for the Vandenberg tracking and acquisition station is scheduled during May.

Ferrett Reconnaissance System

- Ferrett Reconnaissance System payloads are being developed in a minimum number of configurations. The designation and purpose of each configuration is as follows:

F-1—R&D Test Payloads

F-2—Digital General Coverage Payloads

F-3—Specific Mission Payloads—Analog Presentation

F-4—Technical Analysis (study stage only)

Payloads

- F-1 Payloads—Significant refinements were made in F-1 payload design during the report period. Circuitry improvements being tested on an F-1 service test model at Airborne Instruments Laboratory indicate a potential increase of approximately 5 db pulse width measurement sensitivity.

- F-2 Payloads — Environmental test of the F-2 thermal mockup were conducted in the high altitude temperature simulator early in April. Preliminary analysis of the test results indicate that the use of surface coatings will provide the required thermal control for all orbital conditions.

Ground Support Equipment

- Installation of the F-1 data conversion equipment at the Satellite Test Center was completed ahead of schedule. This equipment converts the F-1 payload digital data for data processing. Checkout and preliminary system testing will start soon.

Communications and Control Equipment

- The first of the three AN/GPS-T1A calibration vans was received at LMSD on 8 April. These vans will be used to transmit calibrated signals to F-1 and initial F-2 payloads in orbit. The first van will be used for crew training and will then be transported to its assigned station along U.S. Highway 30. Vans 2 and 3 will be placed at 400 mile intervals along this highway. These vans are scheduled to be delivered during May.

- Seventy percent of the UHF ground system equipment has been delivered to Vandenberg Air Force Base and installation has been started. The majority of angle tracker ranging system and data receiving equipment components (including the 60-foot tracking and acquisition antenna) are on the site. The command transmitter antenna also has arrived at Vandenberg Air Force Base.

- The shortage of acceptable magnetron tubes for the narrow band transmitters may result in the substitution of a transmitter manufactured by General Electronics Laboratories on early SAMOS flights. Because of the tight delivery schedule, installation of the transmitter will be accomplished at Vandenberg Air Force Base on early SAMOS vehicles.

- Installation of the first Model 1604 computer and most of its support equipment in the Satellite Test Center was accomplished on time. Acceptance tests, which include 72 hours of computer operation using programs and operations with known results, were completed late in April.

Figure 8. The vacuum test chamber prior to installation in the Missile Assembly Building at Vandenberg Air Force Base.

Facilities

- Vandenberg Air Force Base—Completion of the technical supporting building is scheduled for October. Completion of the SAMOS laboratory building is scheduled for July. Construction of the data acquisition and processing building is complete and installation of equipment is in progress. Design of a data acquisition and processing building modification to permit installation of a new computer has been completed. Bids for construction have been advertised with completion scheduled for July. The last two consoles for checkout complex 2A in the Missile Assembly Building were delivered on 26 April.

- Offutt Air Force Base—A construction contract has been awarded for the construction of the interim data processing facility. Notice to proceed has been deferred by request of the Under Secretary of the Air Force.

- Point Arguello—Installation of the launch control equipment for pad 1 is nearing completion. All ground handling and service equipment for both pads has been delivered to the launch site and installation of the equipment at pad 1 is essentially complete. Acceptance testing of the launch monitoring control equipment for pad 2 was completed on 25 April at LMSD. Final acceptance of launch pad 2 is scheduled for May. The beneficial occupancy date for the technical support building is now scheduled for August.

Figure 9. Model 1604 computer (left) showing page frame construction for magnetic core memory and printed circuit cards. Control console (below) for model 1604 computer installed in the Satellite Test Center.

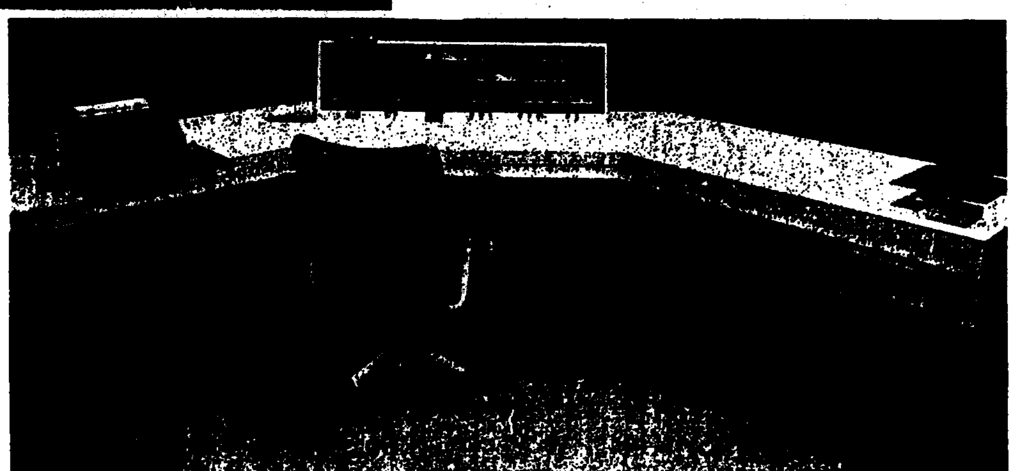
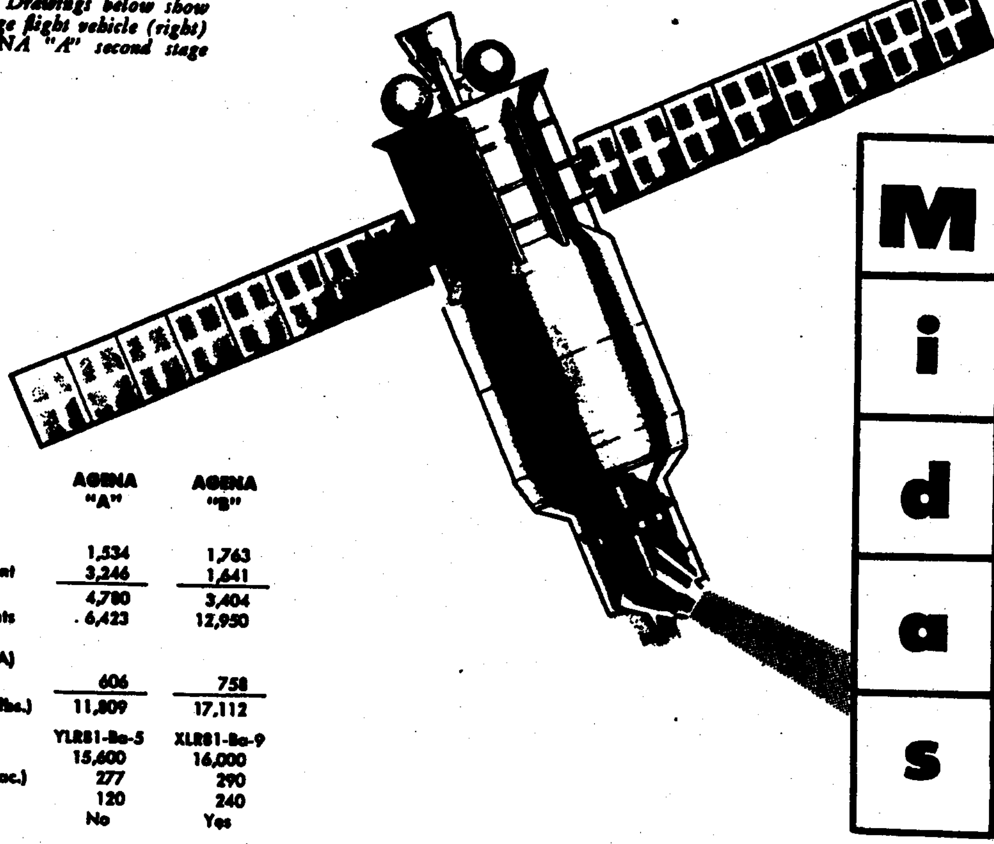
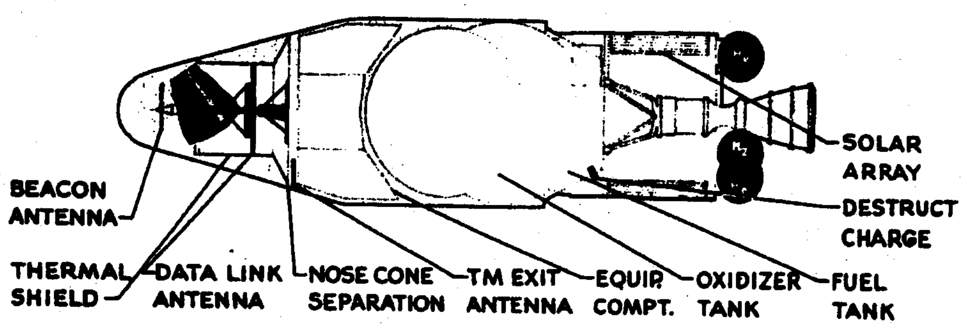
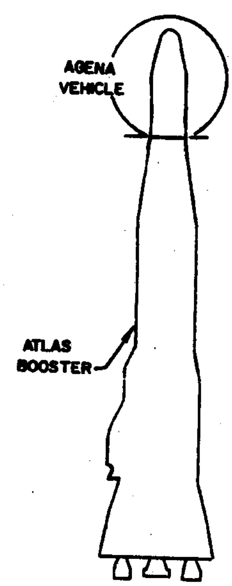


Figure 1. Artist's concept of MIDAS satellite (right). Drawings below show complete two-stage flight vehicle (right) and basic AGENA "A" second stage vehicle (left).



SECOND STAGE	AGENA "A"	AGENA "B"
Weight—		
Inert	1,534	1,763
Payload equipment	3,246	1,641
Orbital	4,780	3,404
Impulse Propellants	. 6,423	12,950
Fuel (UDMH)		
Oxidizer (IRFNA)		
Other	606	758
GROSS WEIGHT (lbs.)	11,809	17,112
Engine	YLR81-Ba-5	XLR81-Ba-9
Thrust, lbs. (vac.)	15,600	16,000
Spec. Imp., sec. (vac.)	277	290
Burn Time, sec.	120	240
Restart Provisions	No	Yes





NOTE: AGENA "A" configuration except for solar paddles (AGENA "B" only).

BOOSTER—ATLAS ICBM		
Weight—Wet		15,100
Fuel, RP-1		74,900
Oxidizer (LOX)		172,300
GROSS WEIGHT (lbs.)		262,300
Engine—MA-2		
Thrust (lbs. vac.)	Boost	356,000
	Sustainer	82,100
Spec. Imp. (sec. vac.)	Boost	286
	Sustainer	310

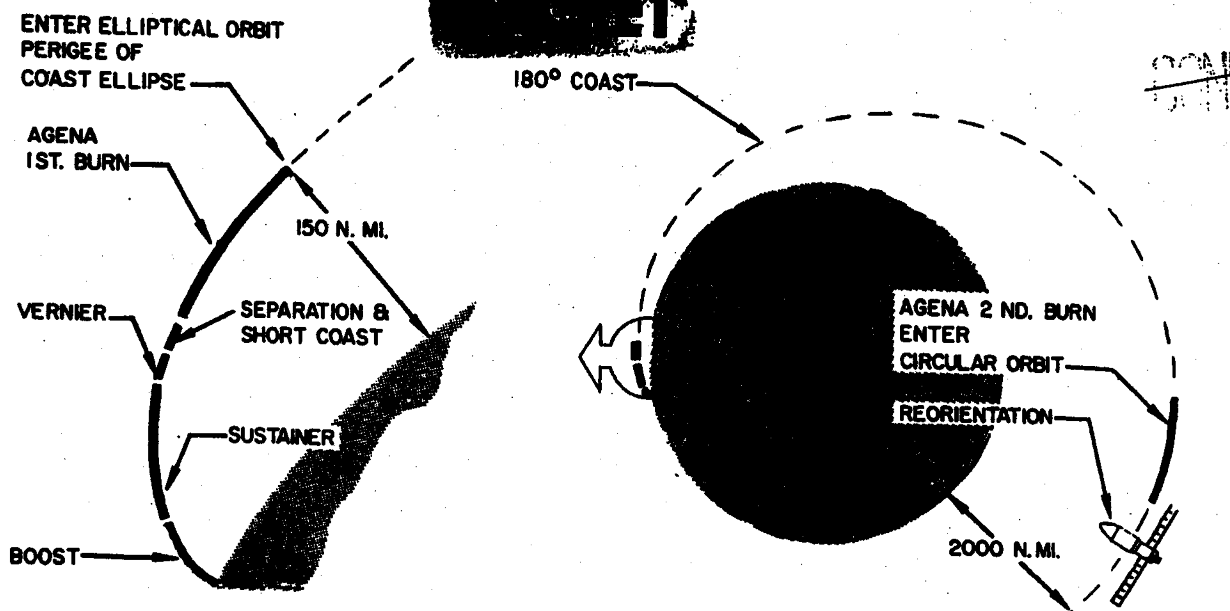


Figure 2.
Launch-to-orbit trajectory for flights 3 and subsequent. Optimum ATLAS boost, guided by radio-inertial system. AGENA ascent (coast, burn, coast, second burn) provides attitude reference. Also governs velocity magnitude and direction by inertial guidance system monitored by horizon scanner. Orbital attitude maintained by reaction wheel and gas jets.

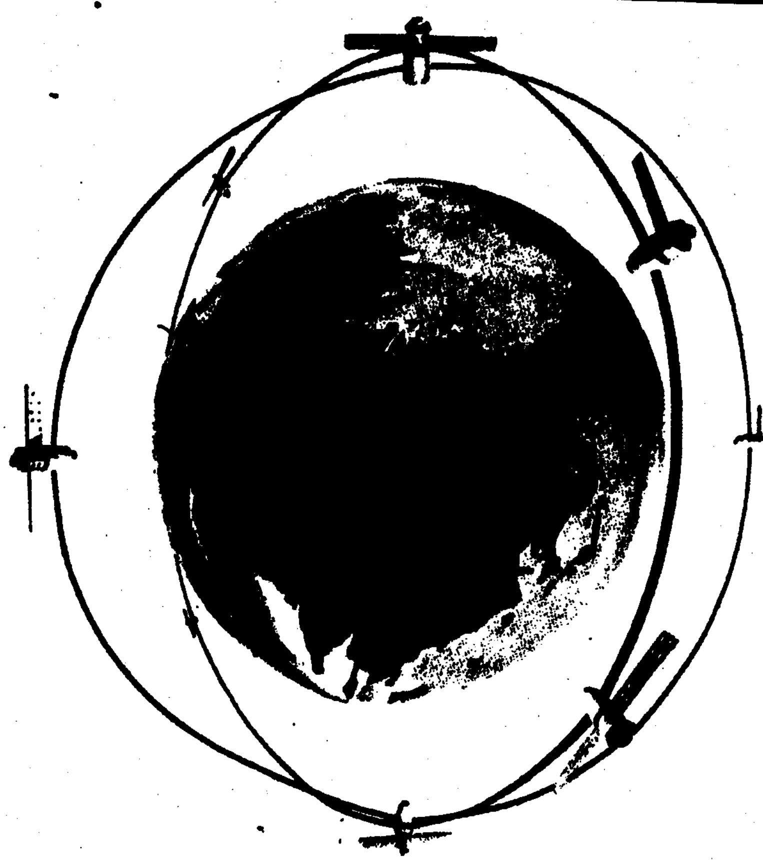


Figure 3.
Proposed MIDAS system. Four satellites spaced equidistant in each of two orthogonal planes at 2,000 n.m. altitude. Provides maximum coverage of USSR with minimum number of satellites.

PROGRAM HISTORY

The MIDAS Program was included in Weapon System 117L when WS 117L was transferred to the Advanced Research Projects Agency early in 1959. ARPA subsequently separated WS 117L into the DISCOVERER, SAMOS and MIDAS Programs, with the MIDAS objectives based on an infrared reconnaissance system. The MIDAS (Missile Defense Alarm System) Program was directed by ARPA Order No. 38, dated 5 November 1958 until transferred to the Air Force on 17 November 1959. An ARDC development plan for a ten flight R&D program has been approved. This R&D program will make possible the achievement of a reliable operational system by 1963.

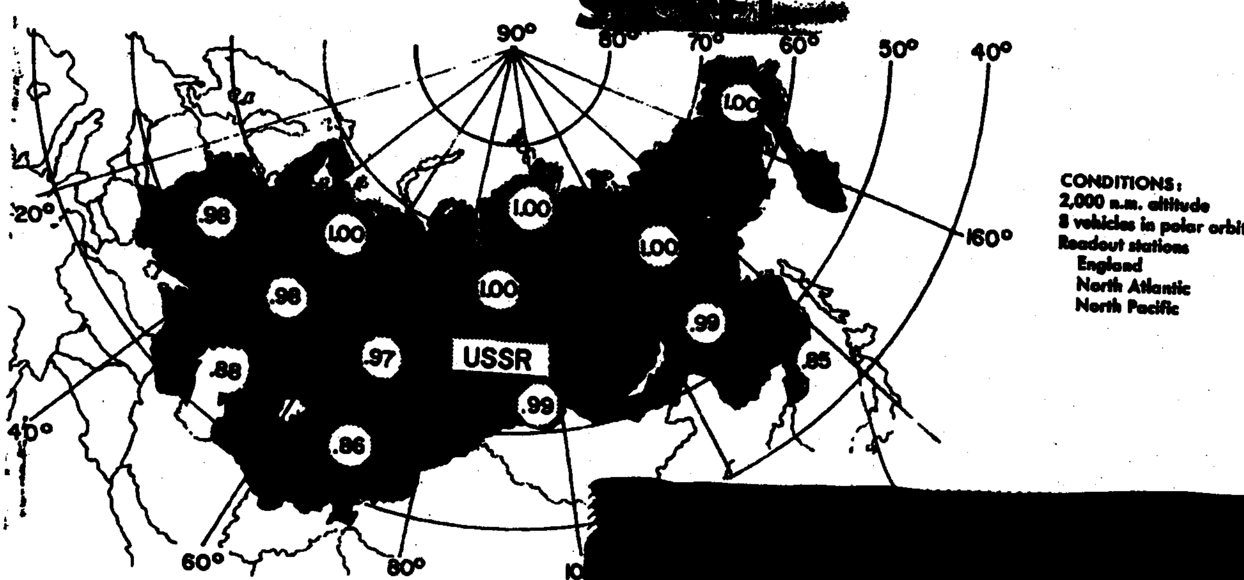


Figure 4.
Orbiting satellites detect infrared radiations emitted by Soviet ICBM's in powered flight. Data telemetered instantaneously to MIDAS Control Center via far north readout stations. Decoded data reveals approximately the number of missiles launched and launch location, direction of travel and burning characteristics. Map above shows probability of at least one MIDAS satellite detecting an ICBM launch in each of the illustrated segments of the USSR. These probabilities are based on geometric considerations.

[redacted]

TECHNICAL HISTORY

The MIDAS infrared reconnaissance payload is engineered to use a standard launch vehicle configuration. This consists of a "D" Series ATLAS missile as the first stage and the AGENA vehicle, powered by a Bell Aircraft rocket engine as the second, orbiting stage (Figure 1). The total payload weight is approximately 1,000 pounds.

The first two of the ten R&D flights will use the AGENA "A" vehicle which is programmed to place the payload in a circular 261 nautical mile orbit. Subsequent flights will utilize the ATLAS/AGENA "B" configuration which will be programmed to place the payload in a circular 2,000 nautical mile polar orbit.

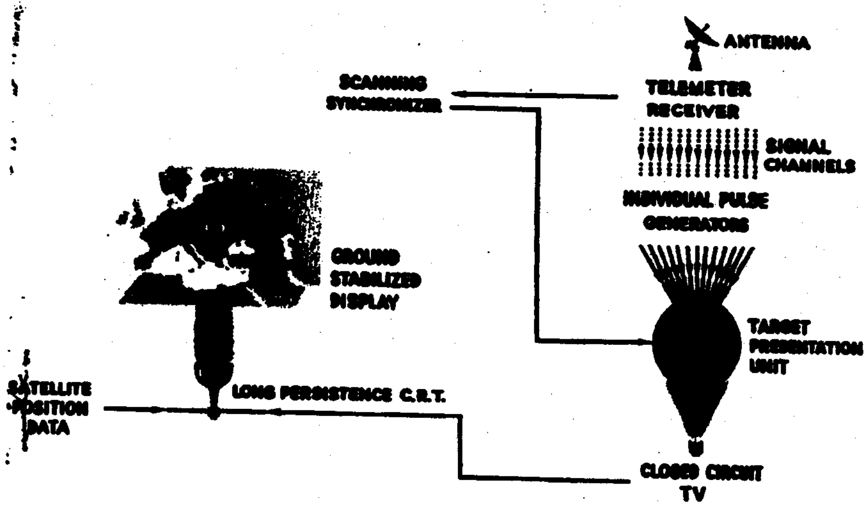
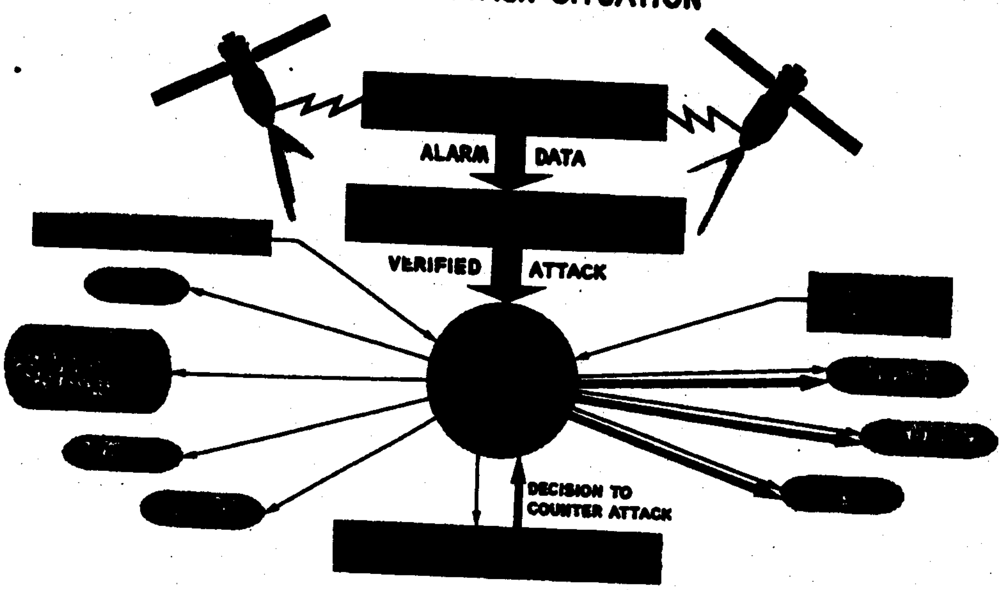


Figure 5.
Simplified version of ground presentation system (left) for display of infrared reconnaissance data. The data is displayed on a TV monitor with a map overlay. The chart below shows data flow from the readout stations to decision-making agencies. The MIDAS Control Center, or other using agencies having a correlated ground stabilized display, can determine when an actual attack has been launched. The decision to counterattack is made by the President, with all affected agencies reacting as preplanned.

ICBM ATTACK SITUATION



CONCEPT

The MIDAS system is designed to provide continuous infrared reconnaissance of the Soviet Union. Surveillance will be conducted by eight satellite vehicles in accurately positioned orbits (Figure 3). The area under surveillance must be in line-of-sight view of the scanning satellite. Mission capabilities are shown in Figure 4. The system is designed to accomplish instantaneous readout of acquired data by at least one of three strategically located readout stations. The readout stations transmit the data directly to the MIDAS Control Center where it is processed, displayed, and evaluated (Figure 5.) If an attack is determined to be underway, the intelligence is communicated to a central Department of Defense Command Post for relay to the President and all national retaliatory and defense agencies.

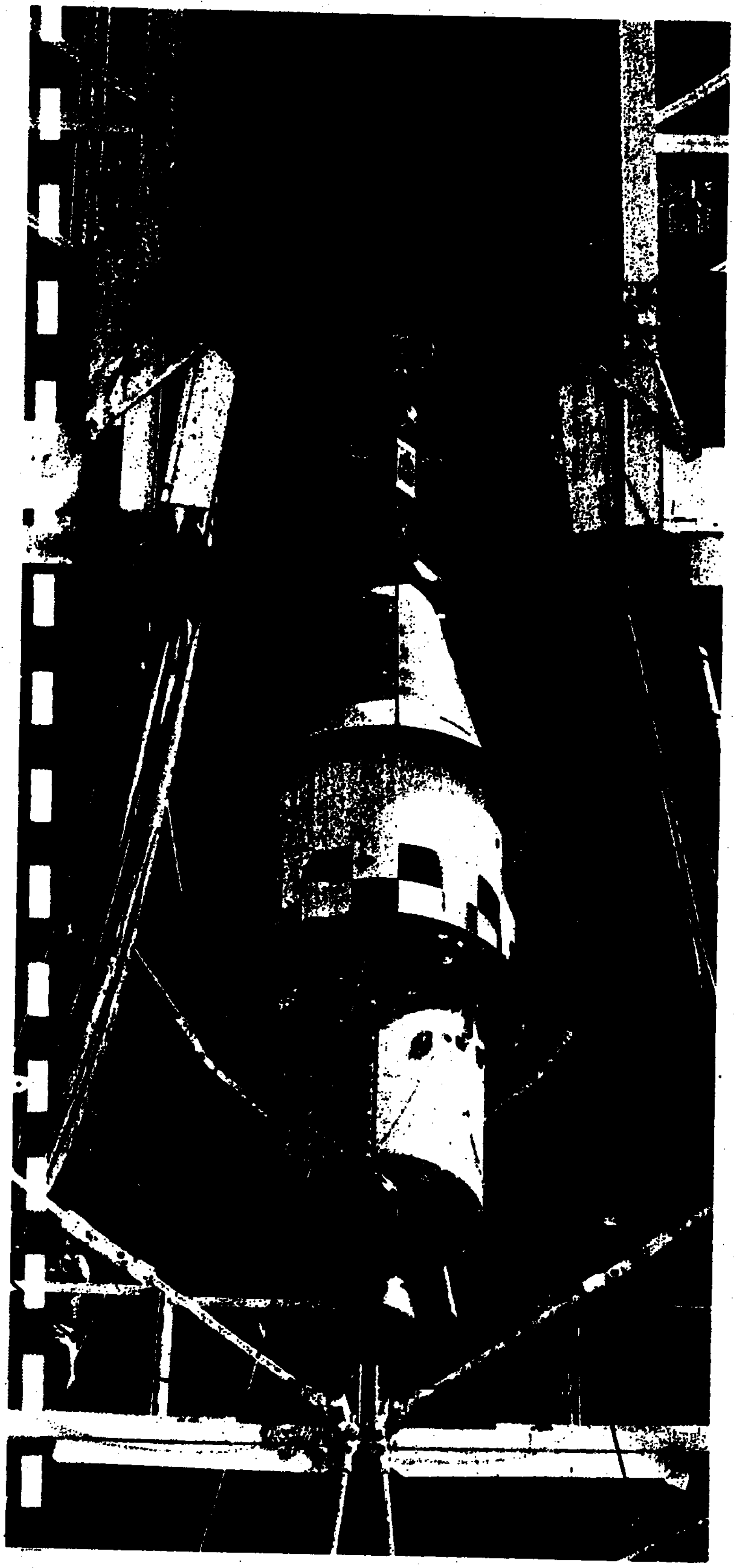


Figure 6. AGENA vehicle for MIDAS flight 2 prior to mating with ATLAS booster at AMR Stand 14.

Monthly Progress—MIDAS Program

Flight Test Progress

- Preparations for the second MIDAS flight continued during the month. This flight was rescheduled from late March to 12 May because of problems with both the AGENA vehicle and the ATLAS booster. The diodes in the AGENA flight control package have been replaced and a special wiring inspection and servicing was accomplished to improve reliability. The present launch date is indefinite pending a solution of the ATLAS combustion instability problems.

- AFBMD has authorized preliminary planning and design work in support of two additional MIDAS flights using THOR/AGENA vehicles from the DISCOVERER program. These flights which would be scheduled for late this year, are contingent upon the results of the second MIDAS flight. The preliminary design of required modifications to the DISCOVERER/AGENA vehicles has been initiated. These THOR boosted flights would be boosted into polar orbits from Vandenberg Air Force Base. The payloads would be the "B" prototype Baird-Atomic scanner, modified for flight purposes, and the Aerojet-General scanner No. 3. Ground support equipment used for flights one and two would be transferred from the Atlantic Missile Range to Vandenberg Air Force Base to support these additional flights. The major objective of the proposed interim flights would be to obtain basic payload data for evaluation and analysis.

- An investigation is being made of the feasibility of extending MIDAS operational system capability to provide worldwide coverage, including detection of IRBM and Fleet Ballistic Missile launches. The study will consider the number of additional satellites and ground stations required to support this expanded program. The final report on this study is due in June.

Technical Progress

Second Stage Vehicles

- Design and fabrication of the AGENA "B" vehicle for the third MIDAS flight is proceeding with completion programmed for 11 July. Because of longer prelaunch pad time than originally scheduled, the launch date will probably be delayed from December to early 1961.

● A program has been developed to test the structural design of the solar auxiliary power array. Two types of tests have been proposed: static—to subject the array to torsion and compression loads; and dynamic—to subject the array to vibrational forces. This program is intended to simulate the orbital conditions which will be experienced by the solar array.

Infrared Scanner Units

Infrared scanner units for the first two MIDAS flights are being manufactured by Aerojet-General Corporation, and for flights 3, 4, and 5 by Baird-Atamic, Inc.

● Acceptance of the first Baird-Atomic scanner has been delayed until 22 May. The binding of the turret bearing during low temperature tests in the high altitude test chamber indicated that a modification of the bearing was required. The schedule slippage was caused by the redesign of this bearing. A new bearing has been delivered to the contractor for installation in the scanner.

● The development of the two Baird-Atomic display consoles is proceeding on schedule. The first console is scheduled for delivery on 15 June, the second will arrive approximately one month later.

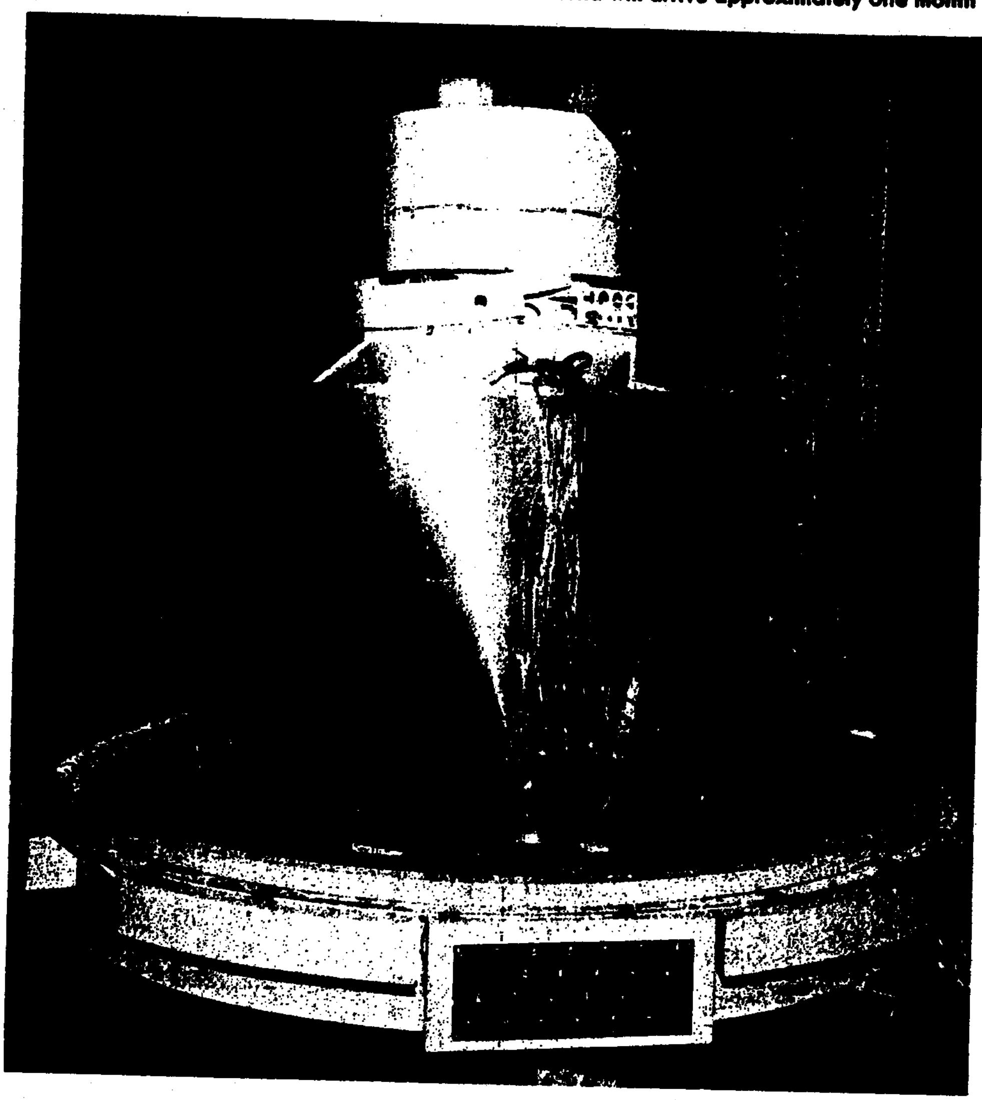


Figure 7. The thermomechanical equivalent model of the Baird-Atomic, Inc., infrared detector mounted on test fixture prior to testing in the High Altitude Temperature Simulation Chamber.

Facilities

[redacted]

● Construction of the North Pacific station technical facilities at Donnelly Flats, Alaska, and the support facilities at Fort Greely, Alaska, were resumed on 1 April. Facilities are scheduled for completion on an incremental basis from July through October.

[redacted]

● Surveys are being continued to locate a suitable site for the North Atlantic station.

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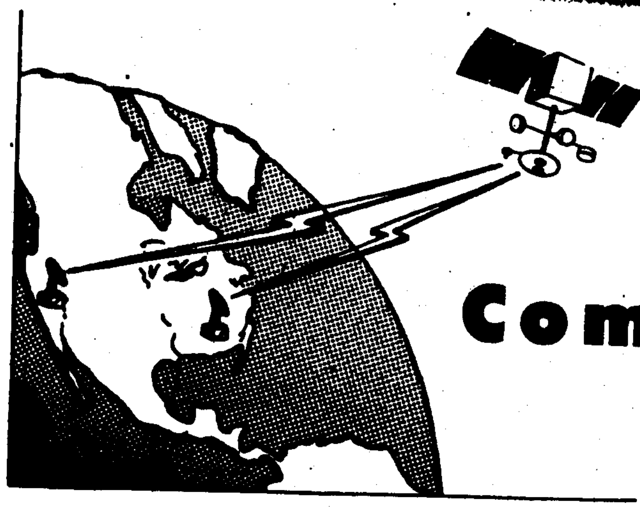


Communications Satellite

The Communications Satellite Program will investigate the feasibility of using synchronously spaced satellites as instantaneous repeaters for radio communications. Under ARPA Order No. 54, as amended, AFBMD is responsible for the design, development, and flight testing of the complete system, including launch, satellite tracking and control, and necessary support facilities and ground equipment. The Army Signal Research and Development Laboratory has been delegated development management responsibility for the microwave communications subsystem as directed by ARPA Order 54.

The Communications Satellite Program is currently being conducted in accordance with amendment 5, (dated 11 April 1960) to ARPA Order No. 54. Under this amendment the previous method of accomplishing the program objectives in three progressively

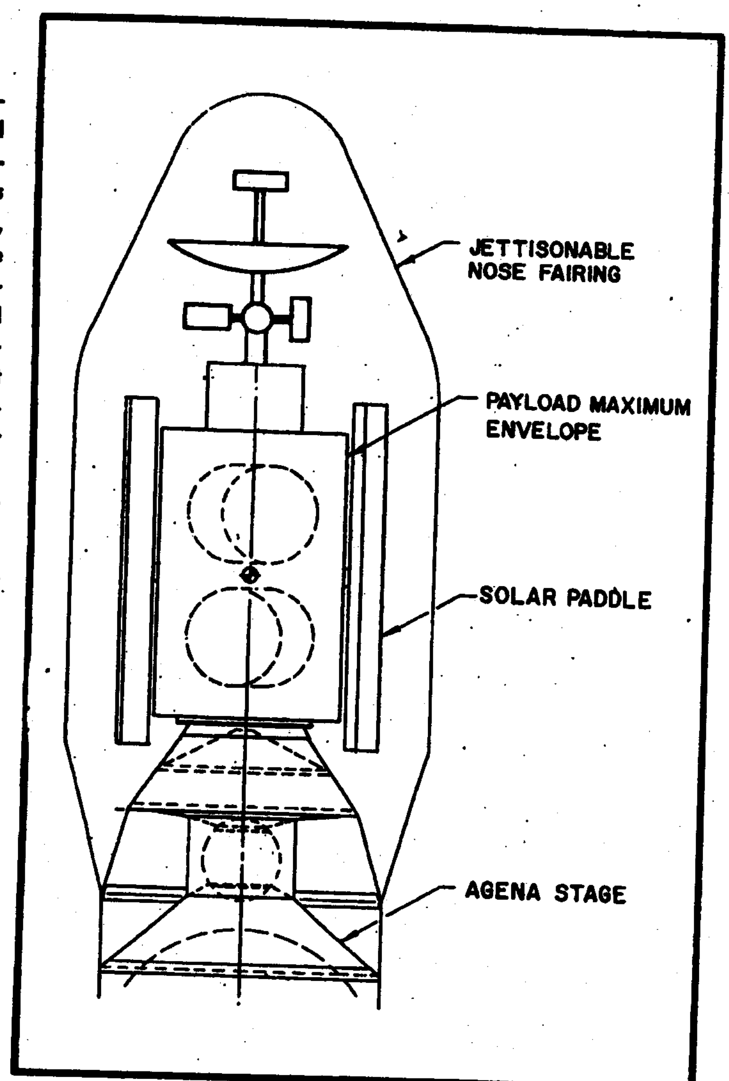


Figure 1. Proposed satellite with jettisonable fairing mounted on AGENA second stage.

CONFIDENTIAL

more advanced phases was replaced by a single integrated effort to which the code name ADVENT was applied. ADVENT calls for an R&D program for a 24-hour global communications satellite system. The feasibility of placing a satellite in a predetermined position in a 19,300 mile equatorial orbit must be demonstrated. The satellite must be capable of providing worldwide communications on a real time basis at microwave frequencies with a high channel wide bandwidth capacity. Amendment 5 also requires the design of a single final stage vehicle for microwave equipment compatible with launching by either AGENA "B" or CENTAUR second stage boosters.

The ADVENT program, as defined in amendment 5, will consist of the following flight tests:

a. Four ATLAS/AGENA "B" flights, nominal 5,600 nautical mile orbits.
b. Seven ATLAS/CENTAUR flights, launched from the Atlantic Missile Range into 19,000 mile equatorial orbits.
c. Three flight tests, using payload space on NASA ATLAS/CENTAUR R&D flights Number 4, 5, and 6.

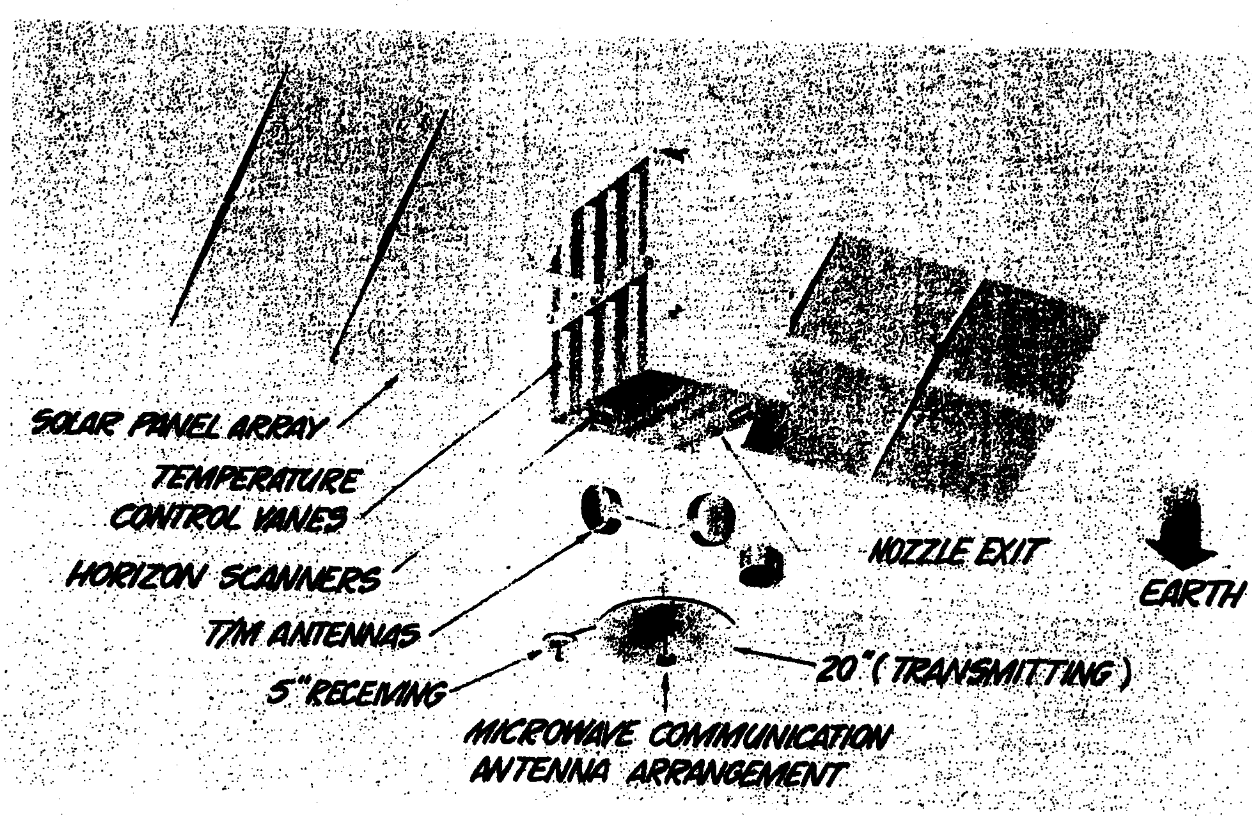


Figure 2. Artist's concept of proposed microwave communications.

Monthly Progress—

COMMUUNICATIONS SATELLITE Program

Program Administration

● Two development plans have been prepared by AFBMD in compliance with Amendment 5 (dated 11 April 1960) to ARPA Order No. 54. The first plan includes four ATLAS/AGENA launches early in the program. The second development plan is identical except that the four early launches are eliminated. The principle program objectives could be more adequately supported if the funds for the ATLAS/AGENA launches were made available for ATLAS/CENTAUR launches later in the program.

Technical Progress

UHF Communications Equipment

● A phasing-out program for the UHF communications equipment has been started, calling for completion of at least three satellite repeater units and a minimum amount of test equipment. These units will be delivered to WADD where reliability life tests and simulated system evaluation tests will be conducted.

Microwave Communications Equipment

● Draft specifications for the ground antenna, ground stations, and the satellite package were completed by the United States Army Signal Research and Development Laboratory and reviewed by the Air Force Ballistic Missile Division on 20-22 April.

● The test report from Varian Associates on the high power, 8000 mc klystron tube will be delivered on 15 May.

Launch Vehicles

● A study has been performed to determine the modifications required and the payload capability increase that would result from using the "E" series ATLAS booster instead of the "D" series. Results of the study indicate greater reliability for the "D" series and an increased payload weight capability of 90 pounds for the "E" series.

● The use of various amounts of liquid fluorine in combination with the oxidizer (LOX) on both the ATLAS and CENTAUR stages was investigated. Results show that a 20 percent fluorine-LOX mixture in the ATLAS increases the final stage vehicle payload capability by 220 pounds and an additional 120 pounds by using the same mixture in the CENTAUR. Further studies will be made to:

1. Determine the toxicity and resulting hazard of fluorine exhaust gases.

2. Evaluate the material compatibility of components with fluorine.

3. Resolve thrust chamber cooling problems.

4. Determine ground support, handling, storage and mixing methods for fluorine.

● A review of CENTAUR static tests indicates that the estimated nominal specific impulse of 420 seconds is correct. Several static tests have indicated a specific impulse of 428 seconds, further development and testing is required before this higher value can be assured for all engines.

● A study of increases possible in payload weight capability by using 24-hour inclined orbits rather than 24-hour equatorial orbits was completed. The payload weight capability for the ATLAS/CENTAUR configuration increases from 1100 to 1600 pounds when the orbit is inclined at 28.5 degrees to the equator. As the angle of inclination increases, the weight capability decreases and at 40 degrees is 1550 pounds. Trajectory studies also were made of 24-hour polar orbits, launched from the Atlantic Missile Range.

Final Stage Vehicle

● General Electric Missile and Space Vehicle Department is making the transition from designing the final stage vehicle for the UHF mission to that of the microwave version. Previous studies are being adapted to the new program. Vehicle analysis, based on the equatorial program description, is being accomplished. Configuration, internal arrangements, a new external environment specification, and test planning are in process.

● A series of studies has been completed to determine the modifications required to make the 24-hour final stage vehicle compatible with a 6-hour orbit inclined at 34.2 degrees. These ATLAS/AGENA flights would be launched from the Atlantic Missile Range. Results of the studies include:

1. The communications antenna must be redesigned to increase the radiation beam width.

2. Temperature control and electrical power subsystems are more than adequate.

3. Modification of both the attitude and orbital control subsystems will be required to maintain antenna and solar array orientations.

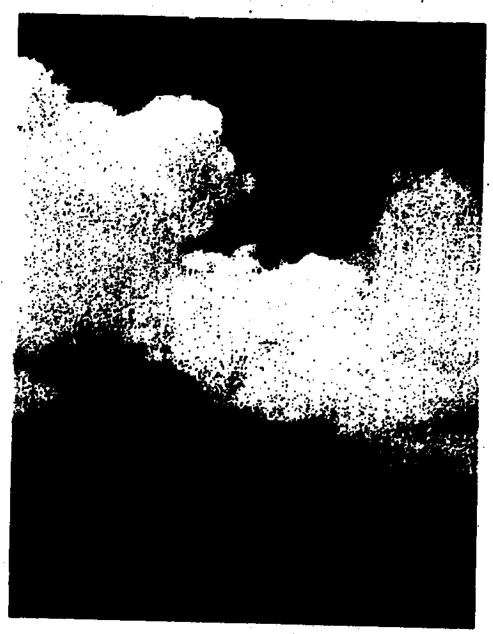
4. The same propulsion system will require less propellant to accomplish orbital injection.

5. Internal structure and packaging will require redesign for the new mission.

6. The 6-hour orbit is feasible. A final stage velocity of 1085 ft/sec is required to complete the launch trajectory and to perform post orbital corrections.

- Vacuum bearing tests, radiation effects on material studies and other test programs for acquiring design data are being continued.

SPACE



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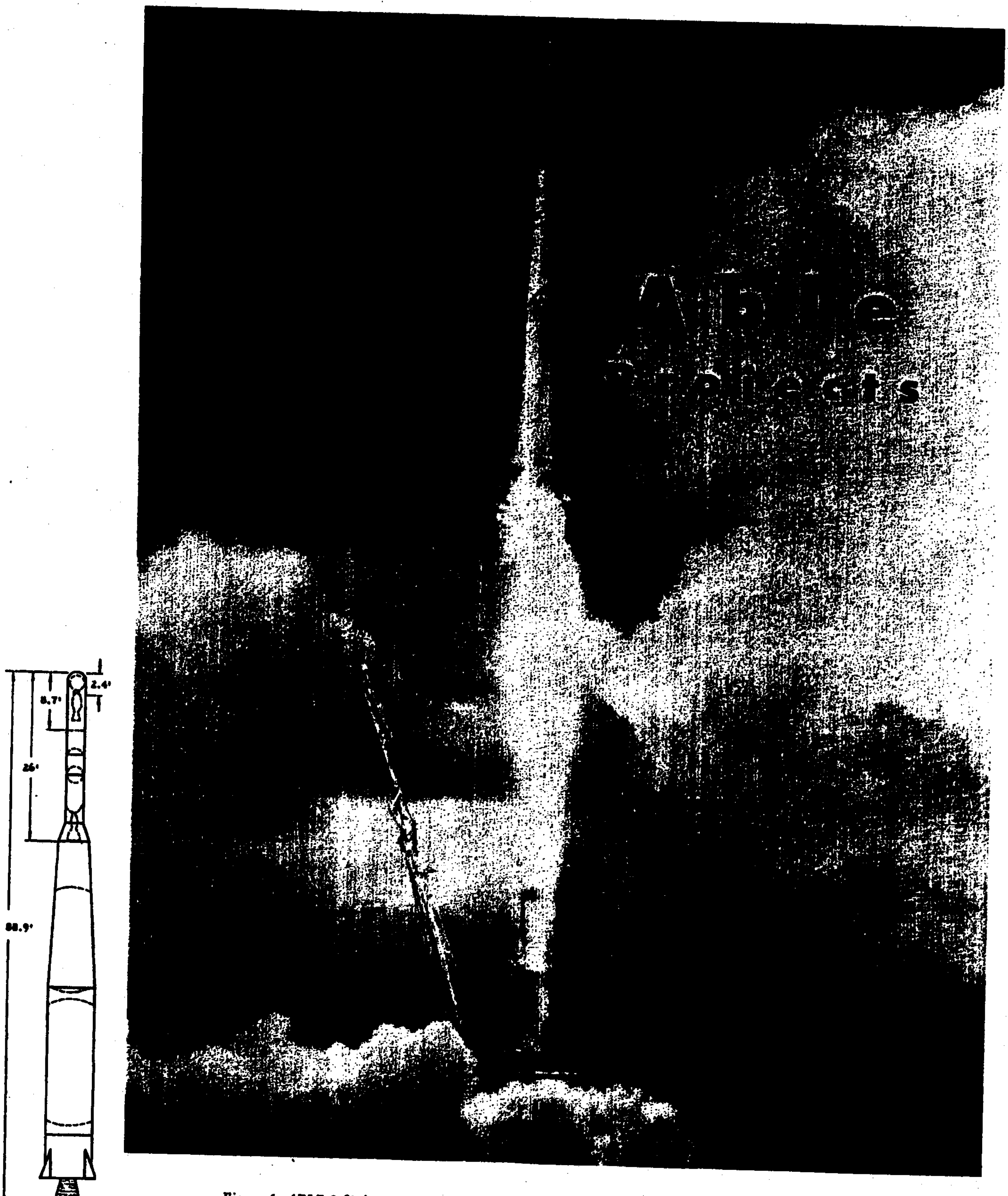


Figure 1. ABLE-3 flight test vehicle being launched from Atlantic Missile Range. Dimensional drawing (left) of four-stage ABLE-3 vehicle.

Flight tests of the three ABLE-1 vehicles in 1958 confirmed the feasibility of using this three stage vehicle to launch satellite payloads on interplaneary space probe missions. Objectives of the ABLE program were further defined in AFBMD proposals submitted to NASA and ARPA late in 1958. In October 1958 NASA, given cognizance over the effort, requested AFBMD to proceed with the ABLE-3 and two ABLE-4 projects. In February 1960 NASA authorized the two-flight ABLE-5 (ATLAS boosted) program. The lunar satellites will be launched late in 1960. General objectives included demonstration of vehicle and communications capability and performance of scientific research experiments over interplanetary distances. A four stage vehicle was selected consisting of a THOR or ATLAS first stage, an ABLE second stage, ABL 248 solid propellant third stage and the satellite vehicle fourth stage. A hydrazine engine with multi-start capability was developed for the ATLAS boosted vehicles to permit midcourse vernier control and to provide controlled thrust to inject the vehicle into orbit about another planet. Solar cell auxiliary power equipment was developed with a useful life period in excess of one year. An extensive network of ground support stations was established, the most powerful of which is the 250-foot antenna at the Jodrell Bank Experimental Station, University of Manchester, England. Central control and data computation is accomplished at the Space Navigation Center, Los Angeles, California, with other military and NASA centers assisting in tracking and telemetry according to the specific requirements of each mission. The flight histories of ABLE-1, ABLE-3, ABLE-4 ATLAS and ABLE-4 THOR are summarized in the following paragraphs, followed by a description of the ABLE-5 projects.

ABLE-3—This four stage flight vehicle was launched from the Atlantic Missile Range on 7 August 1959. The vehicle consisted of a THOR booster, a second stage using the AJ10-101A rocket engine, a third stage powered by the ABL-248 A3 engine, and a fourth stage consisting of the payload and an injection rocket. In addition to carrying a highly sophisticated payload, the ABLE-3 flight was used to demonstrate the validity of the ABLE-4 vehicle and component configurations. All phases of the launching were successful and the advanced scientific observatory satellite was placed in an extremely elliptical geocentric orbit about the earth. Trajectory and orbit were essentially as predicted with deviations in apogee and perigee occurring on the more than nominal side. The payload was the most sophisticated to have been placed in orbit by this nation at the time and contained provisions for conducting 13 experiments in space environment and propagaton. A wealth of valuable data was obtained from

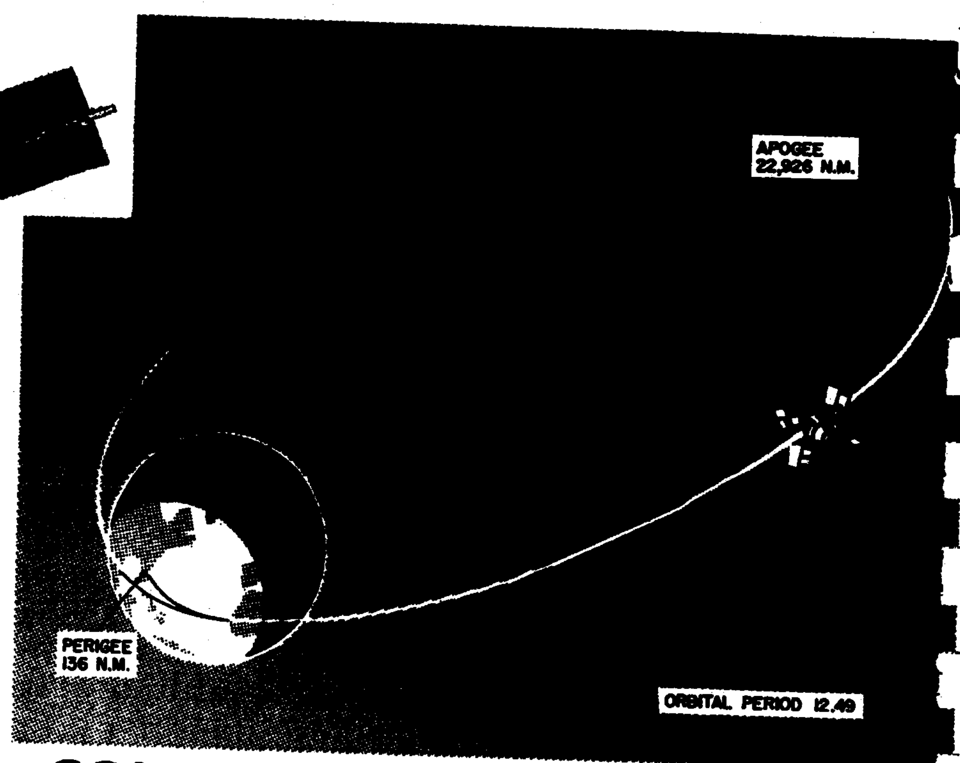


Figure 2. ABLE-3 third stage and payload (above) with solar paddles fully extended. Drawing of extremely elliptical orbit achieved by ABLE-3 (EXPLORER VI).

transmit crude television images of the far side of the moon. This was the first flight in which an ATLAS ICBM was used as the booster for a multi-stage space flight.

ABLE-4 THOR vehicle was launched on 11 March from the Atlantic Missile Range and succeeded in placing the PIONEER V satellite into a solar orbit. At its closest approach to the sun, the satellite will pass near the orbit of Venus, and return to intersect the orbit of earth at its greatest distance from the sun. The vehicle consisted of a THOR first stage, ABLE second stage with AJ10-101 liquid fueled propulsion system and an STL guidance system, and an ABL248A-3, solid fuel third stage. The 95 pound payload contains instrumentation for conducting

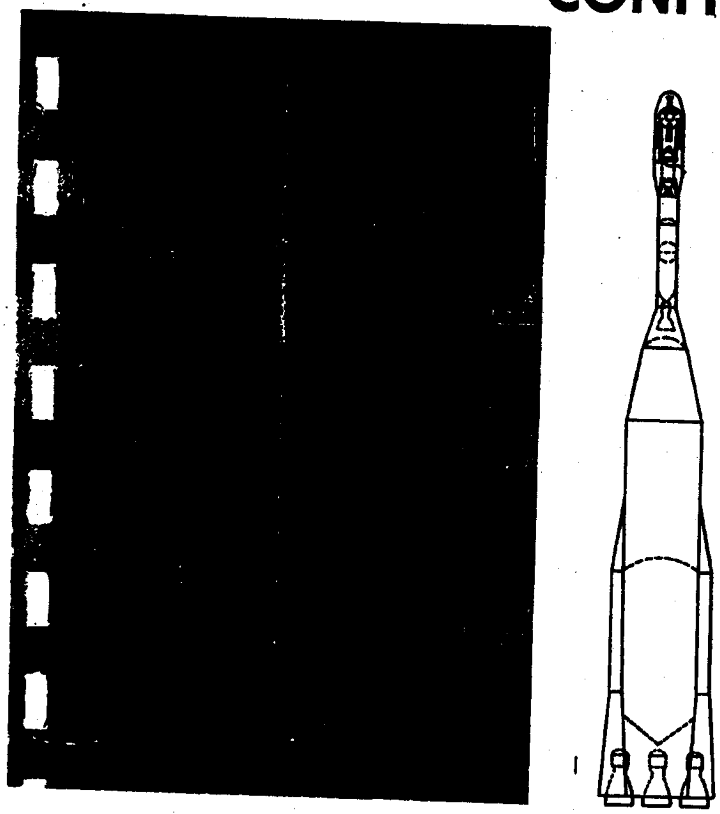


Figure 3. ABLE-4 ATLAS vehicle configuration drawing and photo of vehicle installed on AMR launch pad.

satellite telemetry until the last transmission was received on 6 October. It is believed that the satellite, while yet in orbit, is incapable of generating sufficint power for transmitting signals due to solar paddle damage suffered during initial paddle extension and the resultant unfavorable sun "look" angle.

ABLE-4 ATLAS— This vehicle differed from the ABLE-3 only in that an ATLAS ICBM was used as the first stage instead of a THOR IRBM. The unsuccessful launch of the ABLE-4 ATLAS occurred on 26 November 1959. Structural breakup resulted in the third stage and payload parting from the vehicle approximately 48 seconds after launch. The ATLAS performed as planned over its entire powered flight trajectory. The trajectory of this flight, from the Atlantic Missile Range to the vicinity of the moon, was established to achieve the tightest possible circular lunar orbit consistent with the highest probability of success. The final burnout conditions were to have provided an inertial velocity of 34,552 feet per second. The payload was designed to investigate space environment and propagation effects and to

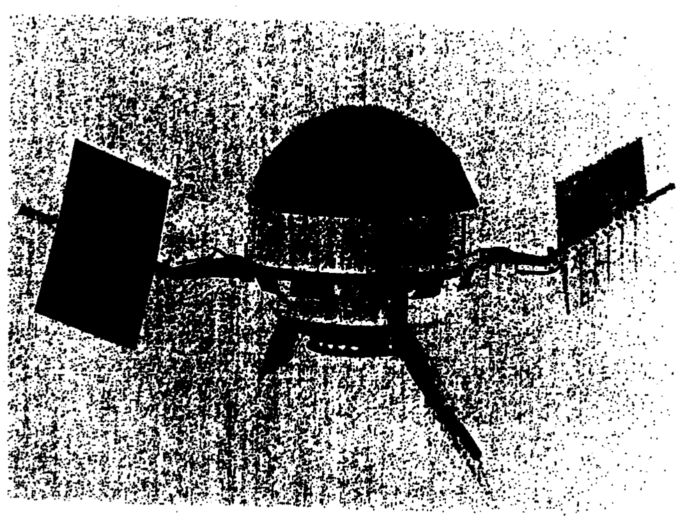
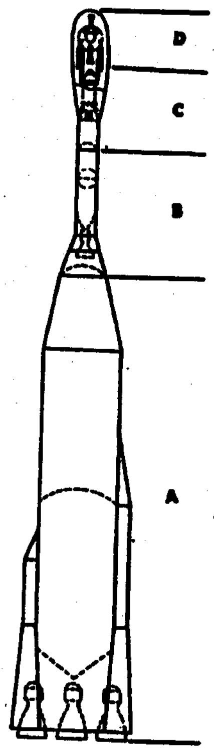


Figure 4. PIONEER V satellite vehicle shown in orbital flight position. This solar satellite was launched from AMR on 11 March 1960.



D. Satellite Vehicle	
Gross Weight	371.6 lb
Gross Weight (Burnout)	233.6 lb
Specific Impulse (vac)	230 sec
Thrust (vac)	18.3 lb
C. THIRD STAGE ABL 248-A9	
Gross Weight	897.4 lb
Gross Weight (Burnout)	432.7 lb
Specific Impulse (vac)	250.5 sec
Thrust (vac)	3100 lb
B. SECOND STAGE AJ 10-101	
Gross Weight	5107.3 lb
Gross Weight (Burnout)	1816.1 lb
Specific Impulse (vac)	268 sec
Thrust (vac)	7575 lb
A. FIRST STAGE ATLAS "D"	
Gross Weight	266,390 lb.
Gross Weight (Burnout)	11,790 lb
Thrust (S. L.)	316.5 sec
Specific Impulse (vac) Sustainer	81,863 lb
Thrust (vac) Sustainer	290.6 sec
Specific Impulse (vac) Booster	251 sec
Specific Impulse (S. L.) Booster	367,787 lb

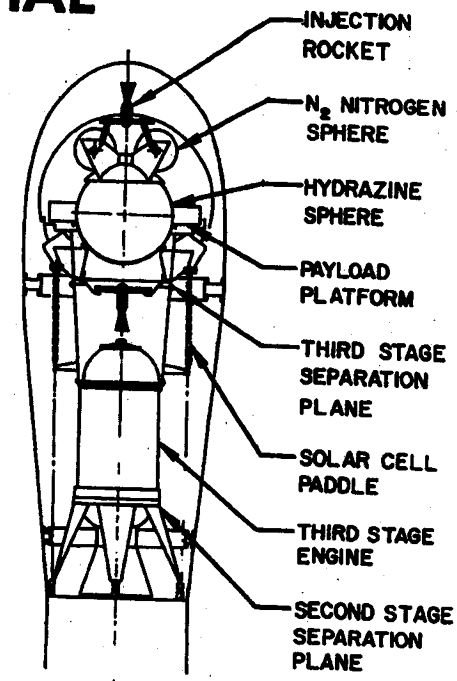


Figure 5. ABLE-5 vehicle configuration drawing and specification list. Third stage and payload configuration (right). Trajectory of ABLE-5 into lunar orbit is shown in drawing (below).

scientific experiments related to magnetic field and radiation phenomenon in deep outer space. Also included in the satellite is a 150-watt transmitter which is expected to permit communications between the satellite and earth over an approximately 90 million mile range.

ABLE-5

The ABLE-5 program provides for launch of two ATLAS-ABLE vehicles to place satellites into lunar orbits late in 1960. A proposed ATLAS/ABLE lunar program was submitted to AFBMD by NASA on 4 Februrary 1960, following discussions between AFBMD and the NASA Goddard Space Flight Center in January.

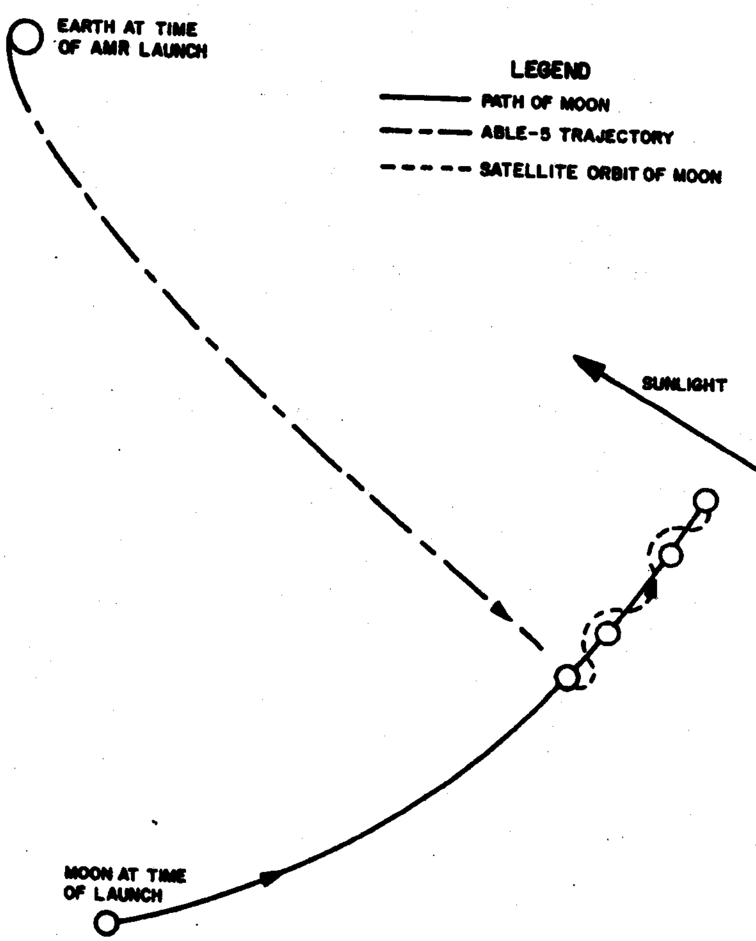
Program Objectives

1. Place a satellite into lunar orbit with an apogee of 3,000 nautical miles and a perigee of 2,000 nautical miles.

2. Maintain adequate earth-satellite communications and establish communications parameters for future space probes.

3. Demonstrate effective guidance system performance, particularly for the satellite vehicle.

4. Successful conduct of payload experiments.



Program Vehicle (see figure 5)

First Stage—ATLAS series D missile General Electric/ Burroughs Corp. Mod 3 guidance system.

Second Stage—ABLE vehicle with Aerojet-General AJ10-101A propulsion system.

Third Stage—Allegany Ballistic Laboratory ABL-248 solid propellant rocket, unguided, spin stabilized by spin rockets fired at termination of second stage thrust.

Fourth Stage (Satellite Vehicle)—Space Technology Laboratories designed, incorporating an injection rocket capable of being restarted four times to increase payload velocity and two times to decrease payload velocity. The satellite also contains a telemetry system (capable of continuous operation), four solar cell paddles, and scientific equipment for conducting the experiments. Satellite vehicle weight is 371.6 pounds.

Launch and Powered Flight

These vehicles will be launched from the Atlantic Missile Range on a true azimuth of 92.5 degrees. ATLAS performance parameters have been based on results obtained from series D R&D flight tests. Parameters for all four stages are shown on figure 5. Final burnout is programmed to occur 23,290,000 feet from the center of the earth at an inertial velocity of 34,552 ft./sec.

Orbital Characteristics

Major Axis	0.209848 x 10^8 feet
Eccentricity	0.245859 degree
Orbital period	765.4 minutes
Apolune	4,303 nautical miles
Perilune	2,605 nautical miles
Duration of eclipses	less than 90 minutes

Payload Experiments (See table 3)

Scintillation Counter and Pulse Height Analyzer—measure electron energy (greater than 50Kev per particle) and proton energy (greater than 1.0Mev per particle).

Ion Chamber and Geiger-Muller Tube—*flux* and rate data for electron particles (greater than 1.25 Mev per particle) and proton particles (greater than 25 Mev per particle).

Proportional Counter Experiment—measure integrated intensity of cosmic ray particles: electrons (greater than 12 Mev per particle) and portons (greater than 70 Mev per particle).

Spin Search Coil Magnetometer and Phase Comparator—map the magnetic field (normal to vehicle spin axis) and investigate very low frequency secular magnetic field variations. Phase comparator circuit uses Spin Search Coil and Flux Gate inputs to determine magnetic field direction relative to inertial space.

Flux Gate Magnetometer—measure magnetic field parallel to vehicle spin axis.

Micrometeorite Flux and Momentum Experiment—count impacts of micrometeorites and interplanetary dust particles on two differing thresholds.

Plasma Probes Experiment—measure the energy and momentum of streams of protons having energies of the order of a few kilovolts per particle.

Ground Support Program

Atlantic Missile Range—track vehicle for first 14 hours after launch (except for a three hour period starting a few minutes after liftoff), provide ATLAS guidance, provide first vernier correction for payload stage.

Manchester, England—track vehicle for 7 hours, starting 13 minutes after launch, provide second vernier correction for payload stage (and additional corrections as required).

South Point, Hawaii—Transmission of commands, including vernier corrections as necessary.

Millstone Hill, Massachusetts—track vehicle for 7 hours, starting 13 minutes after liftoff.

Other support stations include, Singapore, Goldstone, JPL and NASA stations, and the SPAN center at Los Angeles.

Monthly Progress—ABLE Projects

ABLE-4 THOR (PIONEER V SATELLITES)

Injected into solar orbit on 11 March by the ABLE-4 THOR flight test vehicle, the PIONEER V satellite continues its record breaking trajectory toward its first pass around the sun. On 1 May, the satellite was 6,795,334 statue miles from earth and was traveling at a velocity (relative to the earth) of 6,569 miles per hour. The relative speed will remain fairly constant for some time. All systems were functioning normally except the sub-commutated vehicle condition. This problem is discussed fully in a subsequent paragraph.

Powered Flight Evaluation

● Analysis of the powered flight performance of the ABLE-4 THOR vehicle is nearing completion. Part I of this report will be published in May. Discrepancies noted in roll attitude offset during second stage operation and the angular rates developed during second stage engine shutdown are being investigated closely. Although not significant in relation to ABLE-4 THOR flight performance, these conditions are important in relation to future flights.

Orbital Evaluation

● The PIONEER V orbit has been projected through September 1967, including orbital perterbations from the earth-moon system, Venus and Jupiter. The satellite will continue to recede from the earth until December 1960, at which time the distance will be 87 million miles. The payload will then approach within 80 million miles of earth (February 1961), recede to 183 million miles (September 1962), and return to within 16 million miles of earth (4 November 1965). The eccentricity of the orbit will cause the second approach to earth (April 1966) to be 15.6 million miles. This pattern will be repeated every 5.8 years. In 1989, the satellite will close to within 2 million miles of earth.

● Trajectory determinations established by SpaN Center from tracking data for the first 16 hours after launch have not required revision since that time, due to the abundance of high quality initial information. At present, the position of PIONEER V is accurate within 300 miles and velocity within 1.5 ft./sec. A later computation is planned which will refine these accuracies to within 20 miles and 0.1 ft./sec., respectively. Distance from earth at that time (20 million miles) will be known accurately to within 0.00001 percent.

Telemetry

● On 7 April, the SpaN Center ordered the discharge of payload batteries to the minimum to check the operation of the automatic undervoltage cutoff equipment. Communications with the satellite were terminated by inadequate battery voltage. The payload was commanded "ON" a few minutes later to verify that the cutoff had been caused by undervoltage. The occurrence of undervoltage cutoff was within one minute of the predicted time.

● On 16 April, the Manchester station transmitted for the first time the payload "ON" command at the lowest information rate (1 bit/sec.). Five hours later Manchester switched the payload receiver from the wideband to the narrowband sweep frequency (18 kc frequency at 40 cps effective noise bandwidth). The command is irrevocable.

● Since the time of launch, only the 5-watt transmitter has been used to send information to earth. Reception rates at South Point, Hawaii, and Manchester have been closely monitored in relation to establishing the most desirable time for commanding the 150-watt transmitter into operation. Late in April, it was determined that the timing of this event would be based on the following criteria:

1. Distance from earth of 10 million miles, or
2. South Point unable to command satellite battery discharge twice in succession, or
3. Manchester signal strength less than −155 dbm.

● On 7 May, because of reduced quality of Manchester reception at the 1 bit/sec. rate, the 150-watt transmitter was commanded "ON" by the 250-foot radio telescope. On this date, the satellite was

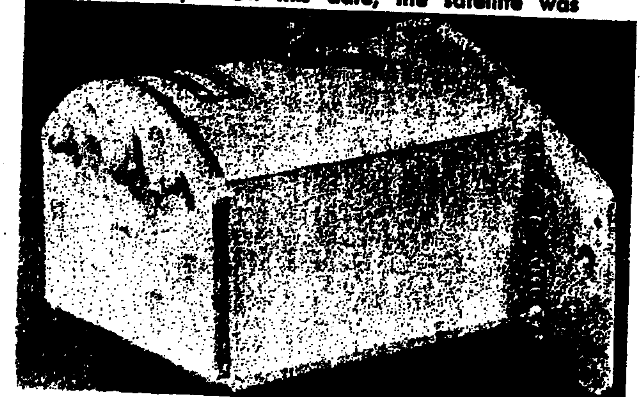


Figure 6. The 150-watt transmitter which was turned on 8 May. It is anticipated that acceptable communications can be maintained up to a distance of 94 million miles.

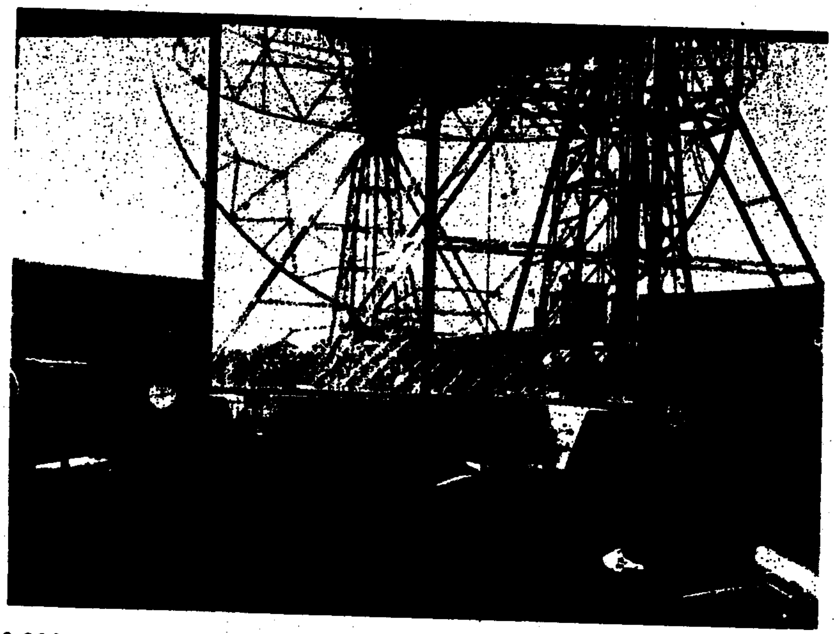


Figure 7. Control room for the Jodrell Bank, Manchester, England, radio telescope. The 250-foot antenna can be seen through the control room windows.

8,000,100 miles from the earth. Initial operation of the 150-watt transmitter was accomplished in a 3-stage sequence. At 0500 hours, EDT, the FILAMENTS ON command was transmitted which put power into a tube filament through a current limiting resistor thereby warming the filament for about a minute. At 1100 hours, the first step was repeated and the second command transmitted which removed the current limiting resistor and permitted full filament heating for several minutes. The circuit passed both tests successfully. At 0503 hours, 8 May, the third command was sent which energized the static converter and the 150-watt transmitter. At 0504.5 hours, Manchester received the first 150-watt transmission from PIONEER V. Manchester is now able to receive satellite telemetry at the rate of 8 or 64 bits/sec. Hawaii will continue to receive only at the 1 bit/sec. rate. Available power aboard the satellite will limit the transmitter operating time to approximately 3 minutes every 6 to 8 hours. It is anticipated that satisfactory communications between Manchester and PIONEER V can be maintained up to a distance of 94 million miles. Neither the static converter nor the 150-watt transmitter had previously been flight tested. The critical factor involved was the ability of these components to survive in the hard vacuum of outer space for nearly two months prior to any operation. Following the 150-watt transmitter "ON" command on 8 May, 3 minutes 28 seconds of telemetry reception provided Manchester with 5059 bits of information (as compared to the 208 bits previously received via the 5-watt transmitter).

● All eight possible commands have now been transmitted to PIONEER V. These were accomplished in the following sequence:

Command	Station	Date	Range (Miles)
1. 5-watt transmitter "ON" at 64 PPS	AMR	11 March	700
2. Third stage-payload separation	Manchester	11 March	10,000
3. 5-watt transmitter ON at 8 PPS	Singapore	12 March	147,000
4. 5-watt transmitter ON at 1 PPS	Hawaii	17 March	972,000
5. Receiver—narrow band	Manchester	16 April	4,848,000
6. Filaments ON	Manchester	7 May	7,851,000
7. Filaments ON—full current	Manchester	7 May	7,898,000
8. 150-watt transmitter ON	Manchester	8 May	8,000,100

● On 8 May, a total of 109 hours of communications with the satellite had been logged and 283 separate tracking exercises performed. The four stations involved in this accomplishment are as follows:

Station	Nr. of Exercises	Hours of Operation
AMR	1	0.5
Manchester	132	46.6
Singapore	4	1.5
Hawaii	146	60.4

Satellite Sensor Telemetry

● This information is transmitted by "word 7" of the seven word Telebit System and includes the subcommutated values of eight satellite condition sensors. These values become meaningless when information received indicates a condition which is known to be impossible (e.g. battery voltage level too low to operate the transmitter at the time the transmitter is operating). Such a condition resulted from analysis of the telemetry received on 16 April. During the next five days a thorough analysis of "word 7" data was made by Space Technology Laboratories personnel. This effort confirmed the existence of a single open diode in the Telebit unit which was causing the logic of the circuitry to be altered. Since the alteration to the logic was constant and consistent, STL was able to break the new code and prepare a translation table which permitted "word 7" values to be interperted correctly.

Experiments

Magnetometer

● Magnetic field measurements performed by this experiment have had significant value in the following three areas:

1. Verified the existence of a magnetic ring current surrounding the earth at an altitude of 5 to 7 times the earth's radius. First observed by EXPLORER VI (ABLE-3), this ring is believed to have an interrelationship with the polar aurorae. Information obtained, therefore, is of great value in the study of interruption of polar communications.

2. Verified PIONEER discovery of extensive magnetic field disturbances between 10 and 14 earth's radii, establishing the existence of a constant solar wind of protons which produce a turbulence at the fringes of the earth's atmosphere. This data lend credence to theories connecting solar winds with ionospheric disturbances.

3. Discovery of a significant ionized gas activity, adding support to the belief that earth's magnetic disturbances, plasma phenomena and cosmic ray modulations are interrelated. The experiment continues to operate successfully.

Proportional Counter Telescope

● This University of Chicago developed experiment is providing excellent measurements of both primary cosmic ray and low energy background radiation. EXPLORER VI data has been verified. The experiment also confirmed the belief that the electromagnetic disturbance which accompanies sudden decreases in cosmic ray intensity is not caused by factors related to the earth.

ABLE-5

Program Administration

● Specifications, Funding, Test Objectives and Technical Direction requirements were in the process of being established and defined during the reporting period. The Detailed Test Objectives document for the first flight will be published in May. Technical Direction meetings were held among representatives of AFBMD, Convair, Aerojet-General Corporation and NASA.

Technical Progress

Flight Parameters

● The nominal trajectory was established during April.

● A study was completed of the feasibility of providing attitude stabilization to minimize tipoff velocity errors experienced on prior ABLE Program launches. Study results are being evaluated.

● Preliminary weight and performance data have been released.

Communication System

● The spare receiver for the ABLE-4 THOR is being converted for use on the ABLE-5. The signal conditioner design is essentially complete. Construction and test of the 2-watt transmitters are on schedule.

● The digital decoder has been assembled from spare ABLE-3 and ABLE-4 components and is undergoing environmental test prior to delivery as a type test item. The ABLE-4 ATLAS digital telemetry unit has been modified to the ABLE-5 configuration and is being prepared for acceptance testing. Delivery of this unit is scheduled for 6 June.

Vehicle Aerodynaimcs

● Wind tunnel data obtained at the Arnold Engineering Development Center has been used to correct pressure distributions estimated for the ABLE-5 configuration. This information has been incorporated into the latest calculations of loads.

Third Stage Vibration Evaluation

● Data obtained from test firings of the ABL 248-A6 engine revealed vibration characteristics consistent with those previously experienced. As a result, NASA vibration specifications established for ABLE-4 THOR will not be altered for the ABLE-5 vehicles.

Payload

● The final basic design and general arrangement layouts were completed during the month. Design completion is anticipated for May.

● Progress on all payload and experiment components is essentially on schedule. Fabrication and testing is underway in several of these areas.

Environmental Testing

● During April, 110 environmental tests were conducted as follows: 86 component parts evaluations, 17 type tests, and 17 R&D tests. Tests were performed on assemblies, components, parts and a simulated payload. The only failure encountered was structural damage sustained by a flux gate magnetometer.

A. THIRD STAGE—X-248 (Allegany Ballistic Lab.)

Thrust at altitude	3150 pounds
Specific impulse (vac)	250 seconds
Total impulse	116,400 lbs/sec
Burning Time	37.5 seconds
Propellant	Solid

B. SECOND STAGE—AJ10-42 (Aerojet-General)

Thrust at altitude	7700 pounds
Specific impulse (vac)	271 seconds
Total impulse (min)	870,000 lbs/sec
Burning time	115 seconds
Propellant	Liquid

C. FIRST STAGE—THOR IRBM

Thrust (s. l.)	151,500 pounds
Specific impulse (s. l.)	248 seconds
Specific impulse (vac)	287 seconds
Burning time	158 seconds
Propellant	Liquid

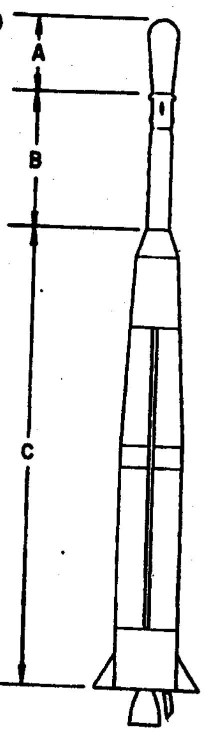
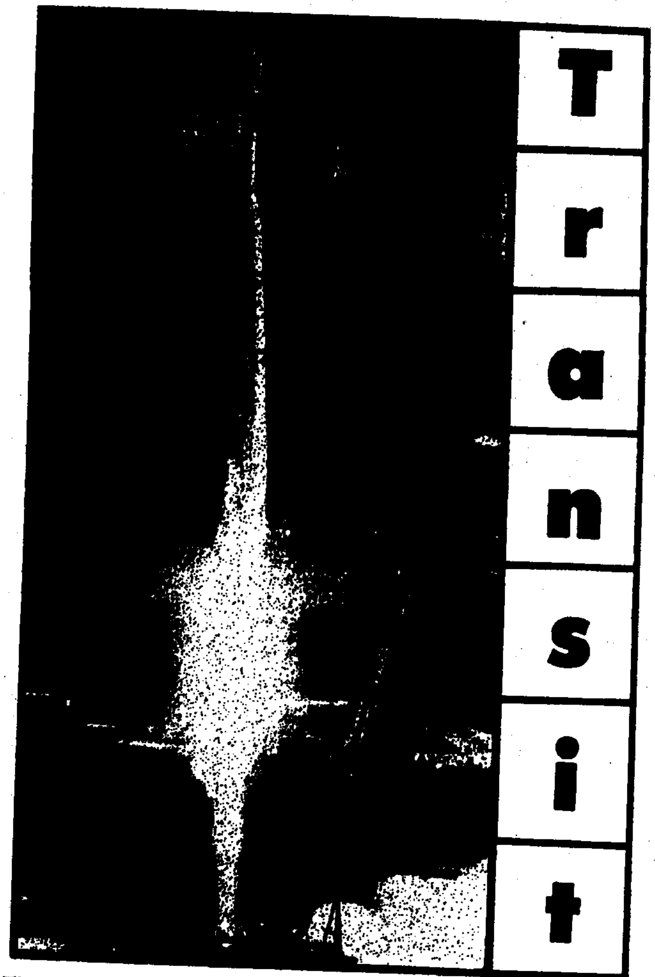


Figure 1. TRANSIT 1A three stage flight vehicle.



TRANSIT 1A launched from Atlantic Missile Range

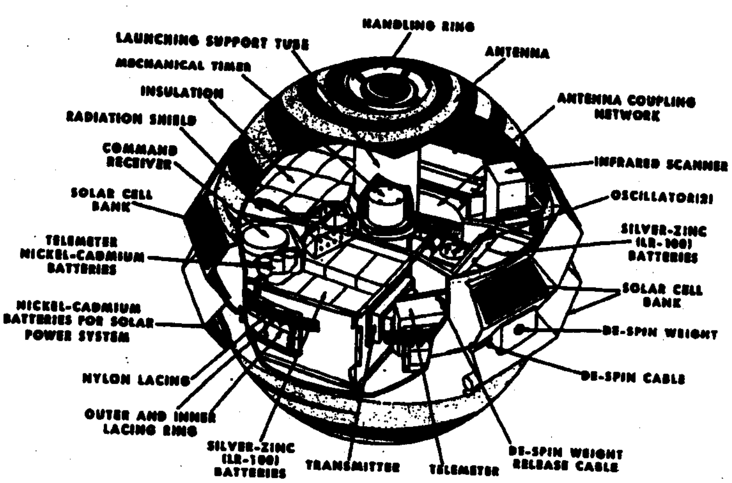
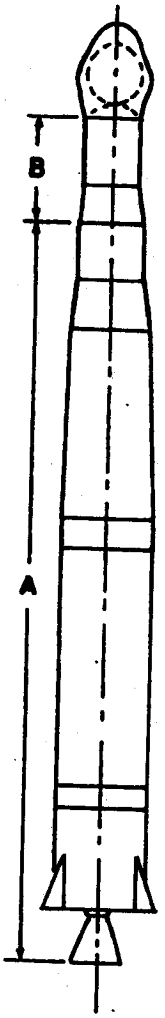


Figure 2. Cut-away drawing of TRANSIT 1A payload (NAV 1).

The TRANSIT Program consists of the flight testing of four vehicles to place 200-270-pound satellite payloads into circular orbits of 400 to 500 nautical miles. The program is designed to provide extremely accurate, world-wide, all-weather navigational information for use by aircraft, surface and subsurface vessels, particularly in relation to POLARIS missile firings. The ARPA Order for TRANSIT 1A was initiated in September 1958 and amended in April 1959 to add TRANSIT 1B, 2A and 2B flights. The program is currently authorized by ARPA Order No. 97, which assigns AFBMD responsibility for providing the booster vehicles, integrating payloads to the vehicles, and flight operations from launch through attainment of orbit, including communications to the tracking and data handling facilities. Payload and tracking responsibility has been assigned to the USN Bureau of Ordnance. Applied Physics Laboratory is the payload contractor.



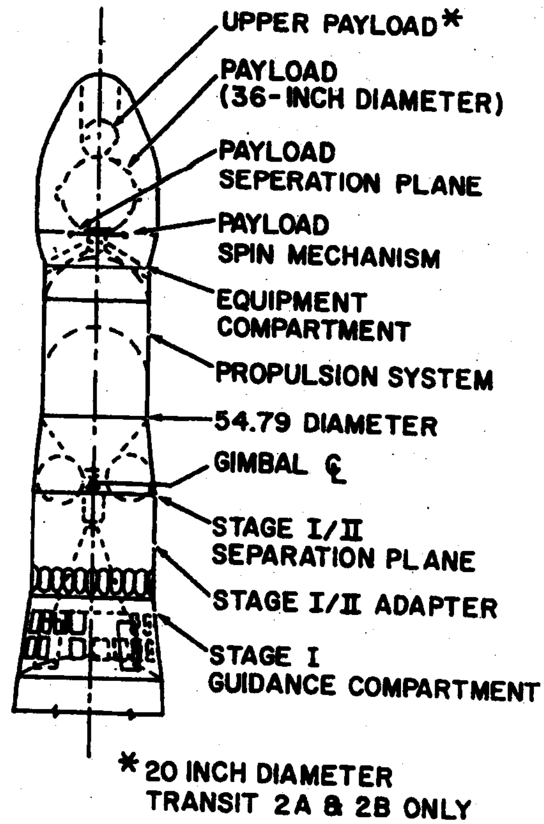
A. SECOND STAGE—ABLE-STAR (AJ10-104)

Thrust at altitude	8030 pounds
Specific impulse (vac)	278 seconds
Total impulse (min)	2.3 × 10⁶ lbs/sec
Burning time	294 seconds
Propellant	Liquid

B. FIRST STAGE—THOR IRBM

Thrust (s. l.)	151,500 pounds
Specific impulse (s. l.)	248 seconds
Specific impulse (vac)	287 seconds
Burning time	158 seconds
Propellant	Liquid

—TRANSIT 1B, 2A and 2B



Program Objectives

1. Provide accurate navigational reference information for POLARIS launches.
2. Precise determination of satellite position by measuring the doppler shift of satellite transmitted radio signals.
3. Investigate the refractive effect of the ionosphere on radio transmissions.
4. Acquire additional geodetic and geographical data by precision tracking of the orbiting satellite.

Flight Vehicles TRANSIT 1A consisted of three stages as shown in Figure . TRANSIT 1B, 2A and 2B are two-stge vehicles as shown in Figure

Launch Plans All vehicles will be launched from Atlantic Missile Range pad 17A or 17B. Launch azimuth for TRANSITS 1A and 1B is 44.5 degrees and for TRANSITS 2A and 2B, 140 degrees.

Powered Flight Trajectory The powered flight trajectory for TRANSITS 1B, 2A and 2B is shown and described in Figure . The sequence of events from launch through payload separation for TRANSIT 1B is given in Table 1.

Payload Description The spherical payloads are approximately 36 inches in diameter and weigh between 200 and 270 pounds. Payload equipment includes four transmitters (on frequencies of 54, 108, 162 and 216 megacycles), two receivers, and a gate which permits the insertion of data only when the gate has been opened at a previously scheduled time. Power for the first five months will be supplied by batteries, recharged by solar cells located in a 12-inch band around the sphere. The TRANSIT 1B payload will also contain an infrared scanner which will operate for the first four days of orbit. On TRANSITS 2A and 2B a 20-inch sphere, mounted on top of the 36-inch sphere, will contain instrumentation for studying solar emissions. The payloads will be spin-stabilized in orbit.

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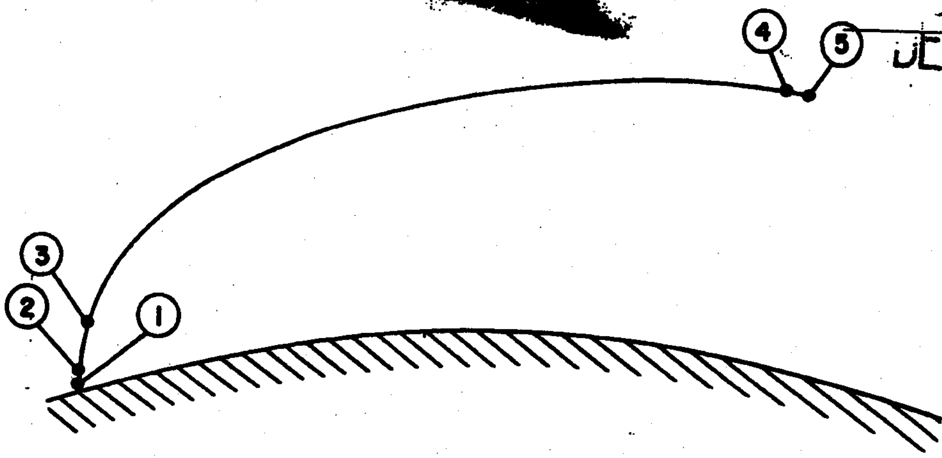

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Point	Flight Time (seconds)		Comments	Inertial Speed (ft/sec)		Downrange Distance (n.m.)		Altitude (n.m.)	
	1-B	2-A 2-B	Transit vehicles	1-B	2-A 2-B	1-B	2-A 2-B	1-A	2-A 2-B
1	10	10	End of vertical rise	1,346	1,346	0	0	0.077	0.077
2	167	167	First stage burnout	13,611	12,929	75.2	79.7	41.2	48.3
3	442	448	End of second stage first burning period	24,539	24,376	785.6	778.0	200.1	203.0
4	1,489	1,447	Restart second stage engine	22,486	22,339	4,233.2	4,080.0	500.0	500.0
5	1,504	1,462	Injection into orbit	24,258	24,259	4,416.3	4,130.0	500.0	500.0

FLIGHT TRAJECTORY—TRANSIT 1B, 2A and 2B

Orbital Performance Achievement of program objectives is based primarily on measuring the doppler shift of satellite transmitted radio signals. During the first three months of flight, the four transmitters will be operated to obtain experimental confirmation of the theoretical mathematical relationship between the frequency and the refractive index of the ionosphere. Studies have shown that refraction effects on the doppler shift can be eliminated by using the transmission from two satellites. After four months of tracking the satellite by measuring the doppler shift of the satellite radio signal, the exact position of the satellite at any point in the orbit should be known. Using known orbital positions, ships and aircraft can then use satellite signals to make analogous computations to establish accurate position. Navigational fixes of 0.1 mile accuracy are expected to be obtained.

Ground Support Stations Tracking stations will be operated in Maryland, Texas, New Mexico, Washington and Newfoundland. First and second stage tracking and telemetry and second stage guidance will be provided by the Atlantic Missile Range. A mobile tracking and telemetry van will be located in Germany for TRANSIT 1B and South America for TRANSITS 2A and 2B. These locations were selected as the closest sites possible to the orbit injection point.

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Time (sec)	Stage	Event	
X + 0.1	I	Liftoff switch activates	
		Programmer starts	
		Gyros uncaged	
	II	Umbilicals eject	
		Arm destruct initiator	
X + 2	I	Roll program initiated	
X + 9	I	Roll program complete	
X + 10	I	Pitch program initiated	
		Ist step pitch rate	As required
X + 25	I	2nd step pitch rate	for trajectory
X + 70	I	3rd step pitch rate	and detailed in
X + 90	I	4th step pitch rate	DTO
		Autopilot gain change	
	II	Programmer armed	
X + 130	I	Pitch program complete	
X + 152	I	Main engine cut-off (MECO)	
		Circuitry armed	
X + 163.5	I	MECO back-up armed	
X + 167.0	I	MECO	
X + 167.0	II	Start programmer	
X + 170.0	II	Engine fire signal	
		Uncage thrust chamber in pitch and yaw	
		Uncage high thrust roll jets	
		Uncage gyros	
X + 170.85	II	Blow separation bolts	
X + 176.0	II	Start pitch program	

Time (sec)	Stage	Event
X + 230.0	II	Jettison nose fairing
Times vary in accord. with trajectory.	II	Stop pitch program
		Pitch command
		Yaw command
X — 429.0	II	Stop pitch program
X — 441.5	II	Engine cut-off signal
		Switch pneumatic coast control system on pitch, yaw and roll
X — 471.0	II	Turn off hydraulic power
X — 480.0	II	Initiate coast phase pitch program
X — 1036.8	II	Stop coast phase pitch program
X — 1458.6	II	Start hydraulic power
X — 1488.6	II	Engine restart fire signal
		Uncage accelerometer
X — 1491.6	II	Cage coast pneumatic control system
X — 1500	II	Arm TPS cut-off probe (back-up)
		Arm oxidizer probe (back-up)
		Arm spin and separation mechanism
X — 1504.0	II	Engine cut-off signal
		Uncage coast pneumatic control system
		Start spin table
		Start timer on spin table
X — 1506.0	II	Engine cut-off (back-up)
		Start spin table (back-up)
X — 1507.0	II	Remove spin table bolt power
X — 1526.0	II	Blow separation bolts
		Activate separation actuators
		Payload separation occurs

Sequence of Events—TRANSIT 1B, 2A and 2B

Monthly Progress—TRANSIT PROGRAM

Flight Test Progress

TRANSIT 1B

● As reported last month, a very successful TRANSIT 1A launch was made from the Atlantic Missile Range at 0702 hours, EST, on 13 April.

Parameter	Nominal	Actual
Apogee	500 N.Mi.	408.64 N.Mi.
Perigee	500 N.Mi.	175.38 N.Mi.
Period	103 Min.	95.25 Min.
Inclination Angle	45.95°	51.28°

TABLE 1. ORBITAL PARAMETERS

● As shown in Table 1, the guidance system did not perform as expected and caused an elliptical orbit rather than the expected circular orbit. The guidance system obtains angular velocity data by doppler measurement and integrates this information to provide the required position data. During launch, a sufifcient amount of rate information was lost to cause the resultant error in position data. This error occurred during first stage flight which, because of the TRANSIT trajectory, is the most critical.

TRANSIT 2A

● The TRANSIT 2A flight test has been rescheduled to 21 June. Analysis of TRANSIT 1B guidance data will result in the following change being made. The FPS-16 radar angular data will be used by the guidance system from liftoff through the first twenty seconds of second stage flight. From this point on the guidance system will use its internal data. This change assures the capability of meeting orbital specifications. No modification to airborne equipment is required. The five week delay will be used to adapt the FPS-16 radar data to the guidance computer and to change the computer program to accept this data.

Technical Progress

TRANSIT 2A

● Assembly and checkout of the second stage was completed and the vehicle was shipped to the Atlantic Missile Range on 21 April. The AMR checkout is proceeding satisfactorily with all subsystem tests having been accomplished.

● Wind tunnel tests indicated that a transonic velocities pressures on the nose fairing had a tendency to separate the fairing valves. The addition of two explosive bolts will prevent premature separation of the nose fairing.

TRANSIT 2B

● No design or assembly problems effecting the TRANSIT 2B vehicle have been encountered.

Ground Support Facilities

● The mobile downrange telemetry and tracking van has been shipped from Germany to Punta Arenas, Chile, and checkout is being accomplished.

COURIER

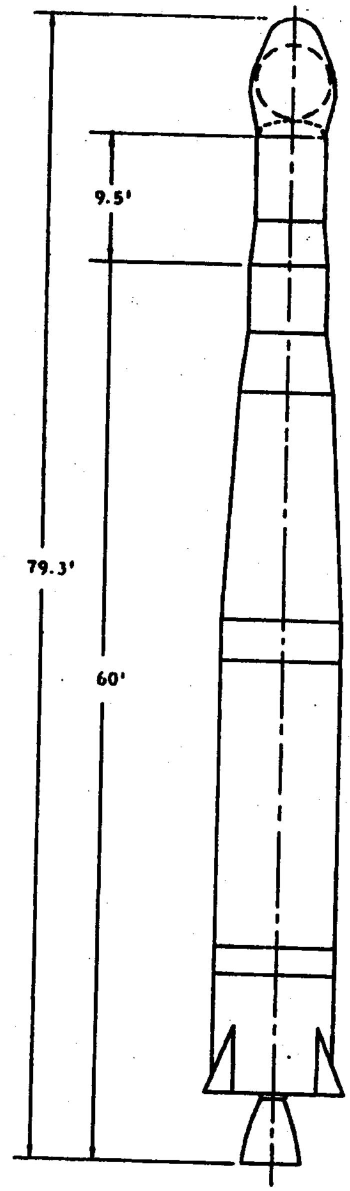
The ARPA COURIER Program consists of two flight vehicles to be launched from the Atlantic Missile Range. The program objective is to test delayed repeater communications between a satellite and ground stations. The program also will be used to determine the operating characteristics and capabilities of the ABLE-STAR (AJ10-104) second stage vehicle. The program is being conducted under ARPA Order No. 98, dated 1 July 1959 (Project Code No. 2200). AFBMD responsibility includes development of the launch vehicle, payload integration, launch, injection of payload into orbit, and verification of orbital parameters at injection. The Army Signal Research and Development Laboratory will design, develop and fabricate the payload, and will be responsible for world-wide ground station requirements. Primary payload contractor is Philco Corporation.

Vehicle Description—The two-stage COURIER vehicle consists of a THOR booster, an ABLE-STAR (AJ10-104) second stage and a 500 pound COURIER payload. Booster flight control is exercised by a gyro platform and a programmer. The second stage is controlled by a gyro used to govern engine gimballing during powered flight. Stability during second stage coast is provided by the "on-off" operation of jet nozzles operating from a dry nitrogen supply. The second stage propellants are inhibited red fuming nitirc acid and unsymmetrical dimethyl hydrazine. The engine will have a restart capability. The 500 pound COURIER payload is a 60-inch sphere, containing radio repeaters, storage and memory equipment, and a battery power source.

Flight Description—Both vehicles are to be launched from the Atlantic Missile Range. After first stage burnout, the ABLE-STAR vehicle will place the payload into the desired trajectory and then shut down. The second stage and payload will coast to the desired 650 nautical mile orbital altitude and the ABLE-STAR engine reignited to attain orbital velocity. The orbital angle of inclination will be 28.5 degrees from the equatorial plane. The orbital period will be 110 minutes.

Payload Objectives—Storage and memory elements in the payload will deliver messages, upon command, to each of three ground stations; as well as exchanging "real time" information when the satellite is within line-of-sight of two ground stations. During these periods a ground station can relay messages direct to the next ground station, through the satellite simplex repeater equipment.

Ground Support Stations—These stations will be located at Camp Salinas, Puerto Rico; Torrejon Air Force Base, Madrid, Spain; and Halemano, Hawaii. Station design and development is under contract to International Telephone and Telegraph Corporation.



SECOND STAGE—ABLE-STAR (AJ10-104)

Thrust at altitude	8030 pounds
Specific impulse (vac)	278 seconds
Total impulse (min)	2.3×10^6 lbs/sec
Burning time	294 seconds
Propellant	Liquid

FIRST STAGE—THOR IRBM

Thrust (s. l.)	151,500 pounds
Specific impulse (s. l.)	248 seconds
Specific impulse (vac)	287 seconds
Burning time	158 seconds
Propellant	Liquid

Monthly Progress—COURIER Program

Technical Progress

COURIER 1A

- The AJ10-104 propulsion system was delivered to the Space Technology Laboratories hangar on 12 April, one month behind schedule. This delay has made necessary extensive revision of checkout vans used in both COURIER and TRANSIT Programs. Checkout of COURIER 1A, using Van #2, will be completed as rapidly as possible to alleviate this situation. The launch date remains 15 July.

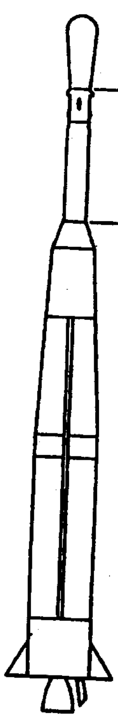
COURIER 1B

- Aerojet-General Corporation and Space Electronics Corporation are continuing component and subsystem fabrication based on a scheduled launch date of 1 September. No slippage in the launch date because of vehicle design changes is anticipated.

The TIROS Program consists of one flight from the Atlantic Missile Range early in 1960. Primary objectives include: (a) To determine the feasibility of using an earth satellite to measure, record, and transmit synoptic weather conditions; (b) To establish system parameters for weather satellites; (c) To acquire information on electromagnetic propagation through the atmosphere and acquisition of additional geodetic and geophysical data by tracking a satellite in a precise orbit. The National Aeronautic and Space Administration is the primary program agency. AFBMD is responsible for supplying the launch vehicle, integrating the payload to the launch vehicle, and providing communications to the tracking and data-handling agencies from launch through attainment of orbit. Payload design, fabrication and testing will be accomplished by the Radio Corporation of America for NASA. NASA retains cognizance for operating, tracking, and recording and processing of satellite data.

VEHICLE DESCRIPTION

The three-stage TIROS vehicle (Figure 1) consists of a THOR Booster, Aerojet-General (AJ10-42) liquid propellant second stage with Bell Telephone Laboratories radio-inertial guidance system, and the Allegany Ballistics Laboratory solid propellant third stage (248). Design specifications for each of the three stages are shown on Figure 1.



THIRD STAGE—X-248 (Allegany Ballistic Lab.)

Thrust at altitude	3150 pounds
Specific impulse (vac)	250 seconds
Total impulse	116,400 lbs/sec
Burning Time	37.5 seconds
Propellant	Solid

SECOND STAGE—AJ10-42 (Aerojet-General)

Thrust at altitude	7700 pounds
Specific impulse (vac)	271 seconds
Total impulse (min)	870,000 lbs/sec
Burning time	115 seconds
Propellant	Liquid

FIRST STAGE—THOR IRBM

Thrust (s. l.)	151,500 pounds
Specific impulse (s. l.)	248 seconds
Specific impulse (vac)	287 seconds
Burning time	158 seconds
Propellant	Liquid

FLIGHT DESCRIPTION

T i r o s

The sequence of events for the powered flight from launch at AMR to injection into orbit is given in Table 1. The payload will be placed in a 380 nautical mile circular orbit having an inclination angle of 48.67 degrees. Orbital life is expected to be five months.

PAYLOAD OBJECTIVES

The 270 pound, cylindrical payload will be 42 inches in diameter and 17 inches in height. Payload equipment includes 2 television cameras designed to observe, record and transmit weather data. Power sources include sixty 20-volt nickel-cadmium chemical batteries and 9260 solar cells to recharge the batteries. The solar cells, installed in the top and cylindrical side walls of the satellite will furnish an average output of 13 watts for the first 140 days of vehicle life. Once during each orbit the satellite will be interrogated and reprogrammed from a ground station. The two television cameras have different resolution capabilities and coverage patterns to permit observation of a wide variety of cloud patterns. Two modes of TV system operation are possible. When the satellite is within radio communications range of a ground station, pictures may be taken on command and transmitted directly to earth. When the satellite is beyond radio communication range, camera operation is controlled by a clock and programming circuits and the images recorded on magnetic tape for readout during the next pass over a ground station. Two beacon transmitters are installed on the bottom side of the satellite to facilitate tracking.

GROUND SUPPORT STATIONS

The Air Force ground station at Kaena Point will be used to support this program. Tracking and data acquisition will be conducted on 108 mcs and command transmission on 140 mcs. Required modifications to the TLM and VERLORT radars are in progress. Use of this support station will result in: (a) minimum cost by maximum use of existing facilities, (b) minimum equipment modification and operation effort, and (c) a satisfactory system configuration with minimum complexity. Use of this facility also will benefit the SAMOS and MIDAS programs by attaining an early buildup of experienced personnel.

Monthly Progress—TIROS Program

Flight Test Progress

● Information on the successful TIROS launch from Atlantic Missile Range stand 17A on 1 April was included in last month's report. The three-stage THOR-boosted flight vehicle placed the TIROS payload into the most perfect circular orbit achieved by this nation to date. Only a 0.3 sigma deviation occurred between the programmed and actual orbit. The two payload cameras have provided excellent photographs of weather conditions around the earth. These and other data obtained will add immeasurably to our knowledge of meteorological phenomena.

● Table 1 presents a comparison of nominal predicted orbital parameters with those actually achieved by the satellite. As of the end of this reporting period, TIROS continues to function excellently, both in vehicle orbital performance and payload operation.

Parameter	*Nominal*	*Actual*
Apogee	381.5 N.Mi.	408.8 N.Mi.
Perigee	379.8 N.Mi.	378.3 N.Mi.
Period	98.67 Min.	99.17 Min.
Latitude at injection	42.336°N	42.277°N
Longitude at injection	56.90°W	57.045°W
Inclination angle	48.330°	48.359°
Payload spin rate (in orbit)	12 rpm	10 rpm

TABLE 1. ORBITAL PARAMETERS

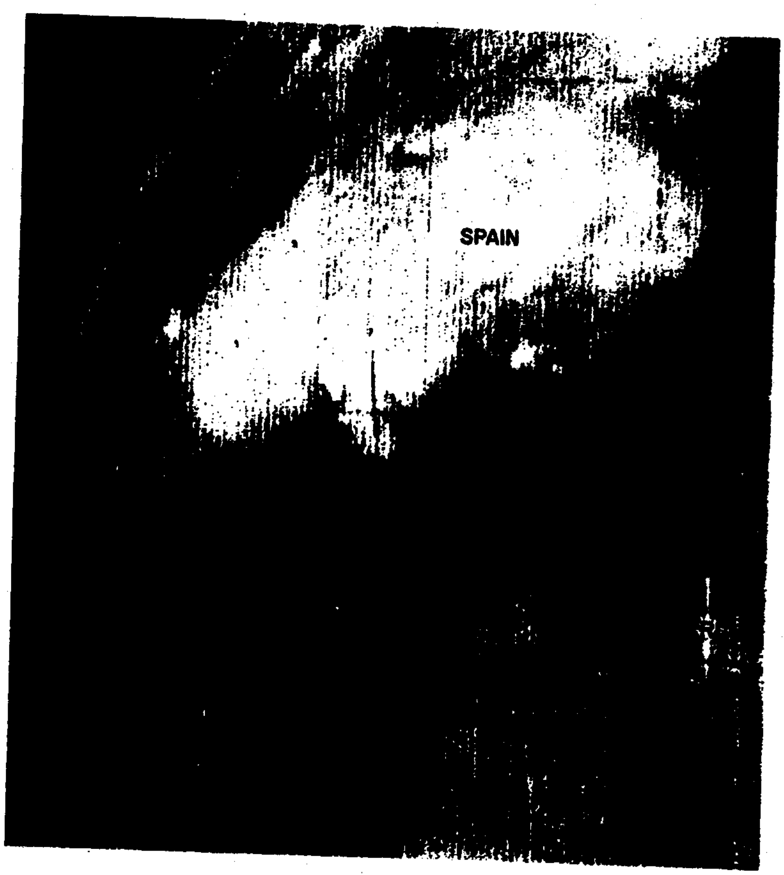


Figure 1. Photo of the Strait of Gibraltar taken from the TIROS satellite looking toward the west from over 400 miles altitude.

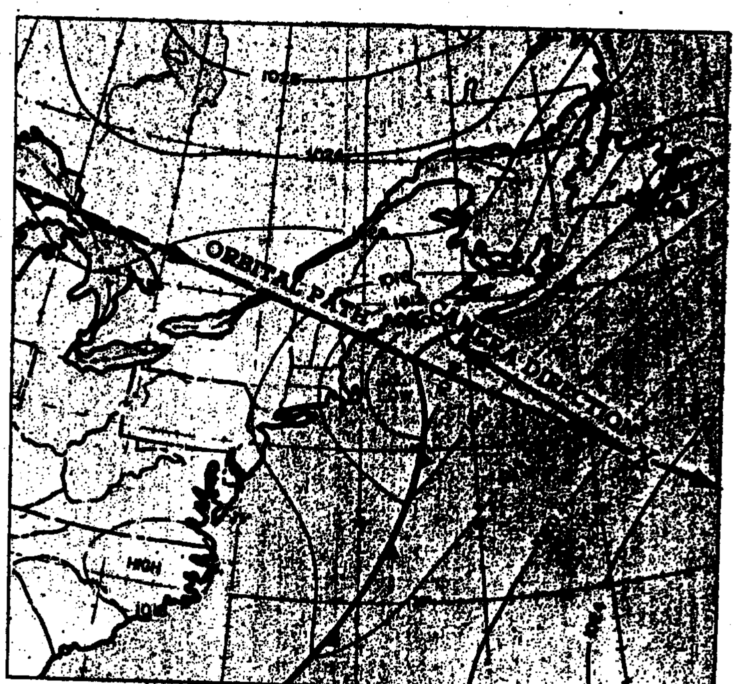
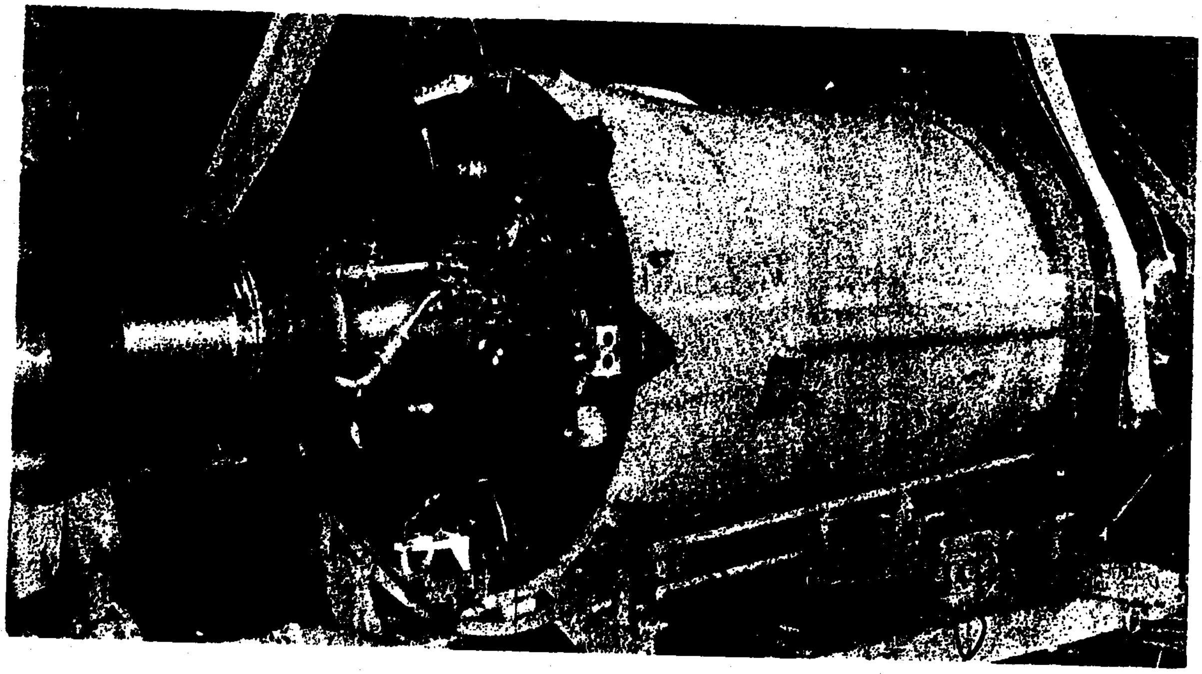


Figure 2. A series of three photographs taken by TIROS on its third orbit showing a storm over New England. The dark area on the left is the middle and South Atlantic coast. The dark area in the upper right is the Gulf of St. Lawrence and the St. Lawrence River. The "X" on the surface weather map indicates the geographic position of TIROS when the photographs were taken...

Able-Star



Three-quarter rear view of ABLE-STAR vehicle mounted on handling dolly.

Monthly Progress—ABLE-STAR Vehicles

Program Administration

● With the successful flight test of an ABLE-STAR second stage vehicle on 13 April (TRANSIT 1B flight), the development program for this vehicle was completed. Under ARPA Order No. 95, AFBMD was directed to develop an upper stage vehicle compatible with THOR, ATLAS or TITAN boosters, and capable of being modified to accept a solid propellant third stage. Funds of $1,708,000 were provided in FY 1959. A contract for design, development, fabrication and test of this vehicle was issued to Aerojet-General Corporation on 6 April 1959.

Flight Test Progress

● The first flight test of the ABLE-STAR vehicle was achieved within one year after issuance of the design contract. All pre-flight tests and checkout procedures were accomplished smoothly and in accordance with the detailed launch procedures. No difficulties were encountered during countdown or launch. All ground support equipment functioned satisfactorily.

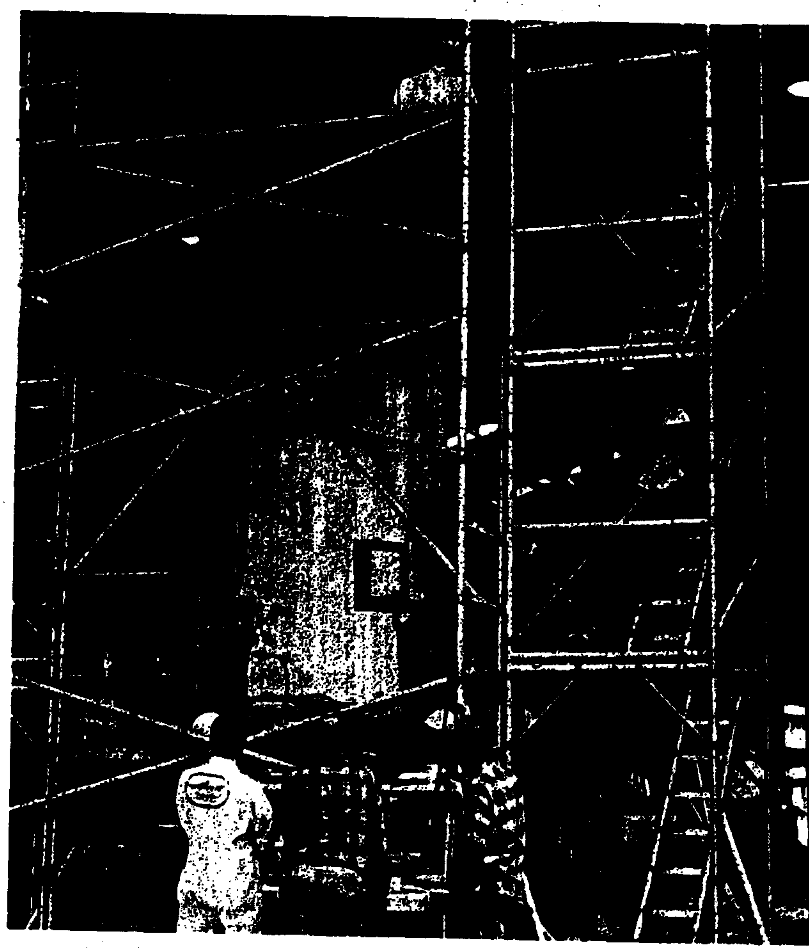
● First ignition of the ABLE-STAR's AJ10-104 propulsion system occurred two and one-half minutes after launch, following burnout of the THOR booster engine. Operation continued within specified limits for the programmed period of just over four minutes. During this time, trajectory corrections were made by the STL space guidance system. This system determines vehicle position by measuring the doppler frequency shift via the vehicle transponder. Deviations from the established trajectory were computed and correction commands transmitted to the vehicle receiver.

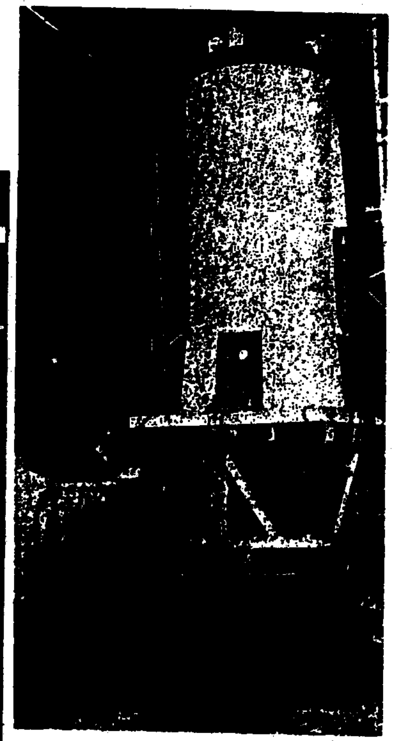
● At the end of the first burn period, the engine was shut-off by signal from the guidance system. At this time the vehicle had attained the programmed velocity of approximately 16,500 miles per hour. During the nineteen minute coast period, the vehicle's attitude was oriented into its nominal attitude by means of the pneumatic gas jet control system.

● Following the nineteen minute coast period, the ABLE-STAR engine was re-ignited and burned for 13 seconds. Vehicle altitude and second burn duration were sufficient to inject the TRANSIT 1B payload into

Component and Subsystem Tests

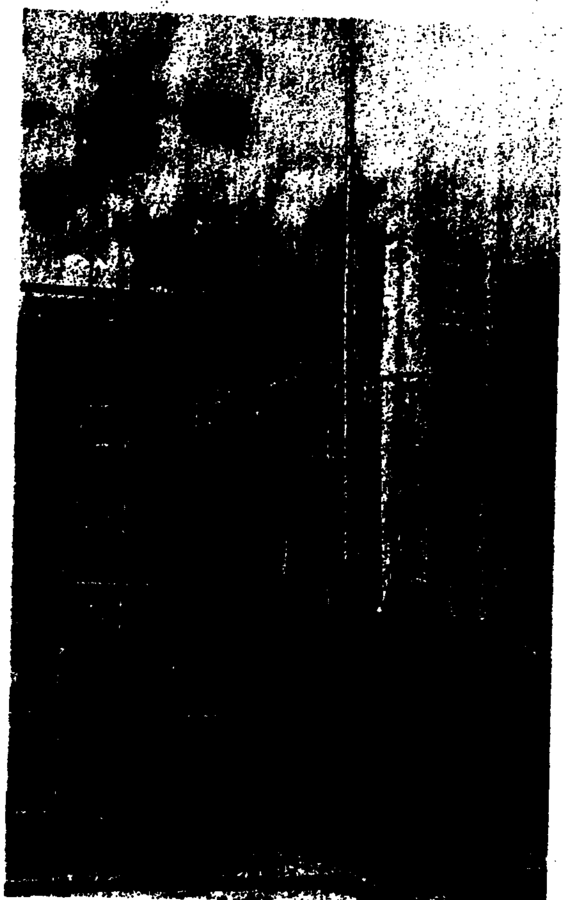
Qualification test setup for ABLE-STAR component test (above) . . . programmer subsystem test (right) . . . and vehicle subsystem tests.

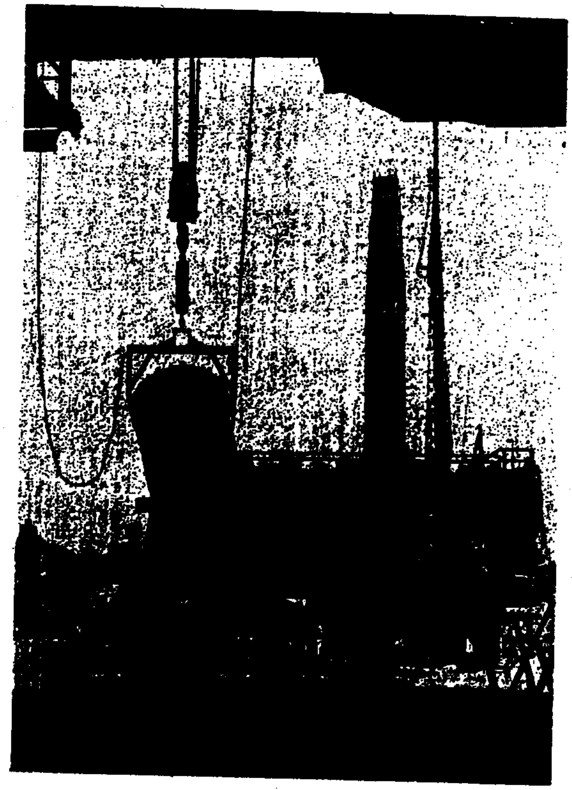




Final Systems Checks

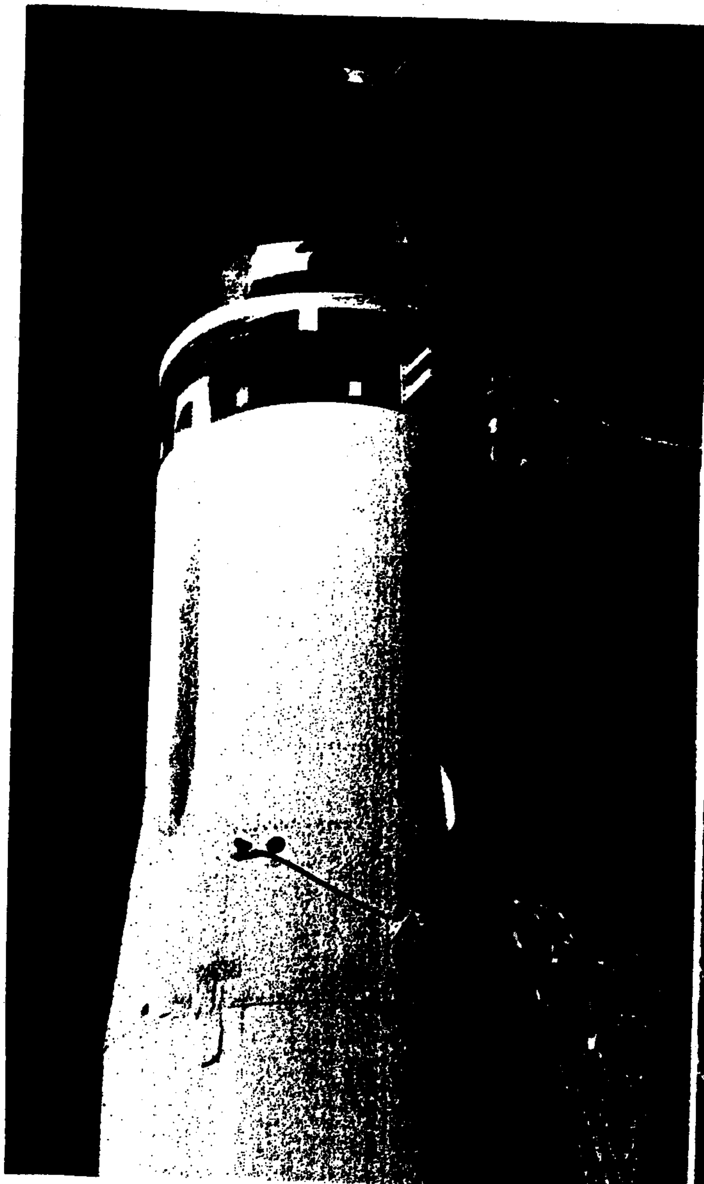
Systems checkout of the ABLE-STAR vehicle at the Atlantic Missile Range. Photo above shows vehicle in verticle position, checkout console in foreground, and mobile checkout vans in background. Closeup (upper right) during engine checks. Photo at right shows complete test layout.





Installation of ABLE-STAR

Delivered to gantry (above) . . . vehicle in gantry being moved to launch pad (above left) . . . being lowered into position (bottom left) . . . mating with THOR.



Ready for Launch

Photo below shows TRANSIT 1B vehicle on launch Stand 17B, AMR. Service tower is on the right. Closeup (left) of ABLE-STAR and payload. Electrical umbilical on top of ABLE-STAR provides power and signals for guidance equipment. Service leads for the propulsion system are attached to the rear of the vehicle.

a successful orbit. This significant milestone marked the first time that an upper stage vehicle had demonstrated the restart capability. All phrases of the restart operation were accomplished successfully and the performance achieved was excellent in relation to programmed times and specifications. This flight also was the first in which compelte control of the attitude and direction of a second stage space vehicle was maintained throughout its flight.

● At the present time, the ABLE-STAR vehicle is programmed for additional flight testing on TRANSIT 2A and 2B and on COURIER 1A and 1B.

Summary of ABLE-STAR

Development Program

● The ABLE-STAR vehicle (AJ10-104 Propulsion System) is a refined version of the earlier ABLE vehicles and Aerojet-General Corporation propulsion systems (AJ10-42 and AJ10-101). Design objectives included: increased payload weight and vehicle range capability by providing two-and-one-half times the propellant capacity and an engine restart capability; and providing positive vehicle control during powered flight and coast periods through pitch, yaw and roll control jets. In addition, two longitudinal acceleration jets were added to settle the fuel in the tanks prior to re-ignition of the engine. Design specifications for the ABLE-STAR are shown in Table 1.

● Throughout the ABLE-STAR Development Program, the guiding philosophy included minimum redesign, over-all simplification and maximum use of flight-proven components to maintain the high level of reliability established by previous ABLE vehicles; and to accomplish these objectives within a minimum amount of time.

● Following contract initiation in April 1959, design studies and preliminary manufacturing efforts proceeded at a sufficiently satisfactory rate to permit simulated high altitude tests of the AJ10-104 thrust chamber to be performed in September. Objectives of this test program, conducted at the Arnold Engineering Development Center, included:

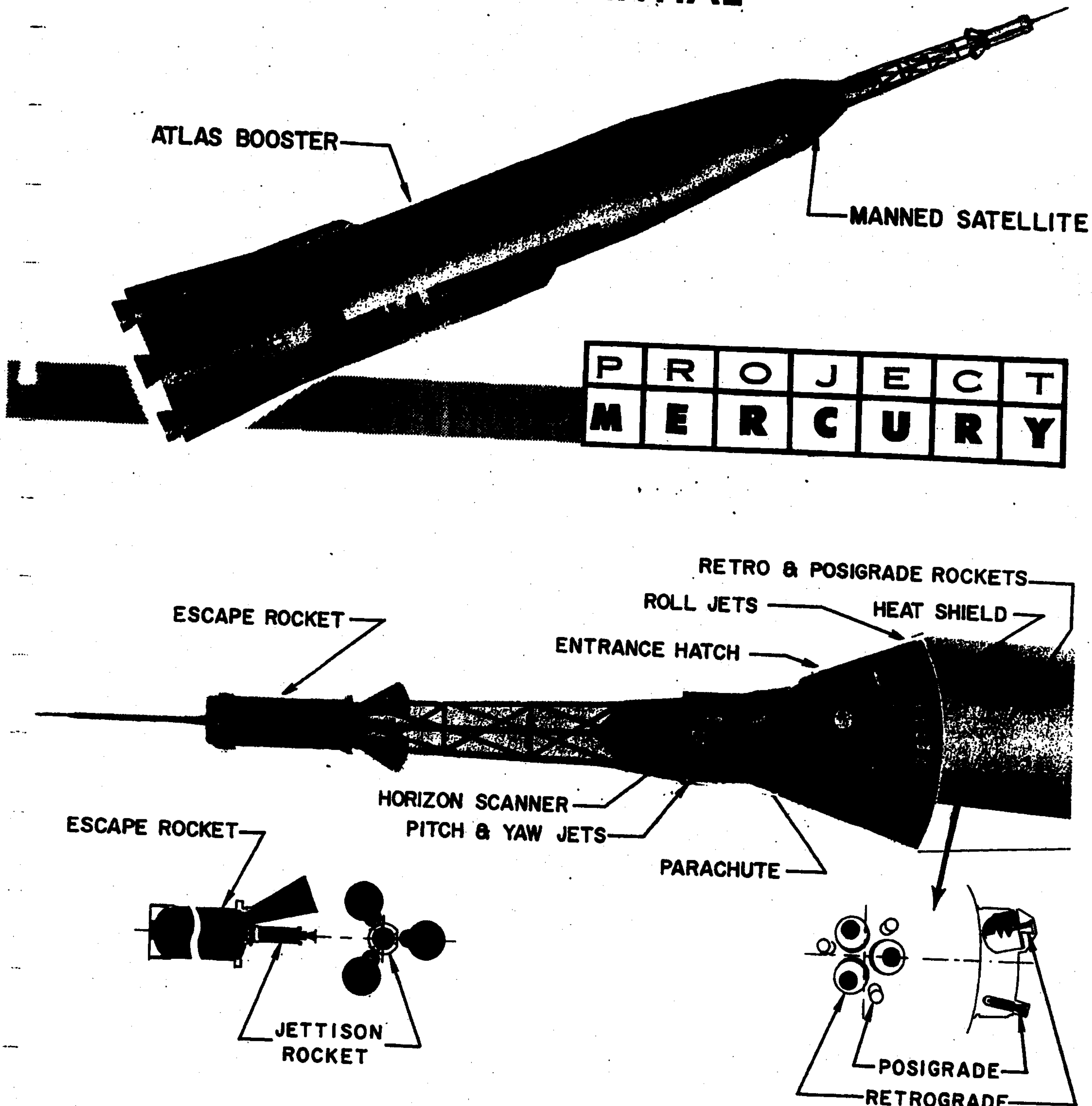
1. Determine the firing life of the aluminum and steel thrust chambers.
2. Obtain data for propellant loading and flow balancing of the propulsion system.
3. Determine accurate chamber performance data by actual thrust coefficients demonstrated in tests.
4. Evaluate thrust chamber starting, restarting and shutdown transients for steady state and coast phase operations.

● During November, operational test runs to full duration (300 seconds) were started. Injector cooling problems associated with injector manifold design and the use of inhibited fuming nitric acid as a coolant, resulted in burn through of the injector plate and cooling tubes. These problems were solved and two full duration tests were completed during the month. Also in November, the first flight test engine passed Air Force acceptance testing and the preliminary flight rating test engine was delivered to the Air Force.

● In January 1960, all preliminary flight rating tests for this propulsion system were completed successfully. A total of seven full duration firings were made with four thrust chamber assemblies accumulating approximately 700 seconds of hot firing time. The first flight article propulsion system was delivered to the Air Force in mid-January. The remaining four systems were delivered in February, March, April and May.

PERFORMANCE	
Total impulse	2,300,000 lb-sec.
Thrust	7,890 lb.
Specific impulse	278 lb-sec/lb.
Chamber pressure	206 ± 6 psia
Nozzle throat area	21.64 sq. in.
Nozzle area ratio	40:1
Propellant flow rate	28.36 lb/sec.
WEIGHT	
Dry weight	1040.7 lb.
Total propellant capacity	8474.3 lb.
Nitrogen, helium, etc.	201.2 lb.
TOTAL	9716.2 lb.
DIMENSIONS	
Overall length	177.68 in.
Diameter, propellant tanks	54.8 in.
Diameter, separation plane	63.6 in.

TABLE 1. ABLE-STAR (AJ10-104) SPECIFICATIONS



WEIGHT AT SEPARATION	APPROX 25 LBS	ORBIT INCLINATION	33 DEGREES
ORBITAL ALTITUDE	105-115 MILES (n)	HEAT SHIELD	ABLATIVE
ORBITAL CYCLES	3-18	RECOVERY	WATER OR LAND

Figure 1. Complete vehicle (top view) with satellite installed on ATLAS booster. Manned satellite (bottom view) showing pilots' flight position, and detail views of retro and posigrade rockets and pilot safety system escape rockets.

Project MERCURY represents the transitional threshold between this nation's cumulative achievements in space research and the beginning of actual space travel by man. The primary program objective is to place a manned satellite into orbit about the earth, and to effect a controlled re-entry and successful recovery of the man and capsule (Figure 1). Unmanned ICBM trajectory and near-orbital flights, and unmanned orbiting flights will be used to verify the effectiveness and reliability of an extensive research program prior to manned orbital flights (Figure 2). The program will be conducted over a period of nearly two years. The initial R&D flight test was accomplished successfully in September 1959. The total program accomplishment is under the direction of NASA. The primary responsibility of AFBMD to date consists of: (a) providing 14 ATLAS boosters modified in accordance with program objectives and pilot safety factors, and (b) determination of trajectories and the launching and control of vehicles through injection into orbit. The division of responsibilities for this program is given in Table 1. Specific details of AFBMD support are given in Table 2.

Major contractors participating in the AFBMD portion of this program include: Space Technology Laboratories, systems engineering and technical direction; Convair-Astronautics, modified ATLAS boosters; GE/Burroughs, ATLAS guidance equipment; and Rocketdyne, engines. All of these companies also provide special studies and engineering efforts peculiar to meeting Project MERCURY requirements.

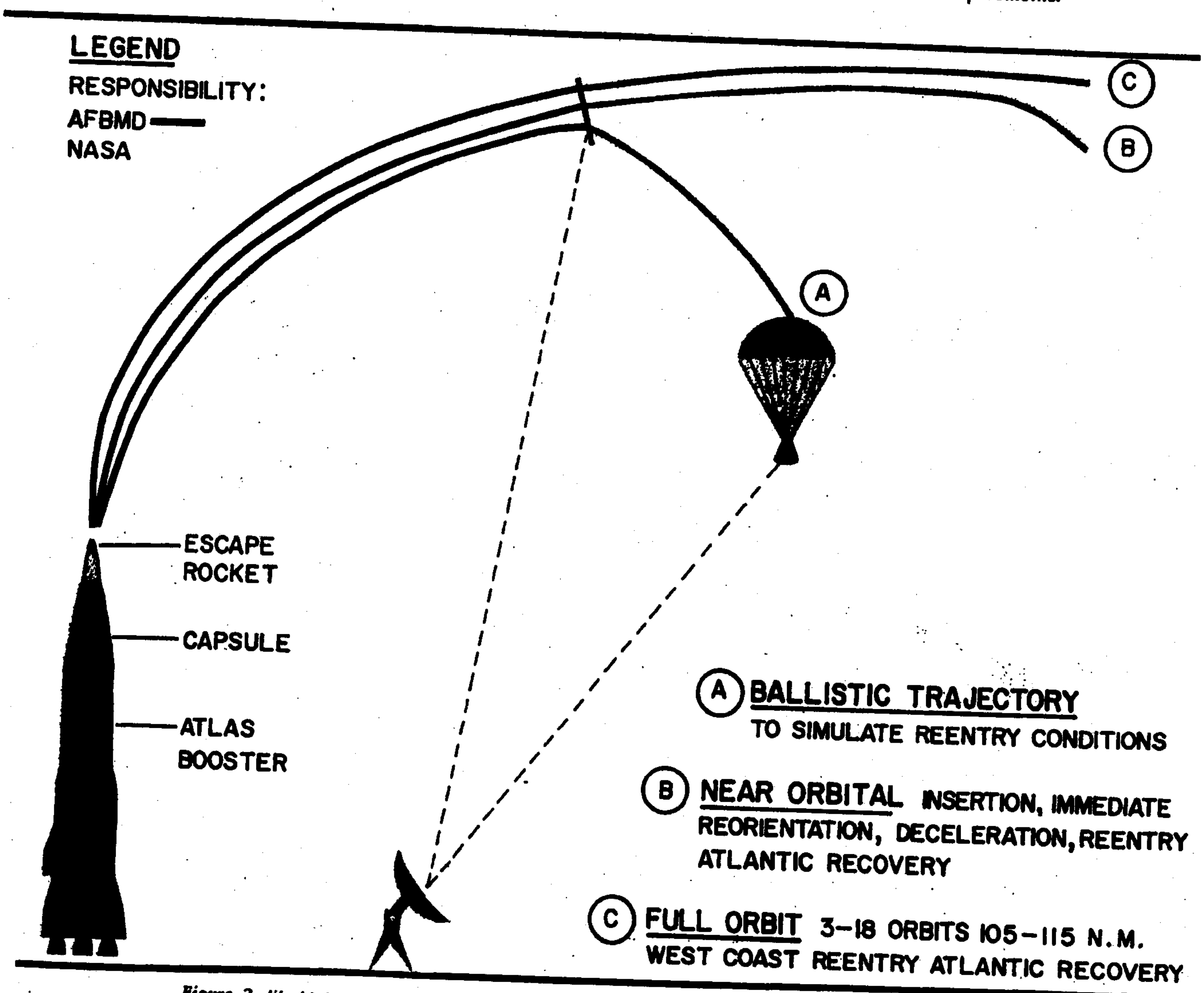


Figure 2. Flight test trajectories for Project MERCURY, defining specific objectives. Trajectory C represents the path of the final (manned) flight. The point at which AFBMD and NASA responsibility is divided represents injection into orbit.

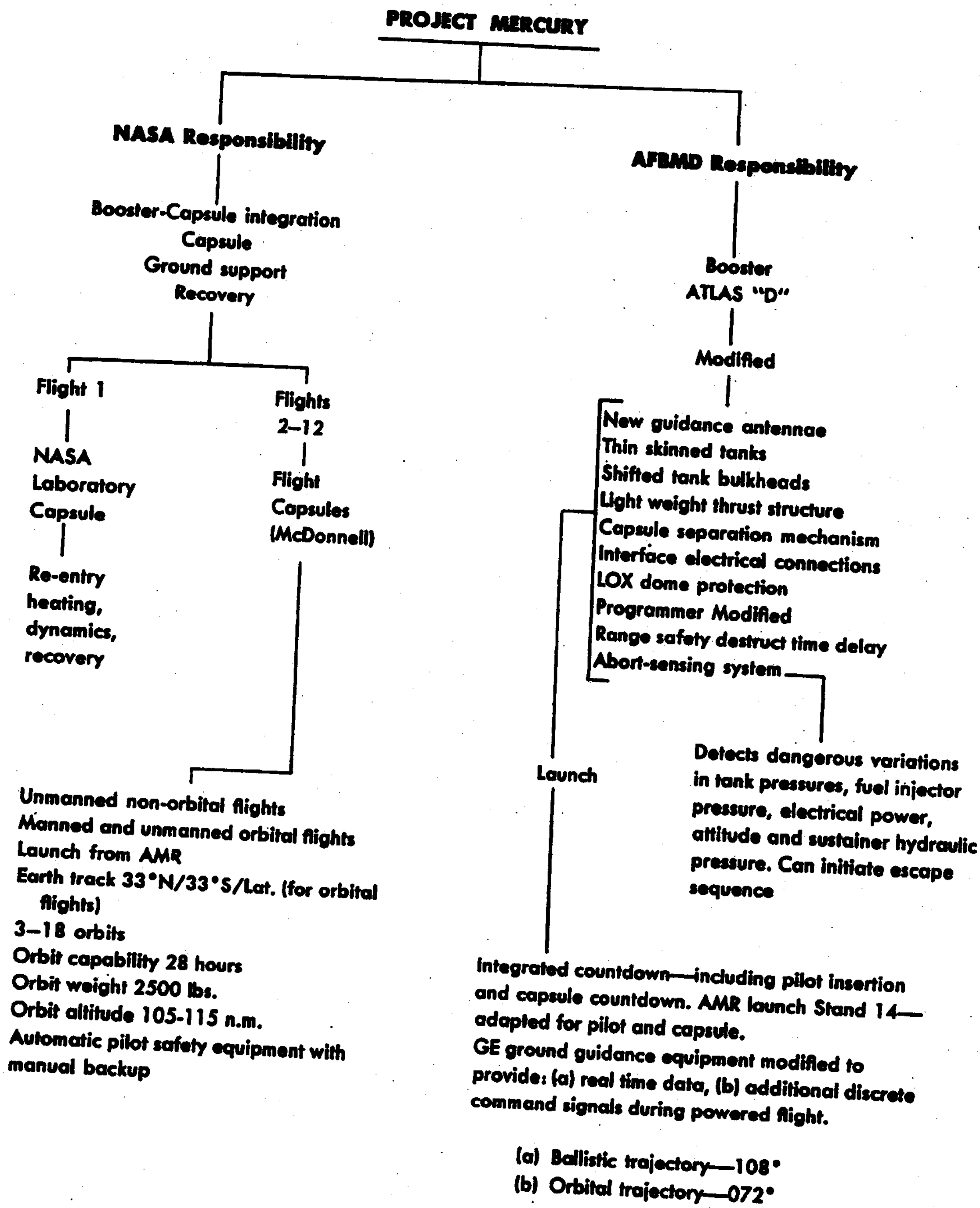


Table 1. Outline of NASA and AFBMD responsibilities in PROJECT MERCURY.

PROJECT MERCURY

AFBMD Responsibility in support of PROJECT MERCURY NASA HS-36 includes:

Design, engineering studies
Equipment modification
Hardware fabrication

Flight scheduling

Launch support
Trajectory data
Missile allocation

Provide fourteen (14) ATLAS boosters.	Modify boosters for NASA preliminary research and manned orbital flight and safety objectives.	Launch, control and define trajectories of booster-capsule vehicle up to, and including, injection into orbit.

Table 2. AFBMD responsibilities in support of PROJECT MERCURY.

Monthly Progress—Project MERCURY

Flight Test Progress

● The second flight test of an ATLAS/MERCURY vehicle has been rescheduled by NASA from late in May to mid-July. The delay was made necessary primarily by capsule delivery problems. Launch will be made from Atlantic Missile Range Complex 14. The vehicle will consist of an ATLAS booster modified for Project Mercury and a McDonnell capsule shell containing instrumentation and components furnished by NASA. The flight capsule will be boosted through a trajectory and released so that re-entry conditions associated with critical abort requirements will be simulated. The proposed trajectory parameters include:

1. Booster-capsule separation at 610,200 feet altitude.
2. Separation velocity—19,400 ft/sec.
3. Flight path angle—4.7 degrees.
4. Predicted impact—1550 nautical miles downrange.

● NASA has established the following capsule test objectives for the MA-1 flight:

1. Measurement of capsule afterbody heating rates during re-entry.
2. Establish adequacy of capsule re-entry system and recovery procedures.
3. Determine integrity of capsule structure and afterbody shingles.
4. Personnel training in MERCURY launch and recovery operations.

● The following objectives also have been defined by NASA for the MERCURY modified ATLAS booster furnished by AFBMD:

1. ATLAS capability to effect capsule release under position, velocity and attitude conditions defined by guidance equations.
2. Evaluate open-loop performance of abort sensing and implementation system.
3. Obtain data on ATLAS missile and ground systems reliability.
4. Demonstrate suitability of equipment and procedures associated with checkout and launch of ATLAS/MERCURY vehicle.
5. Evaluate propellant utilization system performance.

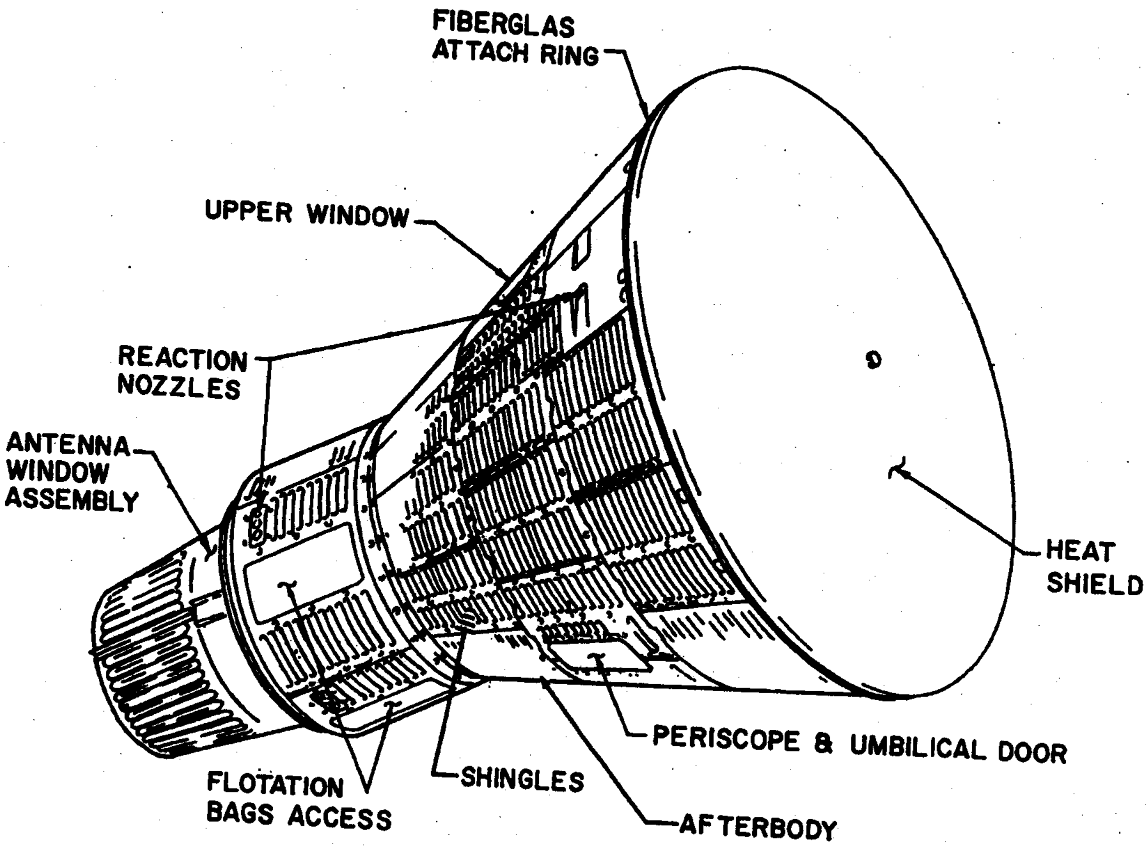


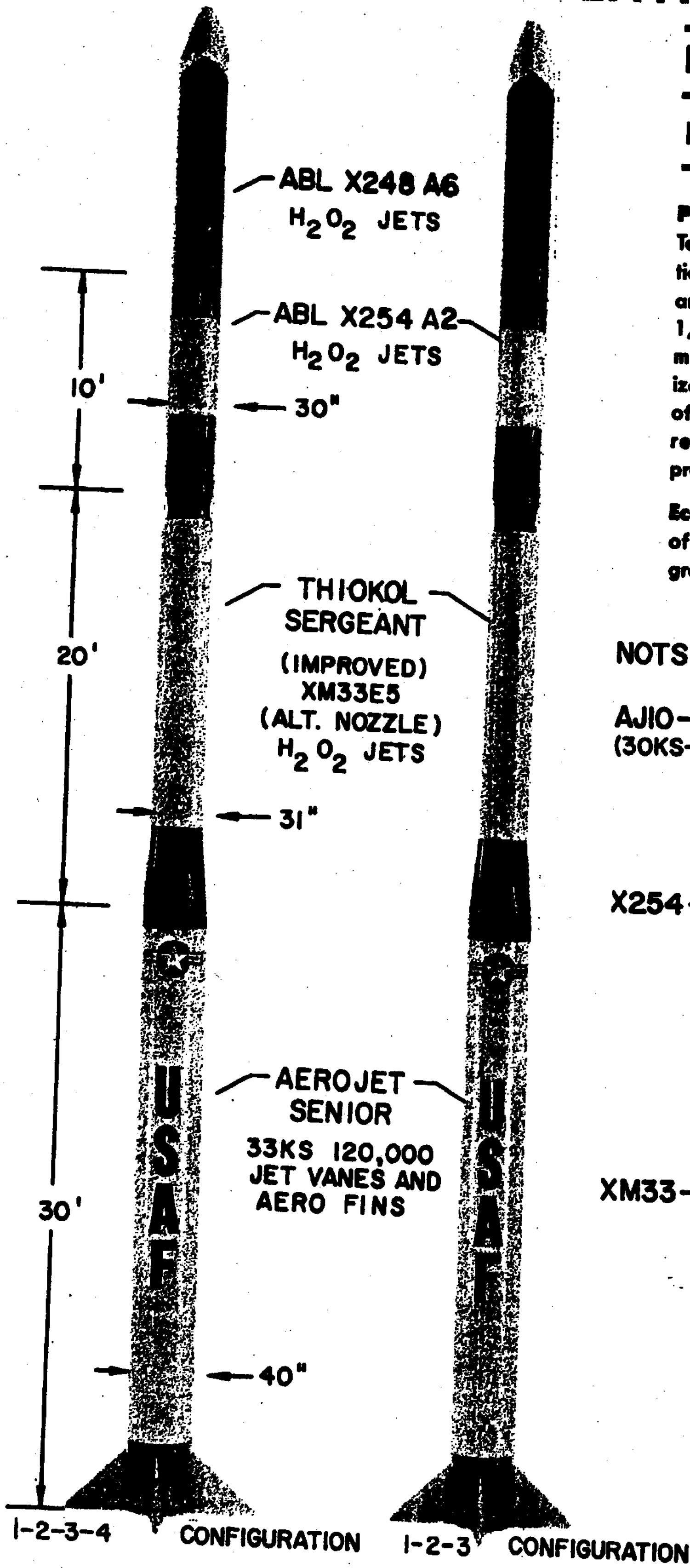
Figure 3. McDonnell shell to be carried on second ATLAS/MERCURY flight test.

PROJECT 609A

Hyper-Environment Test System

PROGRAM DESCRIPTION—The Hyper-Environment Test Program (609A) is divided into R&D and Operational Phases. The R&D phase will be used to develop and flight test vehicles capable of carrying 50 to 1,000 pound payloads to altitudes of 200 to 7,000 miles. The Operational phase will use this standardized vehicle to permit the economical performance of flight test experiments in support of scientific research and advanced military space system programs.

Economy—Reliability—Versatility—In this order of emphasis are the three significant guides to program accomplishment. ECONOMY is being achieved



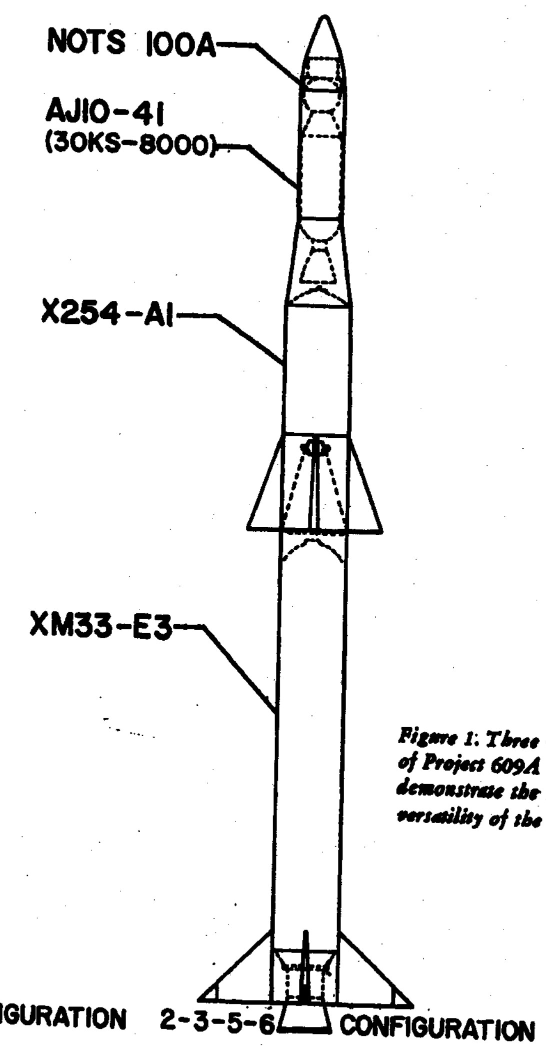


Figure 1: Three variations of Project 609A vehicle demonstrate the mission-versatility of the program.

by long range planning and maximum integration with other programs. Use of the basic four-stage, solid propellant, SCOUT vehicle, developed by NASA and modified to achieve Program 609A objectives, will effect an economy in vehicle development. Necessary modifications include provisions for stabilizing the fourth stage without spin and use of the vehicle in less than the full four-stage configuration. Close integration with the current ballistic missile program will effect an economy by permitting tests and experiments to be conducted on regularly scheduled ballistic missile test flights whenever possible without delaying schedules. Economy in the operational phase will be exercised by the use of this low-cost vehicle as a standard flight test platform to perform scientific and military experimental research in support of all Air Force facilities. RELIABILITY will

program, at least four flights of the basic SCOUT, and maximum use of knowledge gained in prior Air Force ballistic missile flight testing. VERSATILITY will be achieved by designing a vehicle capable of being readily adapted to a wide range of payload variations, and capable of being flown in several configurations of four stages or less. This VERSATILITY results in the following flight capabilities: (a) vertical probes having a wide variance of payload weight/attitude combinations; (b) boost-glide trajectories; (c) ballistic missile trajectories; (d) downward boosted, high-speed re-entry profiles, and (e) full orbit to approximate maximum of 400 miles with 150 pound payloads.

Program Management—An abbreviated development plan, covering the R&D phase only, was approved on 9 January 1959. Funds in the amount

viated portion of the program only. A letter was issued assigning management responsibility to AFMBD, with emphasis on integrating the program with the scientific and military research experiments conducted on regularly scheduled ballistic missile flight tests (Piggyback Program). In June 1959, Aeronutronic Division of the Ford Motor Company was chosen through normal competitive bidding as the Payload, Test, and Systems Integration Contractor. Arrangements have been made for the procurement of vehicle components and associated support equipment, modified to meet Program 609A requirements, through NASA, rather than through the SCOUT Program contractors. Atlantic Missile Range facilities consisting of launch complex 18 will be made available to the Air Force for this program. A Project 609A division has been established within the 6555th Test Wing (Development) at AMR to supply Air Force technicians to participate in the assembly, checkout and launch operations of the R&D phase under the direction of the Payload and Test Contractor. An all-military operational capability will be developed from within this group.

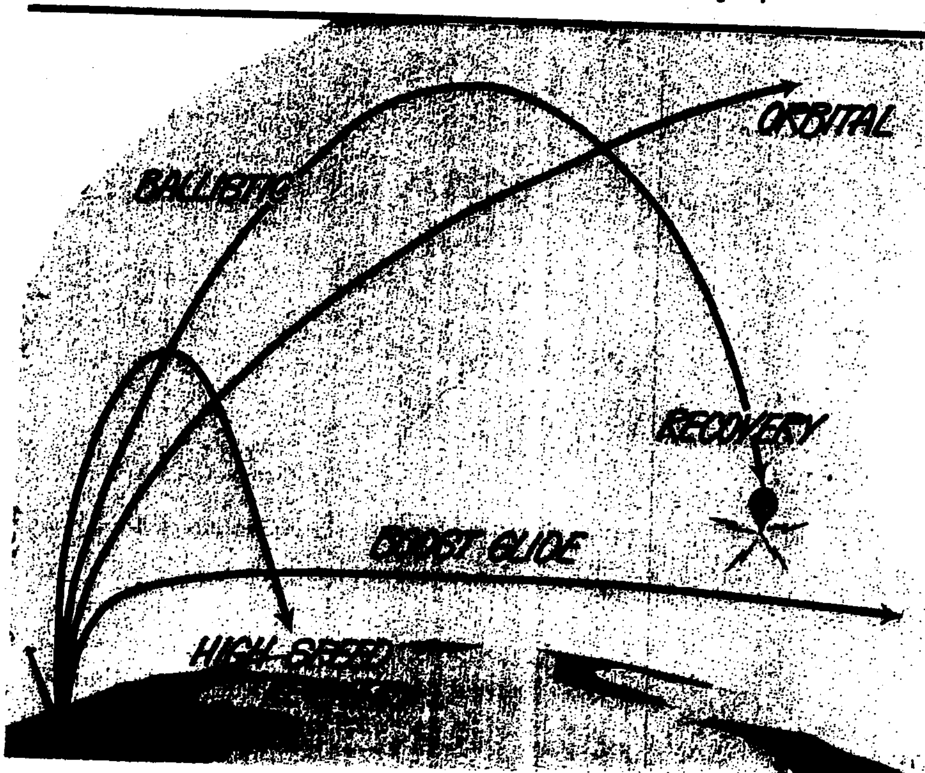
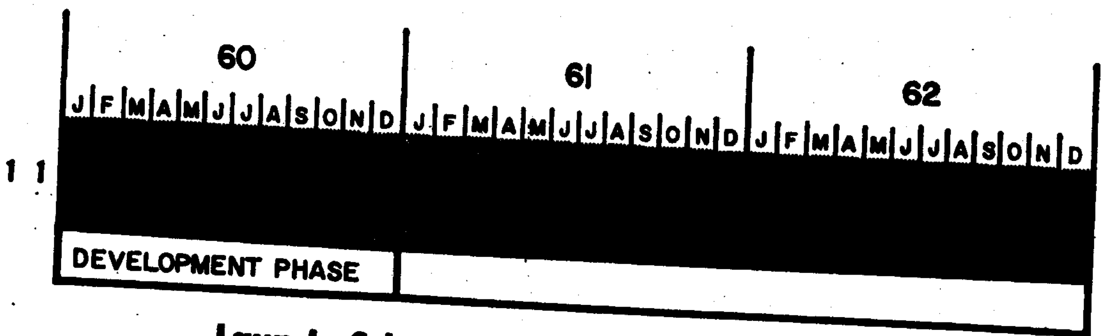


Figure 2. Four different trajectories possible using different arrangements of Project 609A stages.



Launch Schedule

Monthly Progress—Project 609A

Program Administration

- A conference was held with representatives of the Dyna-Soar Weapon System Project Office concerning the flight testing of Dyna-Soar models with 609A vehicles. Four twelve-foot models will be launched by 1-2-3 configuration vehicles (Figure 1) starting in June 1961.
- A request has been sent to ARDC requesting additional FY 60 (P620) funding of $1,043,000 for the Development Test portion of the program. Increased costs of hardware and systems management made this request necessary. Additional information requested by Hq ARDC will be provided in May.
- Funding for design and construction of additional facilities required at AMR was requested. An additional $1,060,000 (P300 series) will be required to support the follow-on program.
- The delays in the NASA program, combined with the firm Hq USAF commitment for 609A support of the Navy TRANSIT Program have necessitated program reorientation. Aeronutronic has been requested to submit recommendations for back-up developments, studies, and supplemental tests required to permit the Air Force to proceed on its own program in case NASA cannot resolve these development problems. This information will be included in the revised 609A Development Plan being prepared by AFBMD for submission to Hq ARDC in May.

Technical Progress

- A regular monthly technical coordination meeting has been established. During this month's meet-

Figure 3. Mockup of 609A payload carrier with jettisonable heat shields removed showing recovery capsule (top) and gyro reference package (center). Typical payload experiment components are mounted on the equipment racks. This carrier can be installed on either the 1-2-3 or the 1-2-3-4 configuration.

ing a discussion was held regarding NASA difficulties in assembling the first SCOUT vehicle. A requirement was established for a complete assembly and fit check of the first 609A guided vehicle at Change-Vought prior to shipment to AMR for launch. Technical difficulties and these new requirements have caused a three week delay in the launch of this vehicle. Launch is now scheduled for 11 August.

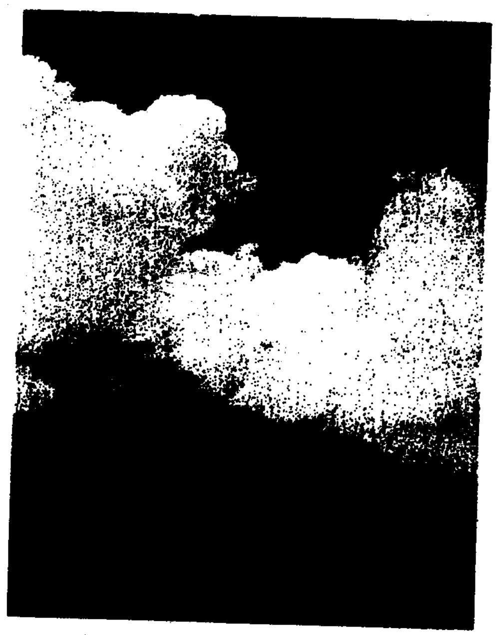
● Simulated high altitude tests of the ABLE X-254 engine conducted at Arnold Engineering Development Center in April revealed nozzle liner blistering problems. Corrective measures have been taken and additional tests are planned. NASA will use the first 609A flight engine for the test and replace it with one from later production. This has delayed the launch of the first 609A (unguided) vehicle until 8 June.

● Prior to approving 609A launch operations Range Safety at AMR has requested that tests of the destruct system be performed using fully operational engines. Procedures for these tests were established at AFBMD on 28 April and a test directive is being prepared. A rejected X-254 engine will be tested at Edwards AFB during mid-May and a rejected Aerojet Senior engine will be tested early in June to satisfy the AMR requirements.

● A modified SCOUT vehicle was launched on an unguided flight on 18 April. This vehicle consisted of live first and third stages, a dummy second stage, and an inert nose cap. This was the first flight Test of the SCOUT first and third stages. The first stage performed satisfactorily, but prior to burnout, oscillations developed and the vehicle forward section broke off. Analysis of flight data indicate that the breakup was caused by the vehicle spin rate. Since the guided version of the SCOUT does not include a spin requirement, these stresses will have no effect on guided flights.

● The first full scale SCOUT missile has been assembled at Wallops Island and final checkout is being accomplished. NASA has scheduled this launch for early in June.

SPACE



studies

ADVANCED SYSTEMS STUDIES

1. The Advanced Systems Studies Division has several space studies in progress. The purpose of these studies is to determine the military missions and mode of operation in space. For the purpose of study, space has been divided into three broad areas; earth orbital, lunar, interplanetary. Studies in the lunar and interplanetary area are being managed and directed at AFBMD. There are two studies in the Lunar area: SR 192 (U) Strategic Lunar System, and SR 183 (U) Lunar Observatory. There is one study in the interplanetary area: SR 182 (U) Strategic Interplanetary System.

2. The objective of SR 192 is to determine a military posture in the lunar area which is defined as the surface of the moon and the area in its surrounding gravitational field. This is a broad conceptual type study which will examine all facets of military operations such as offensive, defensive, and supporting systems. This study was funded with $600,000 in Fiscal Year 1959 and final reports from the contractors are due at AFBMD by February 1960. In addition to the three funded contractors working on this study, there are three voluntary contractors. Consequently, the total effort being applied is estimated as equivalent to one million dollars.

3. An obvious military requirement in the lunar area will be a surveillance and intelligence collection system. Therefore, SR 183 (U) Lunar Observatory was initiated to examine this problem. The objective of this study requirement is to determine a sound and logical approach for establishing a manned intelligence observatory on the moon from which the entire earth and its surrounding area can be kept under continuous surveillance. All earth orbital systems can be monitored and enemy activities in space and on the lunar surface can also be watched. All possible types of sensors and their probable ranges will be examined. This study will also include the means of logistically supporting and establishing the lunar base. This study was funded with $420,000 in Fiscal Year 1959. Three contractors were funded and three additional contractors are performing the study on a voluntary basis. Consequently, it is estimated that this study has the equivalent of $1.5 millions being applied to it.

4. The interplanetary area is being studied under SR 182 (U) Strategic Interplanetary System. The objective of this study is to determine the possible military missions and the type of equipment necessary for operations in the interplanetary area. This area is being studied separately from the lunar area because the operational problems involved appear to be somewhat different, the distances are much greater; our present knowledge of the area is limited, therefore, special types of navigational and propulsion systems will be required. This study was funded with $285,000 in Fiscal Year 1959 which has been distributed among three contractors. Contractors' final reports are due at AFBMD in February 1960.

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