THE DISCOVERER PROGRAM

by

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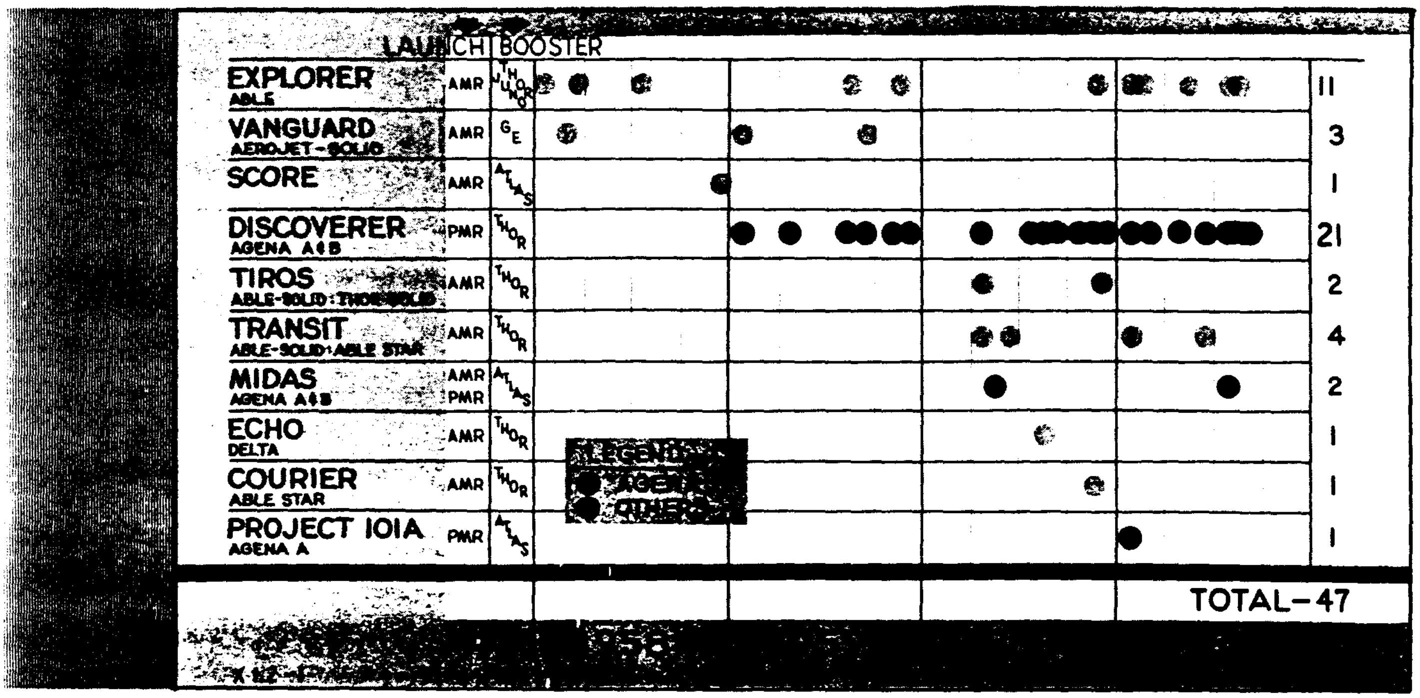
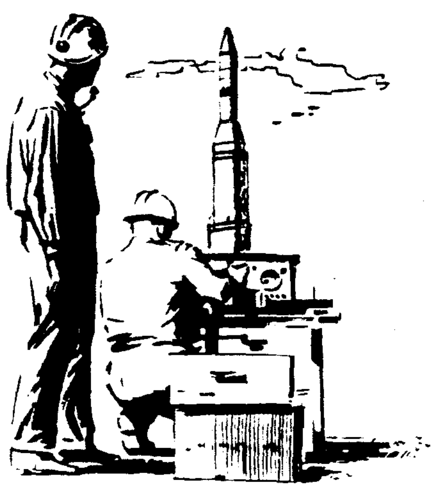
2175-61

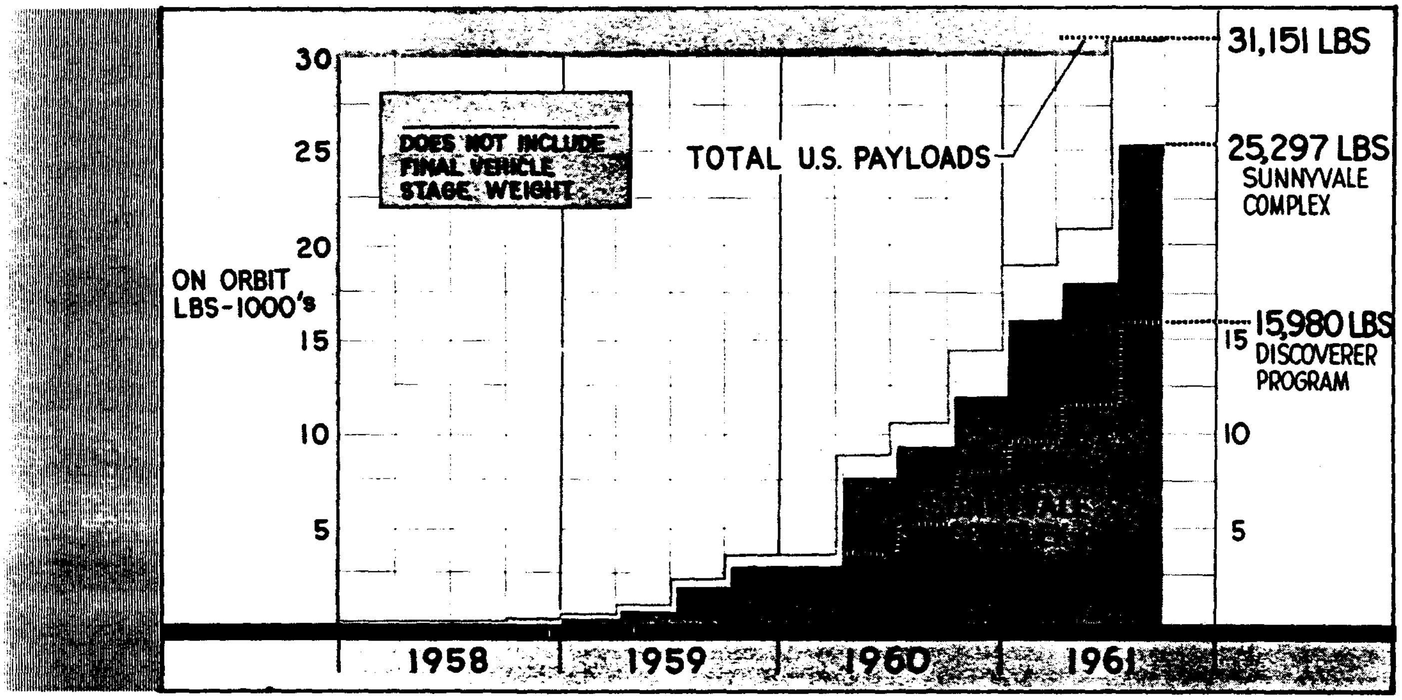
SUCCESSFUL U.S. EARTH ORBITS



Of 47 satellites successfully orbited to date by U. S. Space Programs, 24 have been accomplished by Agena vehicles carrying a wide variety of payloads. The Discoverer Program, using the Agena-Thor combination, has accounted for 21 of the 24 successful orbits. The Agena B has been the basic vehicle used by Discoverer since November, 1961. Prior to that time a first generation vehicle, the Agena A, was successfully utilized to place diverse payloads in orbit.



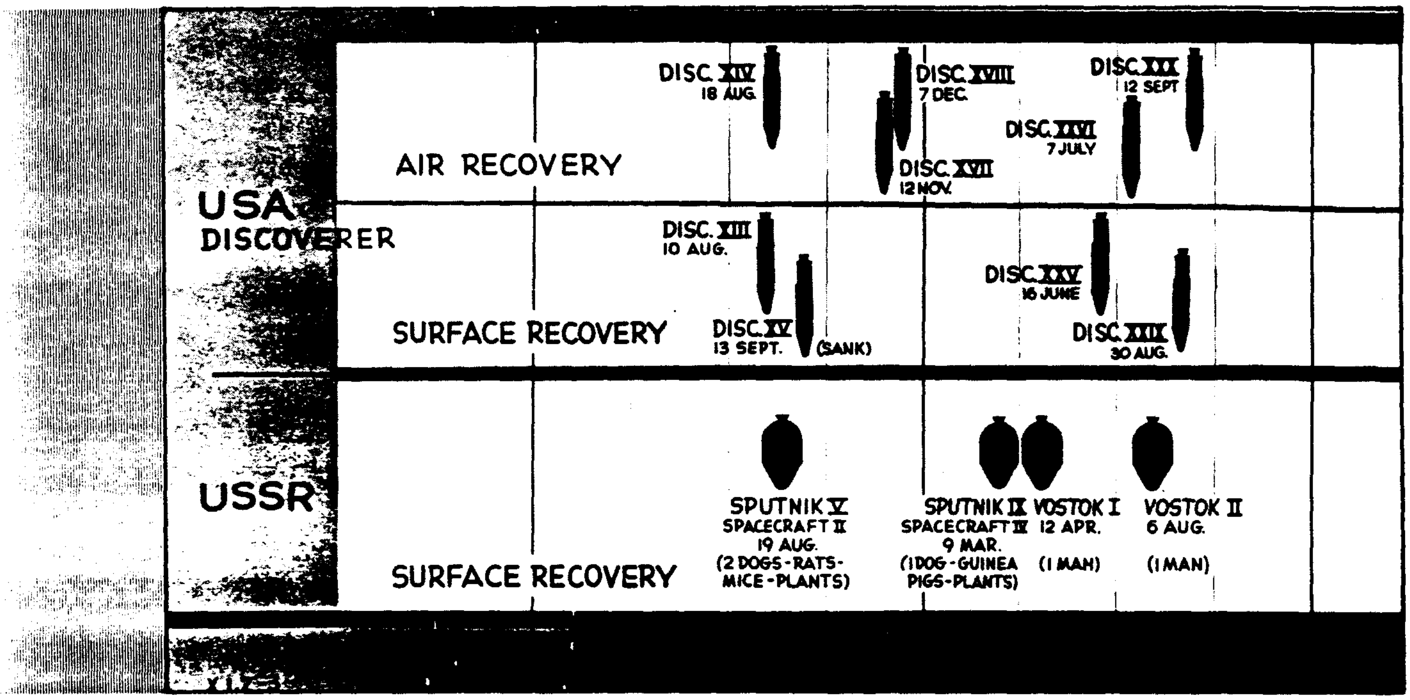
U.S. ORBIT PAYLOADS



Of the total 47 vehicles orbited by the U. S., the useful or functioning portion of the vehicles amounts to 31,151 pounds. This payload weight does not include the vehicle structure, engine, stored propellants or other components not directly used by the active orbiting experiment. The USAF Program at Lockheed, Sunnyvale has provided 25,297 pounds with the Discoverer Program alone accounting for 52% of the total. Such a relatively large percentage of the total has resulted from the large number of flights rather than the size of the functioning payload. For example, Discoverer Agena A and Agena B payloads averaged only about 600 pounds and 1000 pounds respectively.

These figures point up two important considerations: The Discoverer has established a continuous and reliable weight - carrying ability, and it has orbited payloads of all degrees of complexity and application ranging from scientific-experimental modules to advanced systems components.

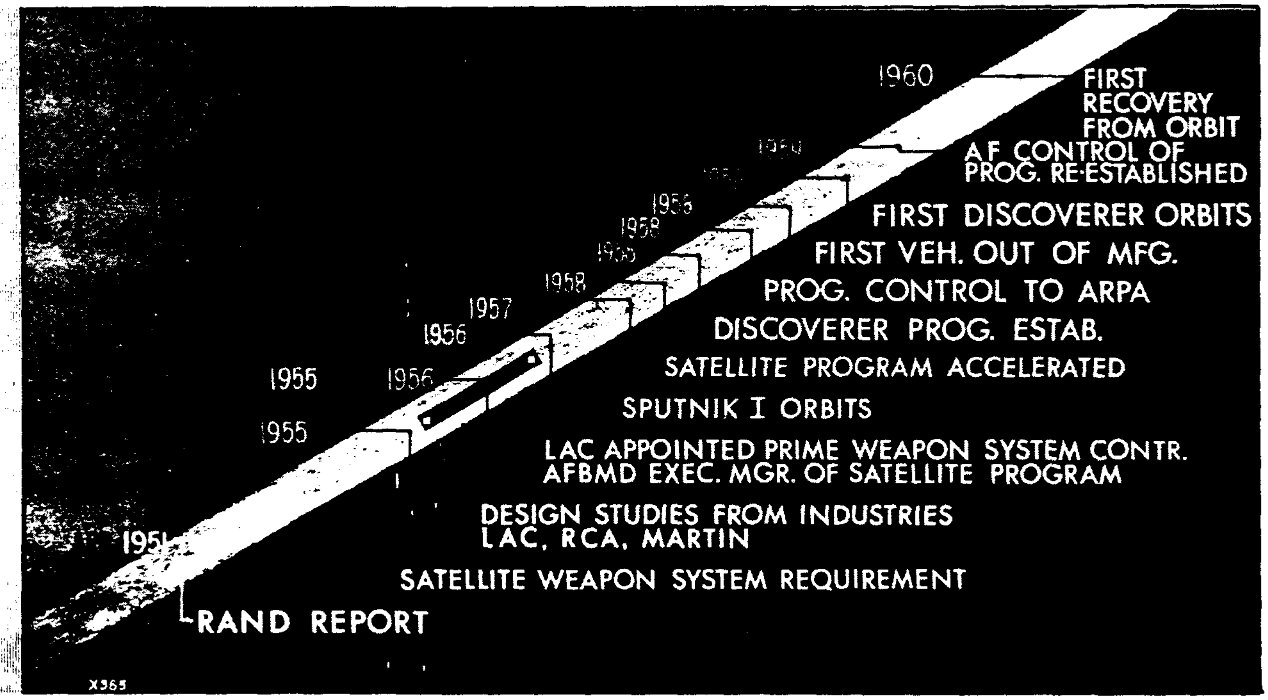
PAYLOAD RECOVERY FROM ORBIT



The United States' Discoverer XIII was the first spacecraft to separate a payload while on orbit and re-enter it through the atmosphere to an awaiting surface force. This event was successfully completed just nine days before Sputnik V returned a biomedical payload, thus establishing a "space first" which was much appreciated by the USAF Discoverer Directorate and its team of contractors. Eight days later another precedent was set. The Discoverer XIV payload was recovered in mid-air by a U. S. Air Force C-119 aircraft, thereby completely fulfilling the original design objectives.

The totals as of 30 September 1961 underscore the unique record of the Discoverer Program – five mid-air recoveries and three successful surface recoveries by contrast with four surface recoveries attained by Russian payloads.

PROGRAM EVOLUTION



LMSC Space Systems has taken its direction and assumed its present responsibilities as a result of combined military, scientific and international political events.

Following the study and preliminary design period which started with work at RAND, the first real development effort was initiated by the awarding of a contract to Lockheed Aircraft Corporation. The normal weapon system development process was greatly accelerated with the successful orbit of Sputnik I, thereby providing the "birth" of the Discoverer Program.

A measure of the degree of acceleration of the program is shown by the achievement of a successful orbit just 11 months after the establishment of the program. Such a short development span resulted from the dedicated efforts of a large number of Air Force — contractor personnel, and also by the establishment of a well defined and simplified set of objectives.

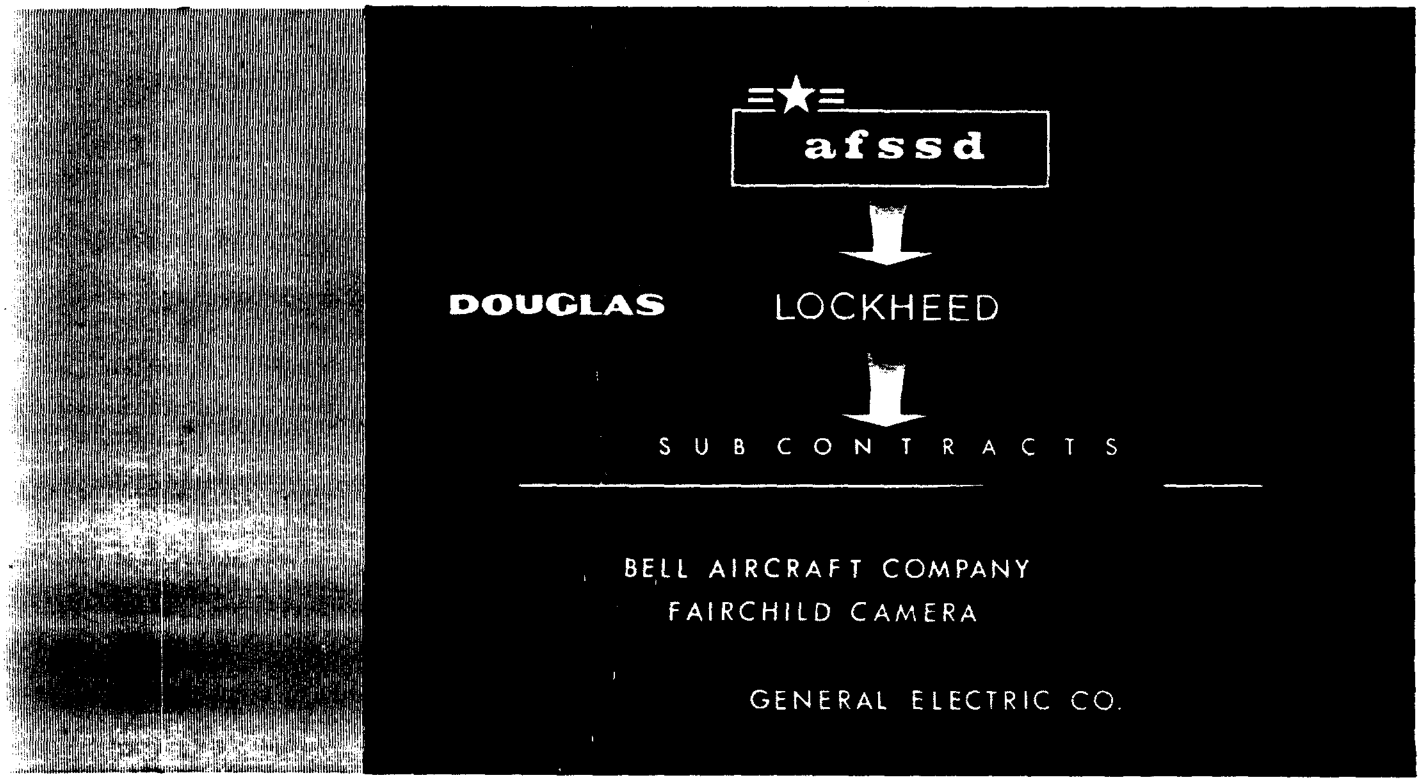
PROGRAM OBJECTIVES

- ✔ DEVELOP & TEST A BASIC SATELLITE VEHICLE
- ✔ DEVELOP [redacted]
- ✔ PERFORM ENGINEERING TESTS
- ✔ DEVELOP RE-ENTRY & [redacted]

The Discoverer, beginning as a general engineering program, has assumed a definite set of objectives directed toward proving feasibility study assumptions, flight-testing hardware, linking ground and space elements in an integrated world-wide network, establishing a platform in space for advanced scientific and military experiments and performing ballistic re-entry. Through the course of 21 orbital missions the Discoverer — Agena propulsion system has been upgraded from the Bell series 8001 to the current model 8096, a turbo-pump fed, hypergolically-fueled, restartable engine. Agena fuel capacity has been doubled since the early configuration; space vehicle power has been sophisticated and improved to the point where primary batteries now produce more than 85 watt hrs/lb., and guidance and communications and control units are presently approaching third generation status.

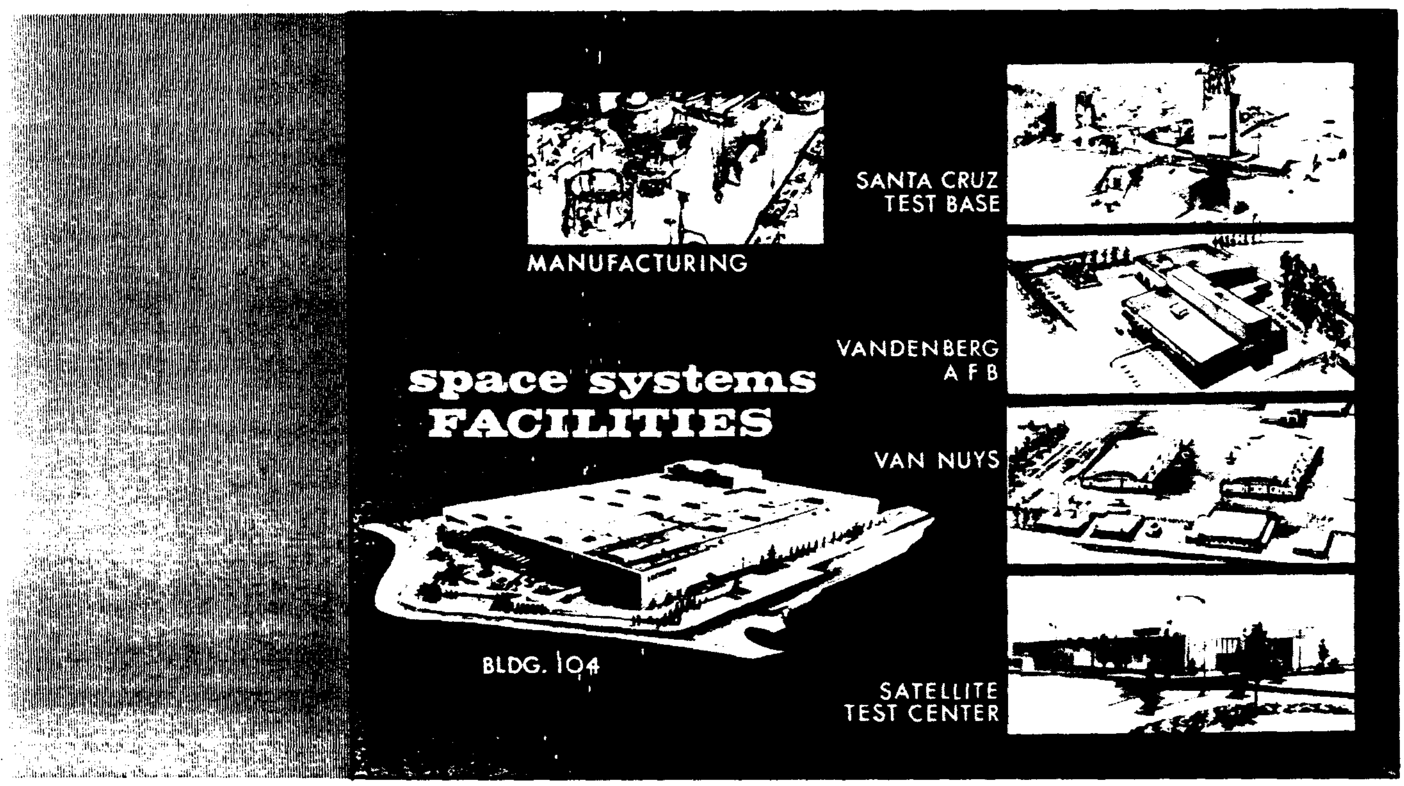
Beyond the research payloads which are flown for various government agencies and their subcontractors, Discoverer derives a large percentage of its payload from the requirement for orbital testing of components and equipments planned for use in other USAF satellite programs.

PROGRAM MANAGEMENT



Overall responsibility for the Discoverer Program is vested in the Space Systems Division of Air Force Systems Command. Lockheed Missiles and Space Company is prime contractor, responsible for technical direction of the program. Douglas Aircraft Company, an associate contractor, provides the Thor first-stage booster together with necessary ground equipment and personnel. [redacted], another associate contractor, is responsible for ground-space communications and satellite control. Some major subcontractors are: Bell Aerosystems, rocket engine; General Electric Company, recovery capsule; [redacted] and Fairchild Camera and Instrument Company, guidance and control components.

SPACE SYSTEMS FACILITIES



The headquarters for Lockheed's satellite and space programs is a 393,600 square foot building at Sunnyvale, California, where program management, engineering, vehicle checkout and laboratory functions are carried on. Manufacturing support is provided by the LMSC Central Manufacturing shops at Sunnyvale. Other major facilities are:

Santa Cruz Test Base - SCTB is a 4,000 acre test area some 35 miles from Sunnyvale. Here static firings of the Agena are conducted in one of the several test stands.

Vandenberg AF Base - Pre-flight checkout of the satellite is performed in the large Missile Assembly Building, where the Agena and Thor are first mated.

Van Nuys - The Van Nuys, California plant was the original site of Lockheed missile and space operations. The facility now serves primarily as the manufacturing center for Aerospace ground equipment and certain spacecraft components.

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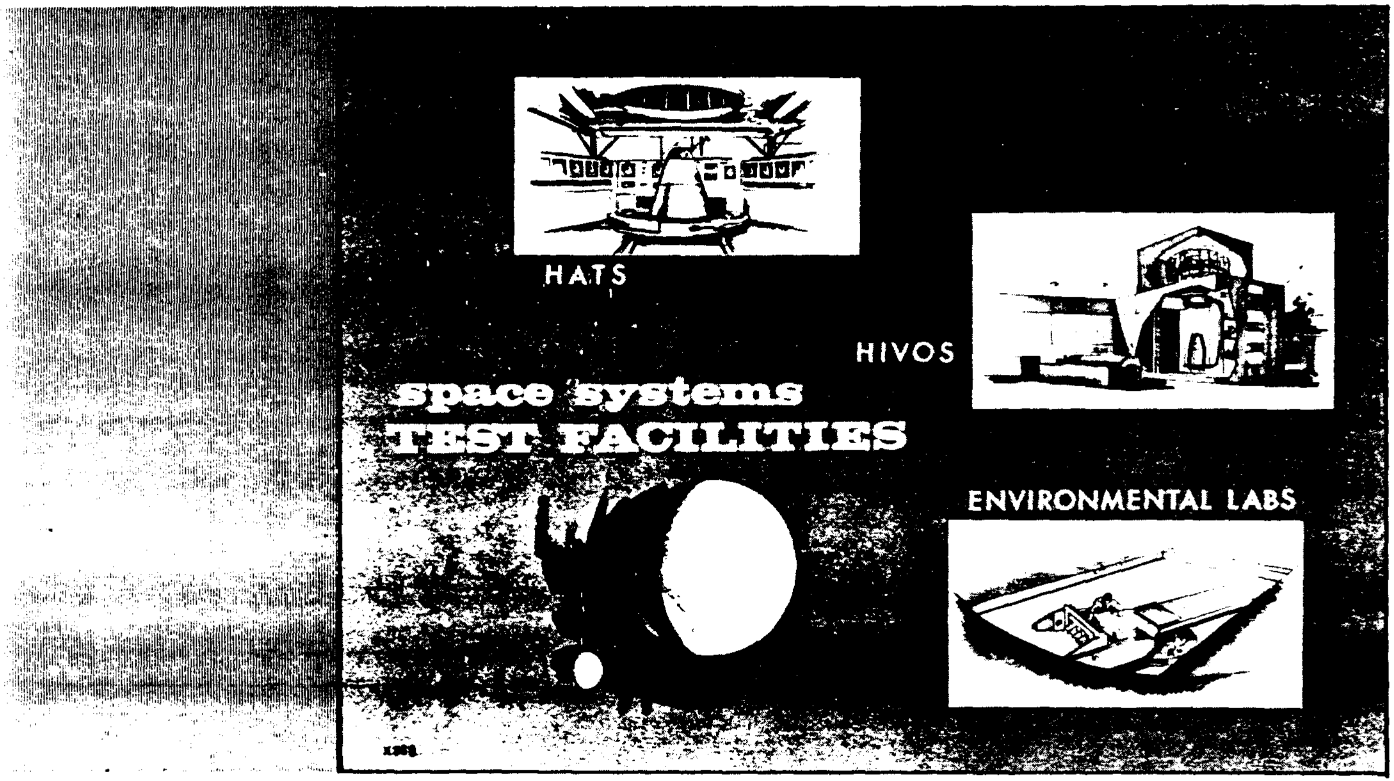
SPACE SYSTEMS FACILITIES (continued)

Satellite Test Center - The STC is an Air Force owned building at Sunnyvale. Under direct control of the USAF 6594th Test Wing, the STC provides for space operations of Discoverer and other programs.

SPACE SYSTEMS TEST FACILITIES



Ground testing facilities and equipment used in support of the Agena programs and the Discoverer Program have been designed to a unique advantage shared by few other space programs. Every calculation and every flight component can be checked out fully on the ground with the realization that the final and perhaps conclusive test under actual operating conditions in space is available through the capacity and capability of an orbiting Discoverer vehicle.

Pending empirical data gathering on orbit, LMSC ground experiments and checkouts are extended by means of these:

1. High Altitude Temperature Simulator - An environmental chamber with a temperature range of $-120^{\circ}F$ to $+320^{\circ}F$, and a maximum altitude simulation of 1×10^{-6} mm Hg. The interior of the chamber is so designed that cyclic temperature changes due to spacecraft day - night cycles in space may be simulated. A 240-channel automatic data system collects test readings on punched cards or an IBM typewriter.

2. Environmental Laboratories - The environmental laboratories also provide the full range of testing equipment necessary to production of highly reliable spacecraft components. A large

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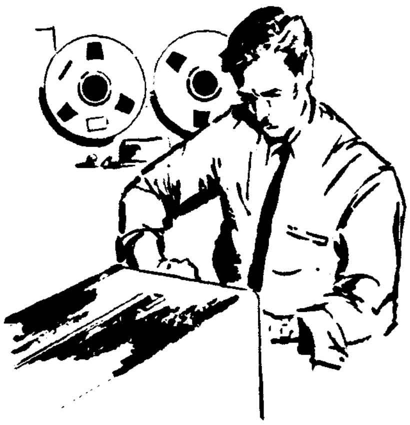
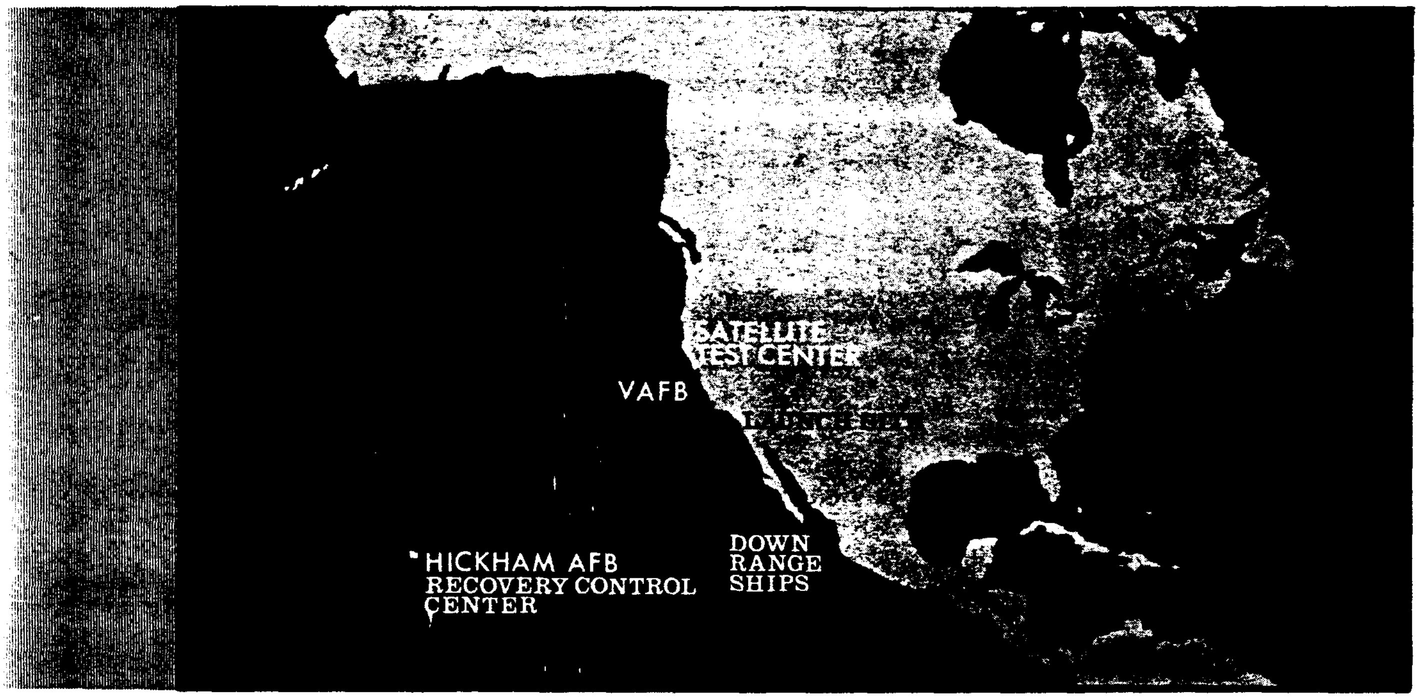
selection of equipments from the large machines required for testing complete systems to the small ones for component testing are provided to permit testing of all phases of standard military specifications.

3. High Vacuum Orbital Simulator - The HIVOS is a new 5,000 cubic foot chamber with a minimum pressure capability of 1 x 10^{-8} mm Hg. It can accommodate a complete Agena space vehicle and can provide continuous test operation for one year. A heat flux simulator can produce a thermal flux input of 1,000 BTU/sq. ft./hr., while a cold wall liquid nitrogen cryopump can drop the temperature to -320°F. The HIVOS will be operational in early 1962.



SYSTEM NETWORK



Discoverer satellite operations involve facilities located throughout North America. Their locations and functions are:

Vandenberg Air Force Base - Launch operations including initial launch tracking and telemetry readout. [redacted] are performed in line with mission requirements.

Downrange ships - Two ships operated by the Pacific Missile Range are located some 1500 miles downrange during launch to monitor Agena engine burn and orbital injection.

[redacted] station is the first to acquire and track the polar-orbiting Discoverer satellite as it completes its initial complete orbit. This station also plays an important part in the recovery operation by recording the vital telemetry data of vehicle and capsule functions in the recovery sequence.

[redacted] This station provides tracking and T/M readout coverage of the Discoverer satellite on its passes over the eastern United States and Canada.

[redacted] - The [redacted] station is the fourth of the tracking and T/M stations. Its functions and equipment are

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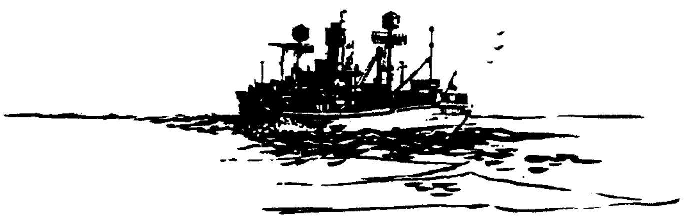
similar to those of [redacted] Because of its proximity to the recovery area, the [redacted] station serves as a prime activity in tracking and recording of re-entry data.

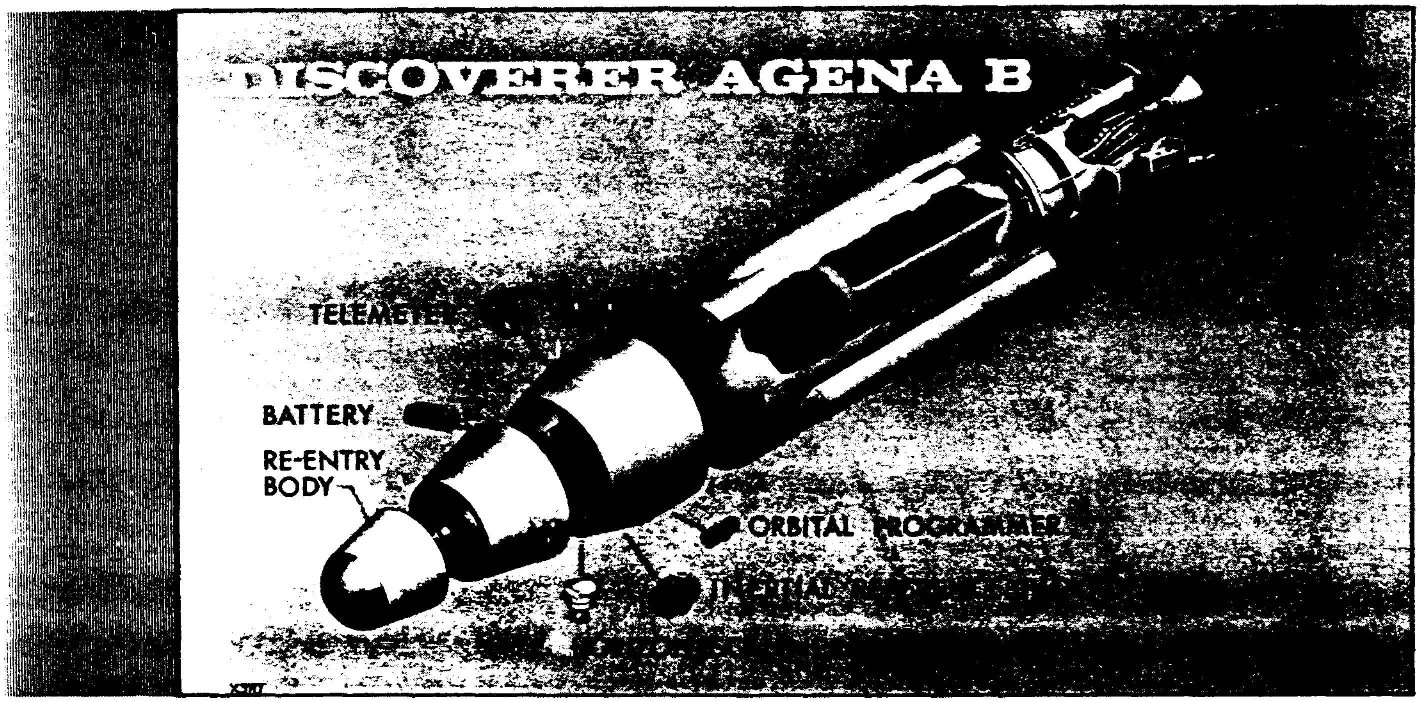
Recovery Control Center - The RCC is located at Hickam Air Force Base, Hawaii. It is the point from which all air and surface recovery operations are coordinated.

Satellite Test Center - The STC at Sunnyvale, California is the nerve center of the tracking station network. It is constantly in touch with all the stations, the launch base and the Recovery Control Center. From the STC, Air Force and Lockheed personnel command and coordinate overall system operations.

Each of these stations is tied to the Satellite Test Center in Sunnyvale, California through an extensive network of communications. All basic orbital calculations are conducted by the computer center in the STC with each outlying station receiving its acquisition messages and other control data via the communications network.

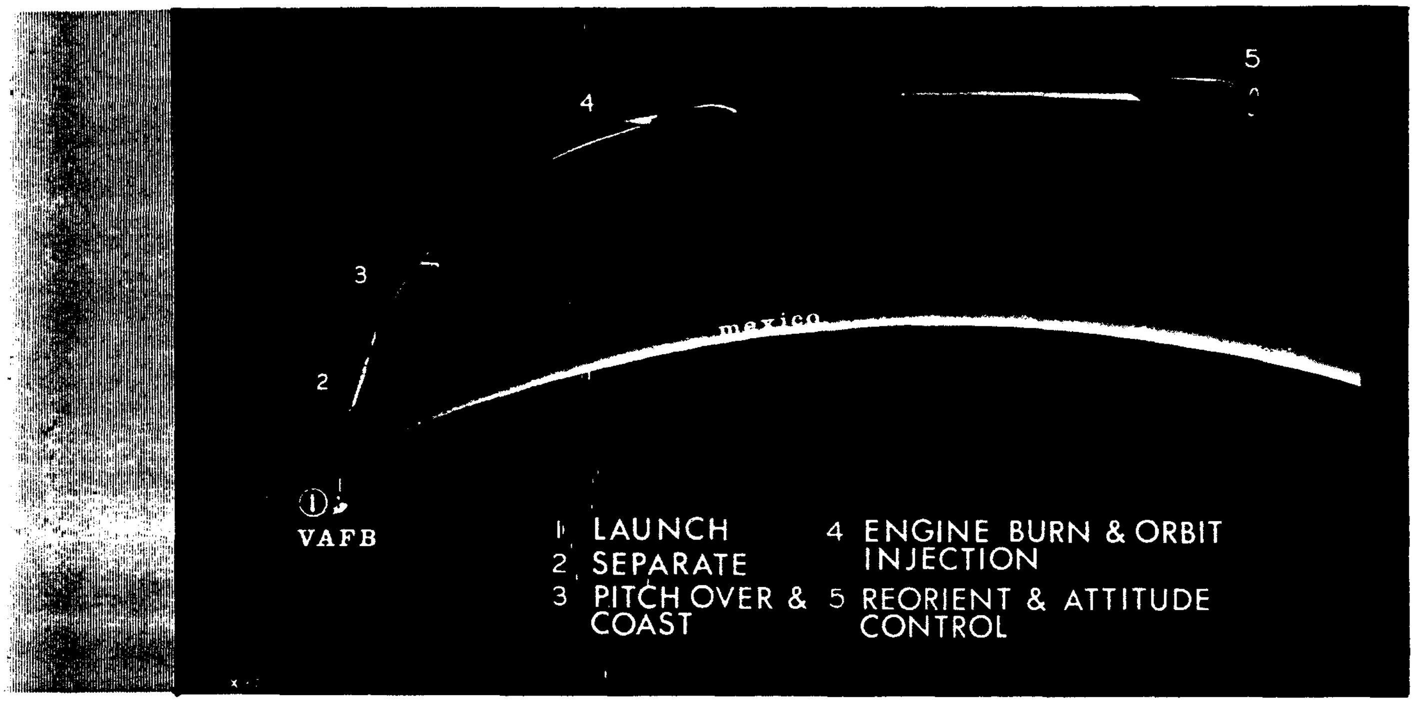


INBOARD PROFILE



The Agena B space vehicle is of semimonocoque construction, 60 inches in diameter and approximately 25 feet long, weighing 1350 pounds without fuel or payload. The largest single component is the integral aluminum alloy fuel and oxidizer tanks, which serve the dual purpose of containing the propellant and supplying a base from which the aft equipment rack is cantilevered. The aft equipment rack mounts the engine and its auxiliary equipment; control actuators and associated hydraulic system to control the direction of powered flight; reaction jets on all axes and a store of compressed gas for control of the vehicle during the orbital phase; and equipment racks for attaching modular payload equipments. The forward equipment rack houses the communications equipment, programmers, guidance and control components, power conversion equipment, storage batteries, and the re-entry body.

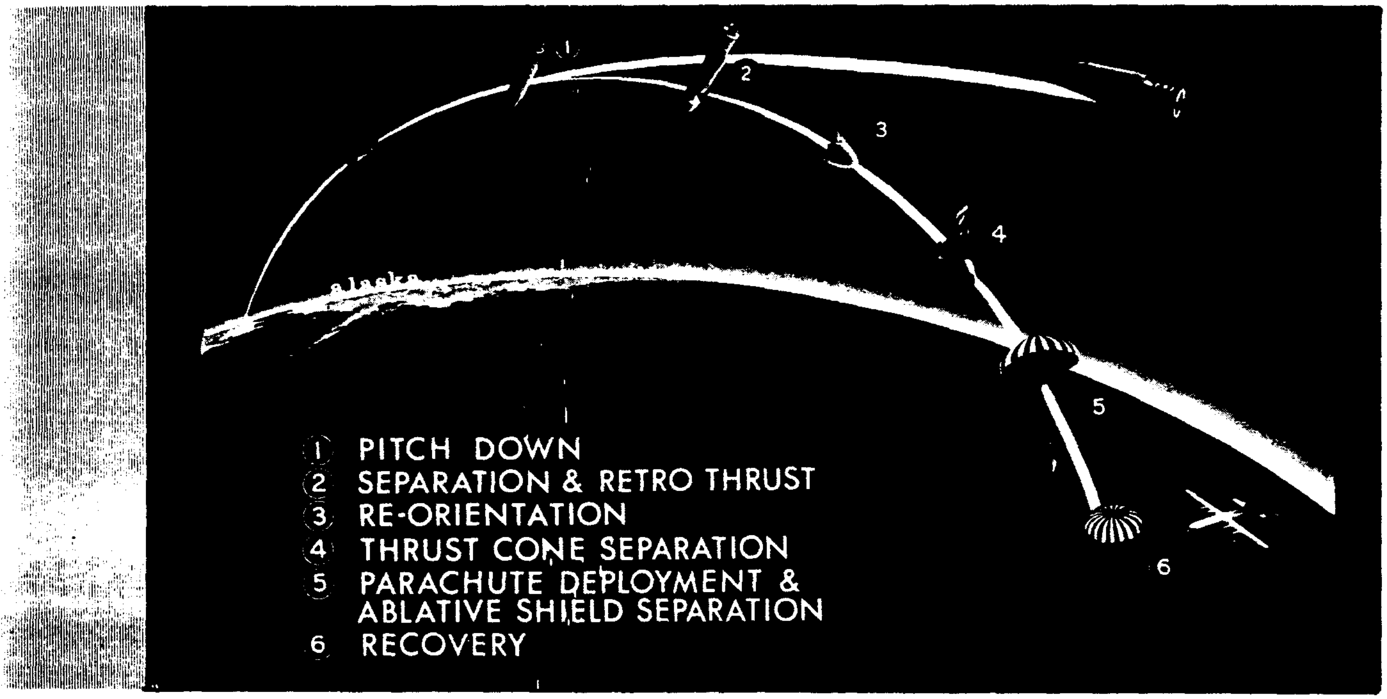
LAUNCH TRAJECTORY



After the Agena has been boosted to an altitude of approximately 70 miles by the first-stage Thor, separation occurs and the satellite is oriented to a horizontal attitude for Agena engine firing. The many functions which must be performed to start the liquid propellant engine in space are controlled by a master timer. Discoverer tests have shown that the engine can be reliably started in space and then restarted at a later time without nozzle closure. All that is required for restart is the addition of a second starter charge and additional ullage rockets to collect the propellants at the tank outlets to the engine.

When the vehicle has attained the required velocity as measured by the accelerometer integrator the engine is shut down. Shortly thereafter, the Agena completes a 180° yaw turn and orbits in a tail-first, horizontal position. This maneuver exposes the research instrumentation to the particles in space and simplifies the sequence required to separate the re-entry body. Attitude control on orbit is provided by an IR sensing device coupled to the inertial reference system and the guidance electronics, which command necessary reaction thrust from proportional gas valves.

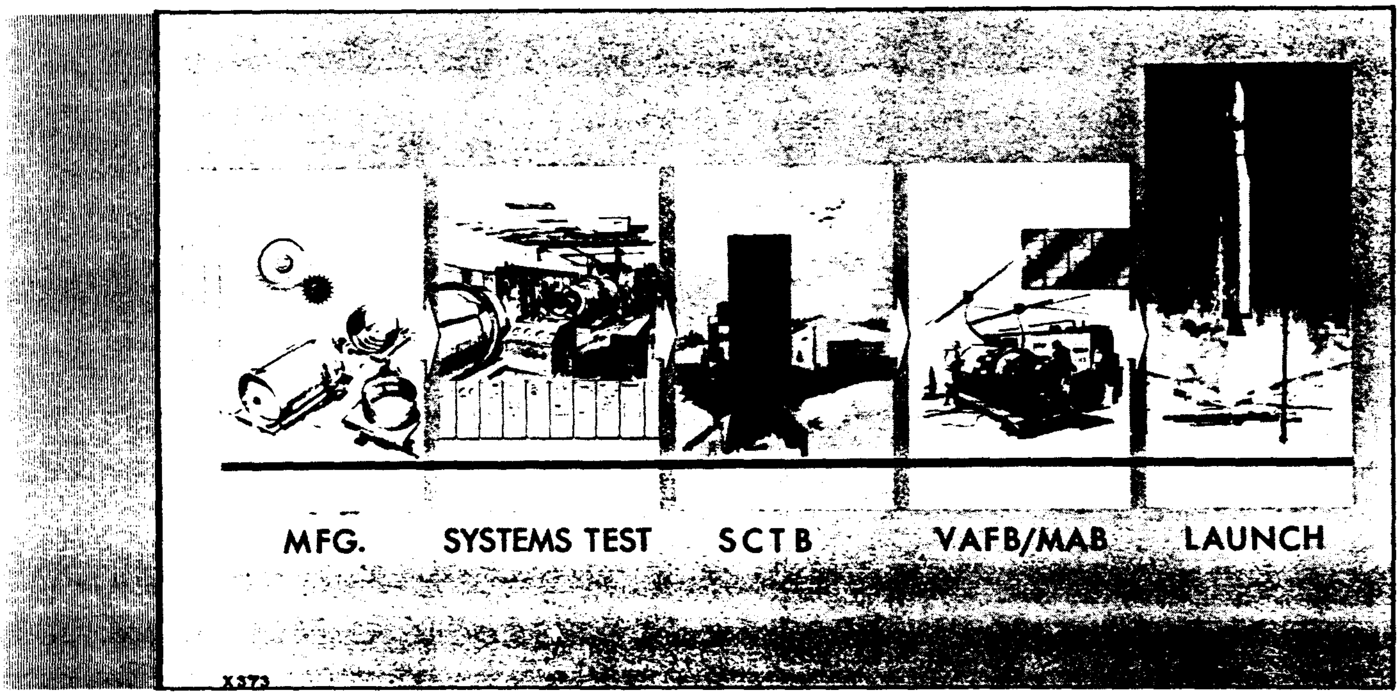
RE-ENTRY AND RECOVERY



Re-entry of the Discoverer capsule is achieved in a ballistic mode without reliance on terminal guidance. By means of a retro rocket the re-entry body is deflected to a new orbit which causes re-entry into the earth's atmosphere. Prior to retro rocket ignition, the vehicle is oriented to a nose down attitude at an angle which minimizes re-entry range and dispersion. The detailed retro sequence involves; capsule spin up to provide stability during the retro phase; retro rocket firing to impart approximately 1300 fps velocity; capsule de-spin to prevent gyroscopic nutation when the capsule reorients by aerodynamic forces; and finally, separation of the spent rocket and attaching structure to provide the necessary aerodynamic stability.

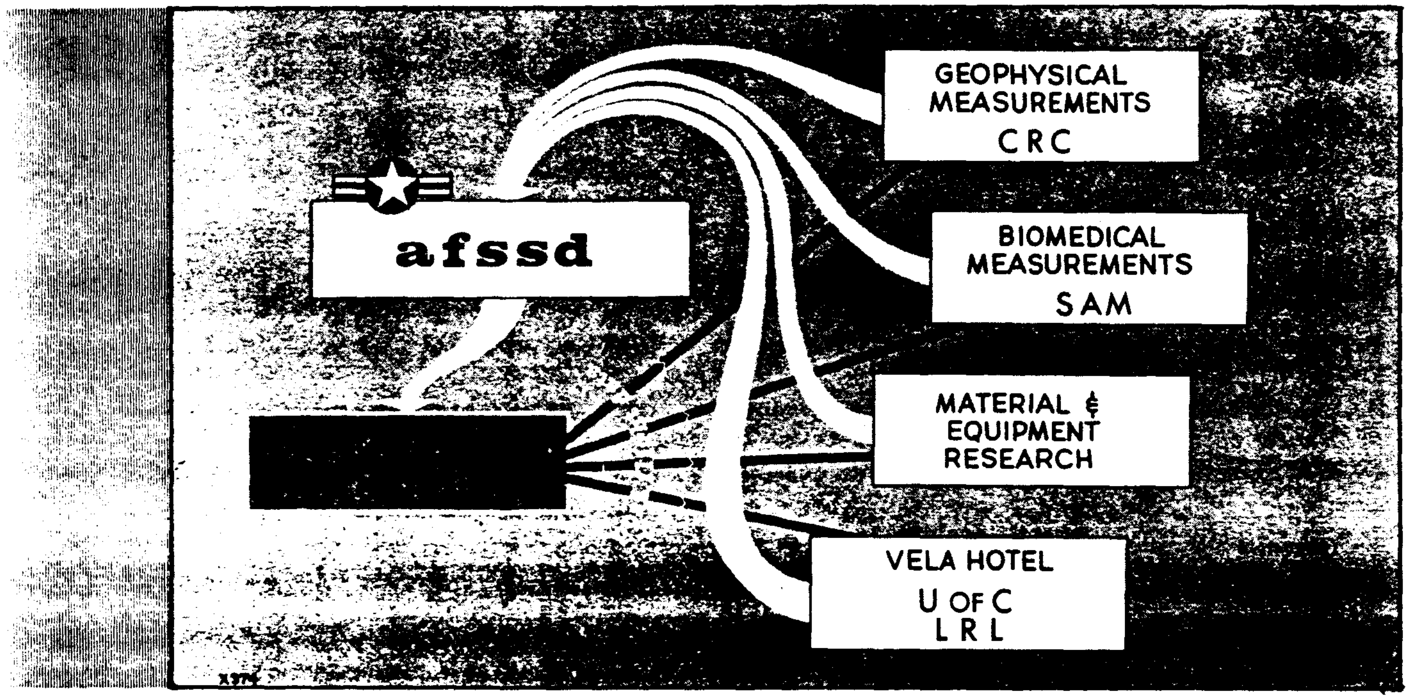
The capsule is protected during thermal re-entry by an ablative shield. The ablative material pyrolizes at peak surface temperatures of approximately 3000°F while insulating the inner capsule to temperatures not exceeding 100°F. At approximately 50,000 feet, the parachute is deployed, simultaneously separating the ablative shield, and the capsule descends at a rate consistent with aerial recovery requirements.

PRODUCTION FLOW



The basic components of the Agena satellite are fabricated at LMSC's central manufacturing shops in Sunnyvale and at the Van Nuys facility. Final assembly, installation of wiring, engine and equipment is accomplished at Sunnyvale, as is vehicle checkout. Subsystems are first tested and then the total integrated vehicle system is run through a 24-hour electronically simulated orbital mission. Selected vehicles, such as the first of a new series, are sent to Santa Cruz Test Base for a static firing. At Vandenberg Air Force Base, the Agena is again system-tested and sent to the launch pad, where it is mated with the Thor and compatibility checks are performed. The long and thorough process of checking and rechecking the vehicle continues until the final checks are completed in its final countdown. Consistent with the R&D nature of the program, these checking procedures add materially to the reliability of the program.

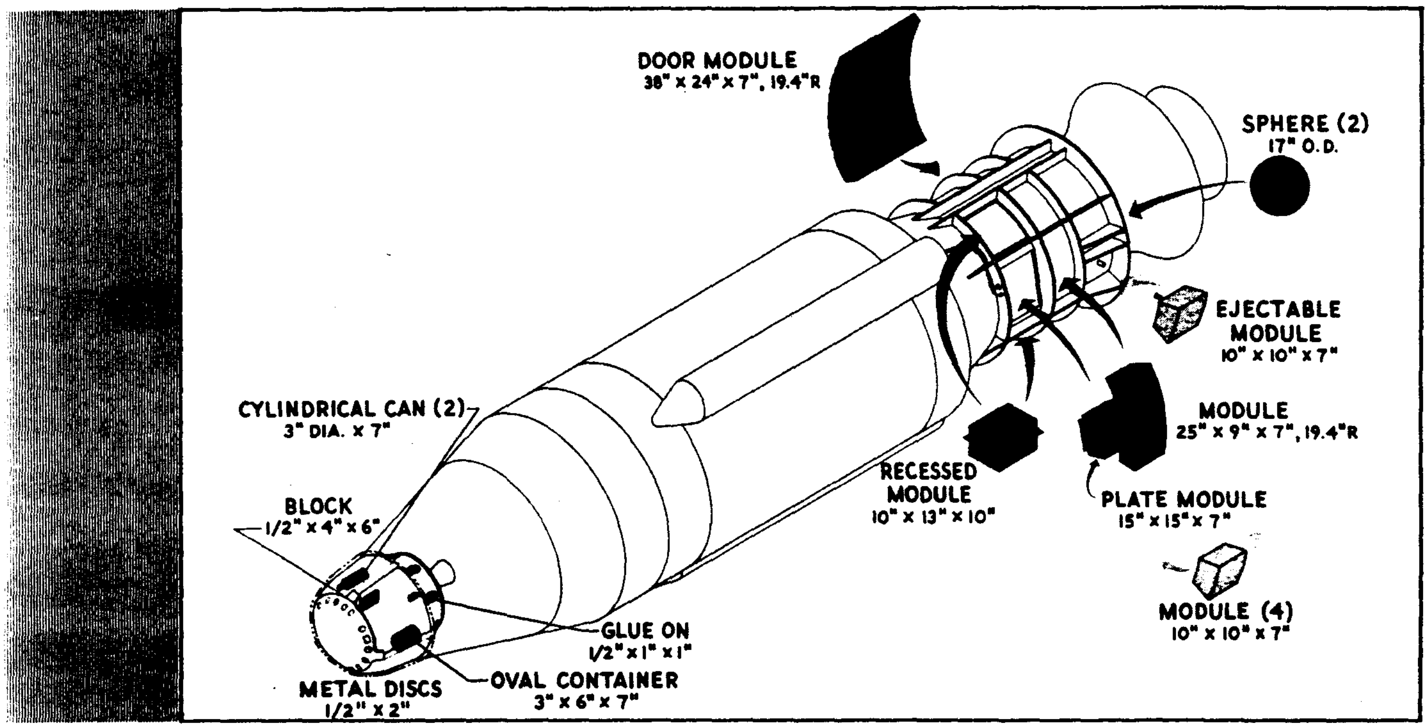
RESEARCH PROGRAM INFORMATION FLOW



One of the less publicized but very significant phases of the Discoverer Program has been its contribution to space research in conjunction with other scientific agencies. Requirements and equipment for space experiments are funneled through the Air Force Space Systems Division to LMSC, while results and findings are transmitted directly back to the originating agency by Lockheed.

Examples of Discoverer research efforts are: geophysical measurements performed for Cambridge Research Center; biomedical experiments for the Air Force School of Aviation Medicine such as the live tissue and embryonic culture carried on Discoverer XVII; and space radiation experiments for the University of California's Lawrence Radiation Lab. Experimentation into the behavior of new materials and equipment in space are performed for many scientific and government agencies including Lockheed's own research organization.

MODULAR DESIGN



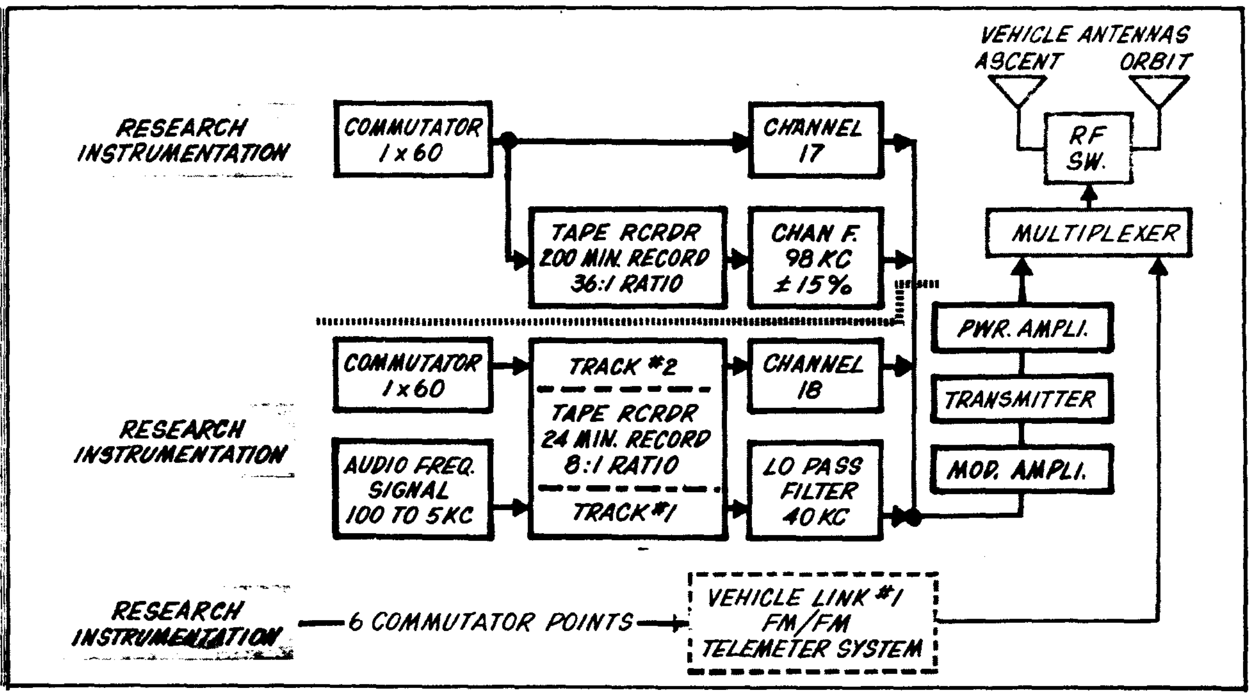
Discoverer research payloads have been flown for 2 years. Currently these modularized payloads are carried aboard the vehicle in both the forward and aft equipment racks in a variety of configurations and in accordance with any one of 3 basic experimental modes.

The first type of research experiment is made possible by the Discoverer's stability in space; it is an experiment designed to make precise, comparative measurements of phenomena associated with the earth below the satellite and with deep space above.

The second variety, calling for a smaller module than the first, measures such values as RF propagation for extended periods of time. The module incorporates its own power source so that it may continue to operate long after the Discoverer Agena has sent the re-entry experiment back to earth.

The third experimental mode is one requiring ejection from the orbiting Discoverer of the module. In this case, the unit is carried aloft, placed in a predetermined orbit, jettisoned and, for its effective orbital life, tracked and monitored by the originating agency of the experiment.

RESEARCH FM/FM TELEMETRY SYSTEM



Discoverer research experiments are supplied with an independent communications link. Operating independently of the vehicle's other communication function and modularized to provide a capability for necessary last minute changes without affecting the system integrity, the link provides the following capabilities:

1. Continuous recording for a complete mapping of the space environment at all latitudes and longitudes as well as during both night and day conditions. This is the function of a 200-minute tape recorder which records 60 samples of data/second and has a read-out to read-in ratio of 36 to 1.

2. Periodic recording under control of the orbital programmer of specific phenomena in specific areas. A 24 minute recorder serves this purpose.

3. Normal real time telemetry for readout while the vehicle is within range of the ground station system.

[redacted]

RESEARCH PROGRAM EXPERIMENTS

TRACKING

- PRECISION DOPPLER - APPLIED PHYSICS LAB OF JOHNS HOPKINS UNIV.
- PRECISION OPTICAL - SMITHSONIAN ASTROPHYSICAL OBSERVATORY, BAKER-NUNN
- SECOR - ARMY MAP SERVICE

SPACE SYSTEMS DEVELOPMENT

- MIDAS RADIOMETERS - AFSSD
- AGENA RESTART - AFSSD
- HORIZON SENSOR - AFSSD
- THERMO SENSORS - LMSC

RECOVERY

- BIOLOGICAL - AFSAM, AFSWC, AFASD, BROOKHAVEN NAT'L LABS, AFSSD (AFSC)
- DOSIMETRY - AFSAM, AFCRL, LMSC R&D, NRL
- COSMIC RAY STUDIES - AFCRL, AFASD, AFSAM LMSC R&D
- FILM DETERIORATION - AFCRL, AFASD, LMSC R&D
- SOLAR CELL DETERIORATION - AFSSD
- SHIELDING STUDIES - AFSAM, AFSWC

GEOPHYSICAL ENVIRONMENT

- COSMIC RAY MONITORS - AFCRL
- DENSITY GAGES - AFCRL
- MICROMETEORITE DETECTORS - AFCRL
- EROSION DETECTORS - AFCRL
- CHARGED PARTICLE ENERGY ANALYZERS - LMSC R&D
- RADIOMETERS - AFCRL
- RADIO FREQUENCY PROPAGATION - DASA, UNIV. OF ILLINOIS
- GALACTIC RADIO FREQUENCY - AFCRL
- IMPEDANCE PROBES - AFCRL
- X-RAY DETECTORS - VELA HOTEL
- NEUTRON-GAMMA DETECTORS - VELA HOTEL
- OPTICAL LUMINOSITY DISTRIBUTIONS - DASA
- ELECTRON SPECTROMETERS - VELA HOTEL
- AURORAL ELECTRONS - DASA
- PROTON SPECTROMETERS - DASA, VELA HOTEL

The results of the Discoverer recoverable and non-recoverable experiments have meaning for a broad span of space activities. Shielding studies, high energy particle measurements and biological experiments are obviously intimately related to the design of life-support systems and ecological units. Discoverer #17 carrying human tissue specimens late in 1960 was subjected to an intense, heightened proton flux which was the result of a class 3+ solar flare. Materials and equipments for advanced systems can be better tested under actual operating conditions then they can when subjected to theoretical extrapolations. For future flights, a continuing series of experiments is planned. As research at Discoverer altitudes is completed, emphasis will shift to testing of satellite components presently being designed for other programs.

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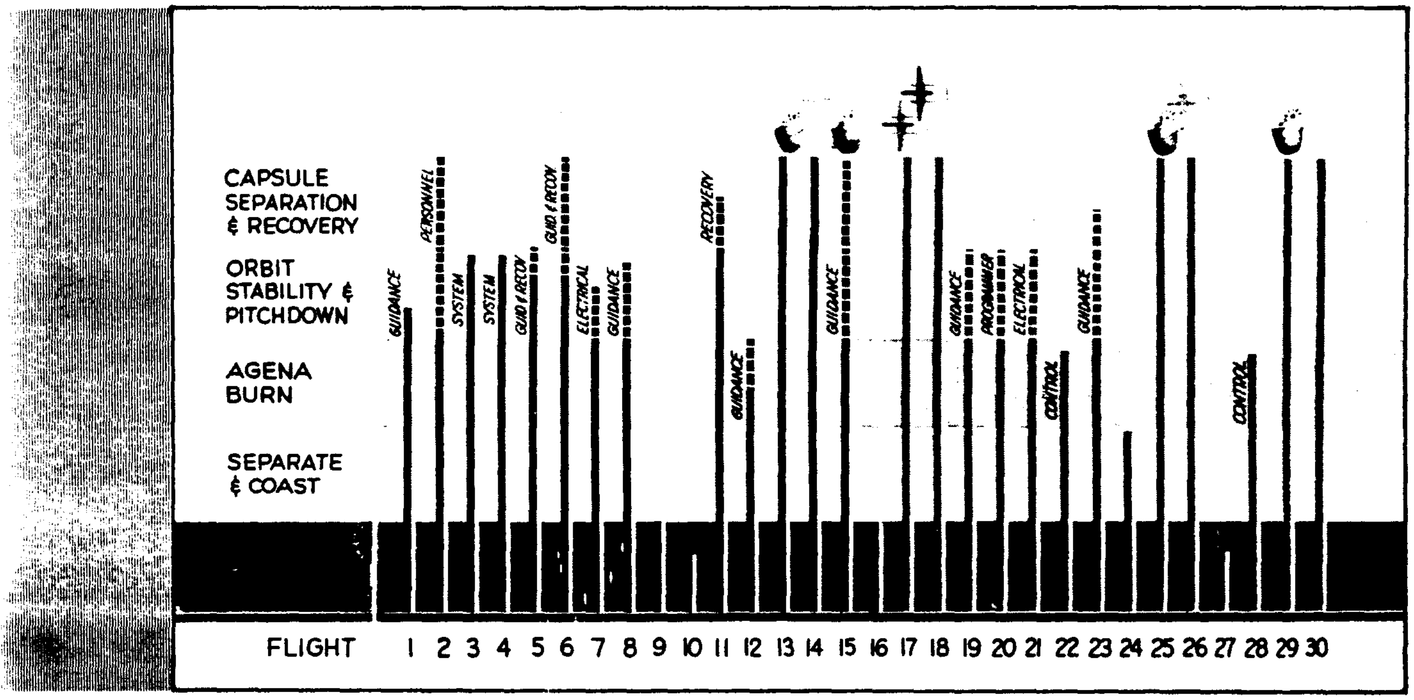
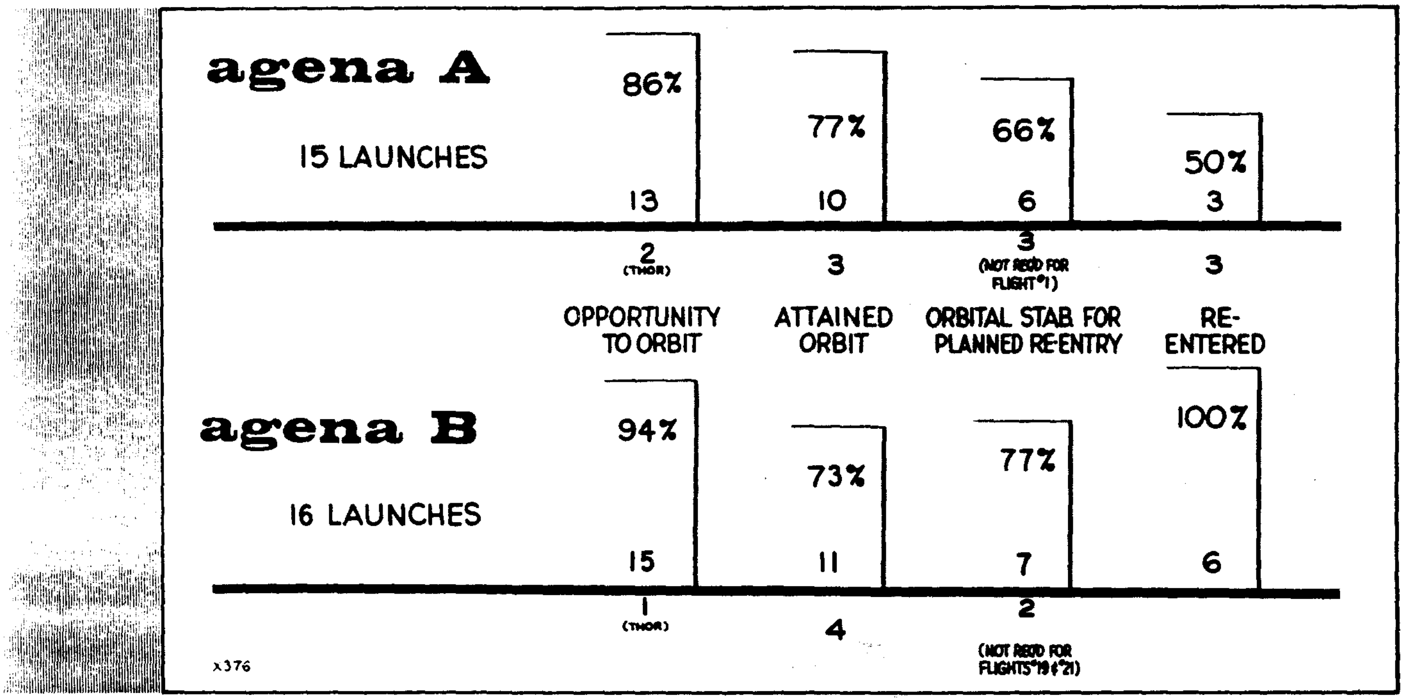
FLIGHT PERFORMANCE SUMMARY



An examination of the performance record of all the Discoverer flights to date reveals some of the widely varying degrees of success that are encountered in an R&D space program. It may be seen that the trend is toward increasingly greater reliability, as flight experience provides a growing background of knowledge. Also evident is the fact that a great deal of work is yet to be done to advance the state-of-the-art of such fields as guidance and electrical power in space.

Conversion from the Agena A to the Agena B, which represented introduction of many design improvements to the Agena, shows an expected drop in reliability. Each new system must apparently go through its series of design-proving failures. In such manner the primary objective of the Discoverer Program is accomplished, namely to prove the basic Agena equipments in an R&D atmosphere, and to reduce equipment and system type failures in later USAF satellite programs.

RELIABILITY/OPPORTUNITY TO PERFORM

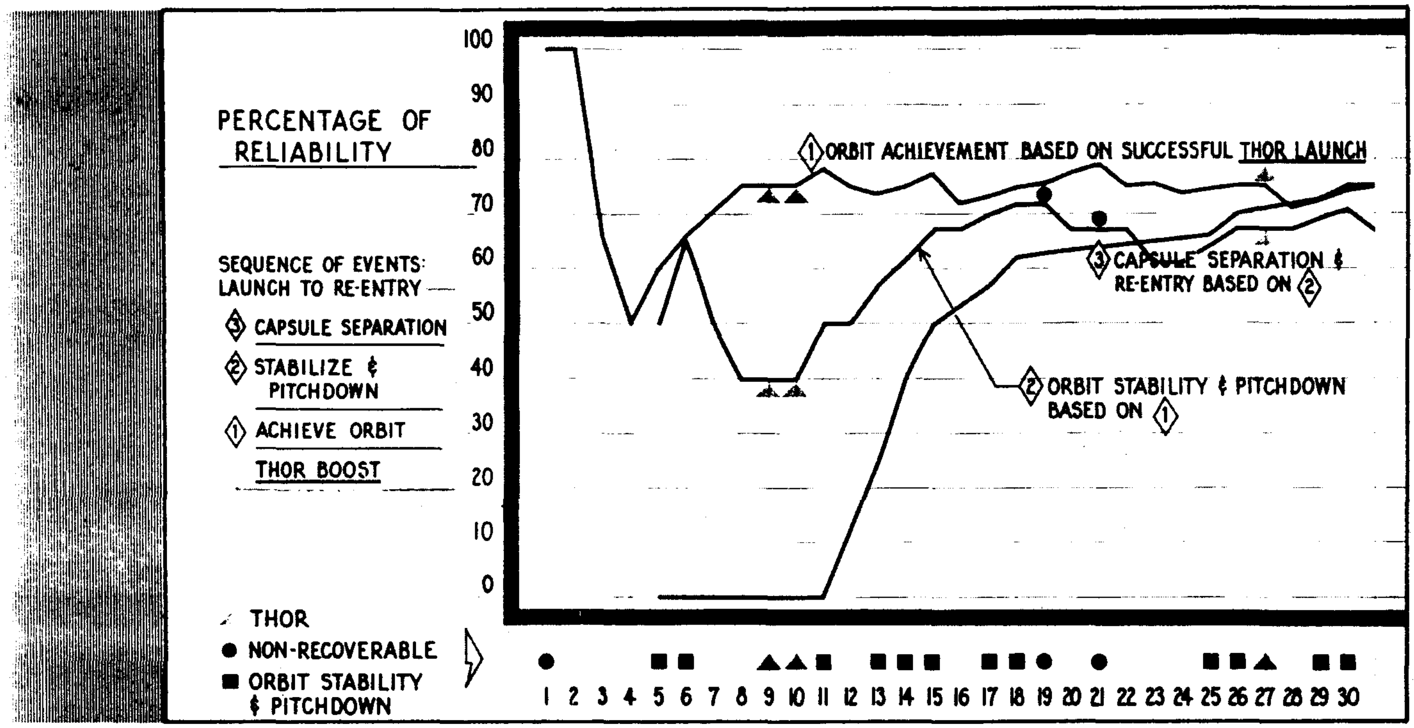


A regrouping of the same basic data as the preceding chart compares Agena A and Agena B.

Agena A: Thirteen of the fifteen Thor-boosted Agena A vehicles had the opportunity to orbit, which produced an .86 reliability figure. Of these thirteen, ten attained orbit while three did not, resulting in a .77 figure. Nine of the ten orbiting vehicles were actually programmed for orbital stability and re-entry, flight #1 not carrying this requirement. The .66 reliability percentage at this point was attained by the six vehicles out of nine fulfilling this requirement. Three of the six actually re-entered effecting a .50 reliability for this final event.

Agena B: Fifteen Agena B vehicles were given sufficient Thor-boost to orbit, one Agena not receiving the necessary initial velocity. Eleven Agenas attained orbit, for a .73 reliability, and of these eleven, nine were programmed for orbital stability and re-entry. Seven stabilized on orbit which resulted in a .77 reliability figure. Recovery of one of the seven was prevented by a malfunction in the orbital programmer, thus re-entry has been successful in all six attempts.

RECOVERABLE PAYLOAD PERFORMANCE



Reliability percentages are plotted here for 3 separate, yet interrelated, events. Curve 1 is a running plot of orbital achievement as a function of Thor performance. Curve 2 plots the reliability of achieving stability and pitchdown on orbit based upon the total number of achieved orbits represented by Curve 1. There are, as a matter of note, 21 orbital achievements, 18 of these requiring stability and pitch-down for re-entry. The 12 of the 18 which stabilized and re-oriented are marked along the abscissa by squares. Curve 3 represents capsule separation and re-entry reliability based on the 12 stabilized possibilities.