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LUNAR EXPLORATION PROGRAM

Unmanned Exploration of the Moon

The unmanned lunar exploration program has the following basic objectives: 1) to design, develop and utilize spacecraft and instrumentation to explore the Moon by rough-landing instrument capsules and soft-landing instrument payloads on the surface of the Moon and by placing scientific instruments in precise lunar orbits, 2) to carry out scientific investigations to further our knowledge of cislunar space (the region between the Earth and the Moon), the environment at the lunar surface, and the physical and chemical properties of the Moon; 3) to provide information leading to an understanding of the origin and history of the Moon and the solar system; and 4) to provide technological, scientific, and operational support to subsequent manned lunar exploration.

The scientific experiments of the lunar program aredirected toward the determination of the characteristics of the lunar landscape and surface features, surface and subsurface structure, physical properties, chemical and minerological composition, the properties of the Moon as a planetary body,

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and the thermal history of the Moon. In addition, the Moon has a biological interest through the possible discovery of organic molecules, precursors of living organisms, in the layers of dust which have accumulated on the lunar surface over many aeons of time. The chemical analysis of this surface dust may prove to be of immeasurable importance to the biological sciences and may provide clues to the origin of life on Earth.

Ranger Project

The Ranger Project consists of nine flights using Atlas-Agena B vehicles launched from the Atlantic Missile Range. The overall objectives of this project are (a) to create and test a new spacecraft design whose features can be exploited in the performance of lunar and interplanetary flight missions, and (b) to use this spacecraft to perform scientific investigations close to and on the surface of the Moon, and to study particles and fields in interplanetary space. The nine flights are divided into three series as follows:

Ranger 1 and 2: The primary mission of the first two Ranger flights was to provide engineering tests of the basic elements of the spacecraft system and the Deep Space Instrumentation Facility (NASA world-wide tracking network). Secondary objectives were to measure significant characteristics of the interplanetary medium along the selected trajectory and to ascertain the performance of and gain operating experience with theAtlas-Agena B launch vehicle. For these flights, a nominal sixty-day, 700,000 mile, highly-elliptical earth-satellite orbit was chosen.

The Ranger spacecraft (Figure I), developed by the Jet Propulsion Laboratory, consists of a basic hexagonal structure, or bus, upon which are mounted the scientific instruments, together with that equipment required to provide attitude-control, communications, electrical power, and spacecraft environmental control. The spacecraft had a total injected weight of 675 lbs.

Scientific instruments carried on the first two Ranger spacecraft included a solar corpscular detector, a rubidium vapor magnetometer, semi-conductor detectors and thin-walled Geiger counters, an ion chamber, triple-coincidence telescopes, and a Lyman-Alpha scanner.

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The main orbital parameters of the Ranger 1 flight were as follows: apogee height: 312.5 statute miles, perigee height: 105.3 statute miles, period: 91.1 minutes, inclination: 32.9 degrees, lifetime in orbit: approximately 1 week. The corresponding data for Ranger 2 were: apogee height: 145.7 statute miles, perigee height: 94.9 statute miles, period: 88.3 minutes, inclination: 33.3 degrees, lifetime in orbit: approximately 9 hours.

In spite of the failure of the Ranger 1 flight to accomplish all of its objectives, considerable data were obtained on the performance of the spacecraft and its major subsystems. For example, the aerodynamic fairing and the spacecraft separated properly from the Agena vehicle. The solar panels opened, the high-gain antenna unfolded and the solar instrumentation boom deployed. The spacecraft controller operated and sent all ten of its programmed commands, which were executed properly. The spacecraft attitude-control system appeared to function, at least as well as could be expected so close to the Earth. Acquisition of the Sun took place at least once and solar power was fed to the battery. There was a malfunction of the attitude-control electrical converter on the second day, but this seemed to correct itself subsequently.

On the third day, the attitude-control gas was depleted. This was not surprising since the passage of the spacecraft into and out of the Earth's shadow on each orbit placed undue demands on the control system. The communication system appeared to function properly. Radio commands to transfer transmitter output from the omni-antenna to the high-gain antenna were sent four times and were successfully executed. Hinge-override-commands were sent twice and were executed; a roll override command was sent and executed. The spacecraft temperatures appeared to be normal for these orbital conditions. As far as could be ascertained, the scientific instruments operated properly; however, the usefulness of the data is very limited since the ranges of the measured parameters were generally quite different than the design conditions because of the proximity to the Earth. Quite a bit of data was obtained from the spacecraft friction experiment.

In the case of the second Ranger flight, the total amount of data obtained was considerably smaller, since the spacecraft remained in orbit for only a few hours (about 6 orbits) before it reentered the atmosphere. The attitude-control system apparently ran out of gas very quickly because of the high tumbling rate on separation, which resulted from the tumbling of the Agena, and because the spacecraft entered and left the Earth's shadow so rapidly. Again, however, the communication system, the spacecraft controller, and the internal power system appeared to operate properly. The spacecraft friction experiment yielded 25 excellent data points which correlate very well with those obtained on Ranger 1. Practically no useful data were obtained from the interplanetary experiments, however. The Deep Space Instrumentation Facility (DSIF) performed brilliantly in this exercise. As a result of the Ranger 1 flight the stations became quite expert at acquiring and tracking non-standard trajectories; in fact each station tracked every visible pass of Ranger 2.

Ranger 3, 4, and 5: The next three Ranger spacecraft are intended to approach the Moon and rough land about 56 pounds of survivable payload. This series of spacecraft has been designed for the primary objective of gaining detailed data on lunar surface characteristics. Each spacecraft (Figure II) has two major parts: a) the "bus", the basic hexagonal structure with power supplies, communications equipment, attitude-control, and midcourse guidance; and b) the "capsule", a separable survivable instrument package, and its retrorocket. The total weight of the spacecraft is 750 lbs.

The complete spacecraft will be launched on a lunar impact trajectory, and midcourse corrections applied to improve accuracy. At a suitable distance from the lunar surface the spacecraft will be properly oriented, and the landing capsule and retrorocket will be separated from the bus. The bus will continue on to crash into the Moon, but the retrorocket will decelerate the capsule, allowing it to impact at a nominal speed not exceeding several hundred feet per second. A balsa-wood impact absorber cushions the landing shock to a level which can be sustained by the instruments.

Experiments will be carried by both bus and capsule. The primary experiments on the bus will be an advanced vidicon camera system, a gamma-ray spectrometer, and a radar reflectivity experiment; the major experiment in the landing capsule will be a single-axis seismometer.

The spacecraft will complete its terminal maneuvers, including stabilization and the establishment of a telemetry link with the tracking station, before the first picture is taken. Thereafter, one complete picture will be transmitted to the tracking station every 13 seconds, providing a total of 100 pictures during the lunar approach. The first picture will contain a field of view 25 miles square with a resolution of 650 feet. The final picture will be of an area 2,000 feet square with a resolution of 10 feet. (The best photographs available from Earth telescopes have a resolution on the order of 2,000 ft.)

The gamma-ray spectrometer experiment is intended to determine whether or not the Moon, like the Earth, has formed a crust which contains a relatively high concentration of naturally radioactive isotopes. This information bears on problems such as the formation of the Moon, the heat balance of the Moon, and the source of chondritic meteorites.

The primary experiment in the landing capsule is a seismometer to record moonquakes and other possible disturbances originating within the Moon, as well as impacts of meteorites. Seismic measurements can answer fundamental questions about the interior of the Moon and provide clues to its origin.

The lunar landing capsule system is being developed for the Jet Propulsion Laboratory by the Aeronutronic Division of theFord Motor Company. Principal subcontractors are Hercules Powder Company which provides the retrorocket and Wiley Electronics Company which supplies the radar altimeter used to trigger the retrorocket.

At this writing, preparations are in process for launching Ranger 3 in early 1962.

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During this reporting period the Ranger Project was extended by the addition of four flights to be carried out during calendar year 1963. The primary mission for these flights will be to obtain very high-resolution television pictures of the lunar surface. The spacecraft will be basically the same as that used for the previous three flights, except that the retrocapsule will be replaced by a cluster of six television cameras fixed to the bus. The spacecraft weight for these missions will be about 800 lbs. The television system will begin operation at a distance above the lunar surface that will provide pictures of a resolution equivalent to present Earth-based photographs. Coverage will continue until impact, with the resolution of the last picture on the order of 0.2 to 0.3 meters. A total of about 1600 pictures of the lunar surface will be obtained. In addition to the television equipment, several experiments for studying the radiation environment around the spacecraft during its flight will also be provided.

On July 24, 1961, a letter contract was issued to Radio Corporation of America for the development and fabrication of the high-resolution television system and associated electronics and communication equipment. The basic Ranger spacecraft will, as before, be supplied by the Jet Propulsion Laboratory.

Surveyor Project

The Surveyor Project includes two related spacecraft systems, namely' the Surveyor Soft-Lander and the Surveyor Orbiter.

Surveyor Soft-Lander: TheSurveyor Soft-Lander spacecraft is currently under contract to the Hughes Aircraft Company for a series of seven flights with Atlas-Centaur vehicles launched from the Atlantic Missile Range. The primary objectives of the Surveyor Lander are to successfully accomplish the soft-landing of a number of scientific payloads on the lunar surface, to provide for a minimum of 30 days (design goal: 90 days) of scientific observations and measurements on the lunar surface, and to telemeter the data to Earth for reduction and timely disemination to the engineering and scientific community.

The scientific objectives of Surveyor are to provide close-up views of the lunar landscape, to measure the physical properties of the Moon, and to analyze the composition of the lunar surface and subsurface in various selected maria regions visible from Earth. The scientific measurements are intended to aid in establishing a better understanding of the internal structure and composition of the Moon and its local atmosphere, and to obtain additional data that may provide clues to the origin of the Moon and an understanding of the physical phenomena associated with the origin of the solar system.

Additional objectives of the Project are to demonstrate the engineering feasibility of lunar exploration with soft-landing spacecraft systems, and to contribute to the technology required for the successful accomplishment of eventual manned lunar landings and operations.

To obtain maximum flexibility relative to the accommodation of selected scientific instruments in various combinations, the spacecraft is designed to provide a relatively simple and standardized interface between the bus and the scientific mission payloads.

The bus consists of those elements of the spacecraft required to accomplish the transit phase and soft-landing on the lunar surface. The principal elements of this basic spacecraft bus are the spacecraft structure and landing gear, the power supply consisting of batteries and solar cells, the FM wideband telecommunications system, a multiple-mode guidance system, a cold gas attitude-control system, and a propulsion system consisting of a solid rocket engine for the main retro phase and small throttlable liquid vernier engines for midcourse velocity correction, main retro-thrust-vector control, and terminal descent decelerations.

The weight of the spacecraft will range between 2100 and 2500 lbs., including up to 345 lbs. of scientific instruments. The spacecraft will be injected into a lunar impact trajectory to yield a nominal 66-hour transit time. Midway in flight a midcourse-trajectory-correction maneuver will be performed to ensure a satisfactory encounter with the Moon. The terminal maneuver consists of orienting the spacecraft and firing the main retromotor and vernier engines in a controlled manner, so as to arrive at the lunar surface at near zero velocity.

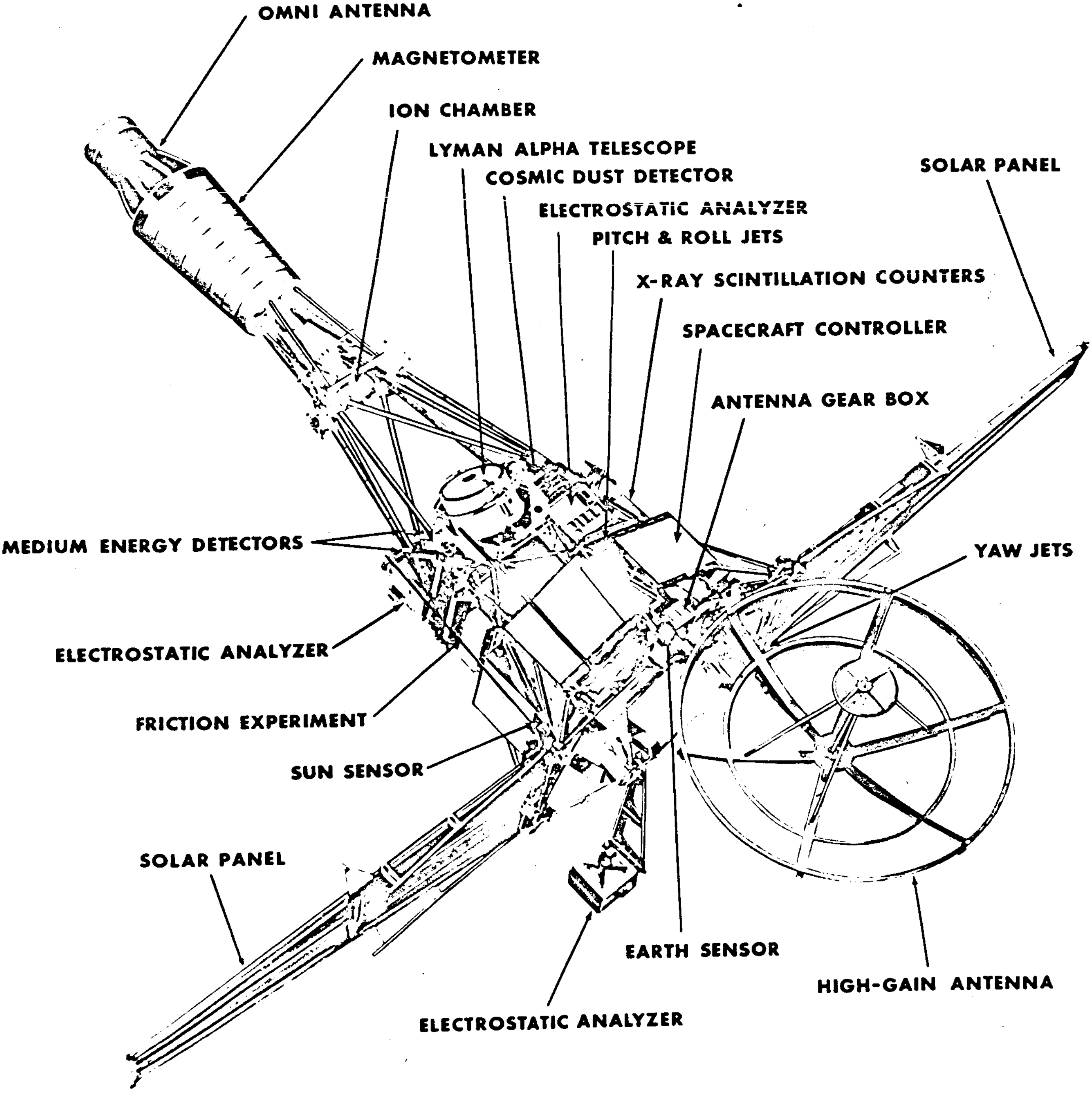
<u>Surveyor Orbiter</u>: Much of the basic Surveyor technology and subsystems (e.g. structure, guidance and control, telecommunications, etc.) will be utilized in the Surveyor Orbiter. This advanced spacecraft system will provide an oriented space platform for overall lunar reconnaissance and topographic mapping as well as preliminary selection of desirable sites for subsequent Surveyor landings and later manned landings. The Orbiter will also function as a long-life lunar space station to investigate and monitor the radiation environment and other physical parameters in the immediate vicinity of the

Moon. It will also yield new knowledge on the size and shape of the Moon, its mass distribution, and the properties of its gravitational field. Studies have been made to identify the changes necessary to convert Surveyor soft-landing spacecraft into a lunar orbiter for photographic reconnaissance and have established the feasibility of this approach. It is expected that implementation of the development of the Surveyor Orbiter will be started shortly.

Prospector Project

The Prospector spacecraft will have the ability to land anywhere on the Moon, to inspect particular areas prior to landing, and to carry to the Moon a variety of mission payloads, such as roving lunar-surface exploration vehicles and lunar sample-return systems. In addition to its purely scientific functions, Prospector will be capable of providing direct support for manned landings on the Moon by performing detailed landing-site surveys, emplacing guidance aids, and monitoring the manned landings. The Prospector roving vehicle should be useable by manned expeditions as a remotely controlled scout in potentially hazardous areas, and to extend the radius of exploration activity. The Prospector spacecraft will also be capable of providing logistic support both prior to and during manned operations on the Moon. Such support will include transportation of supplies, equipment and shelter required for the establishment of a lunar base, as well as any emergency resupply to the manned expedition, should this be necessary.

RANGER SPACECRAFT



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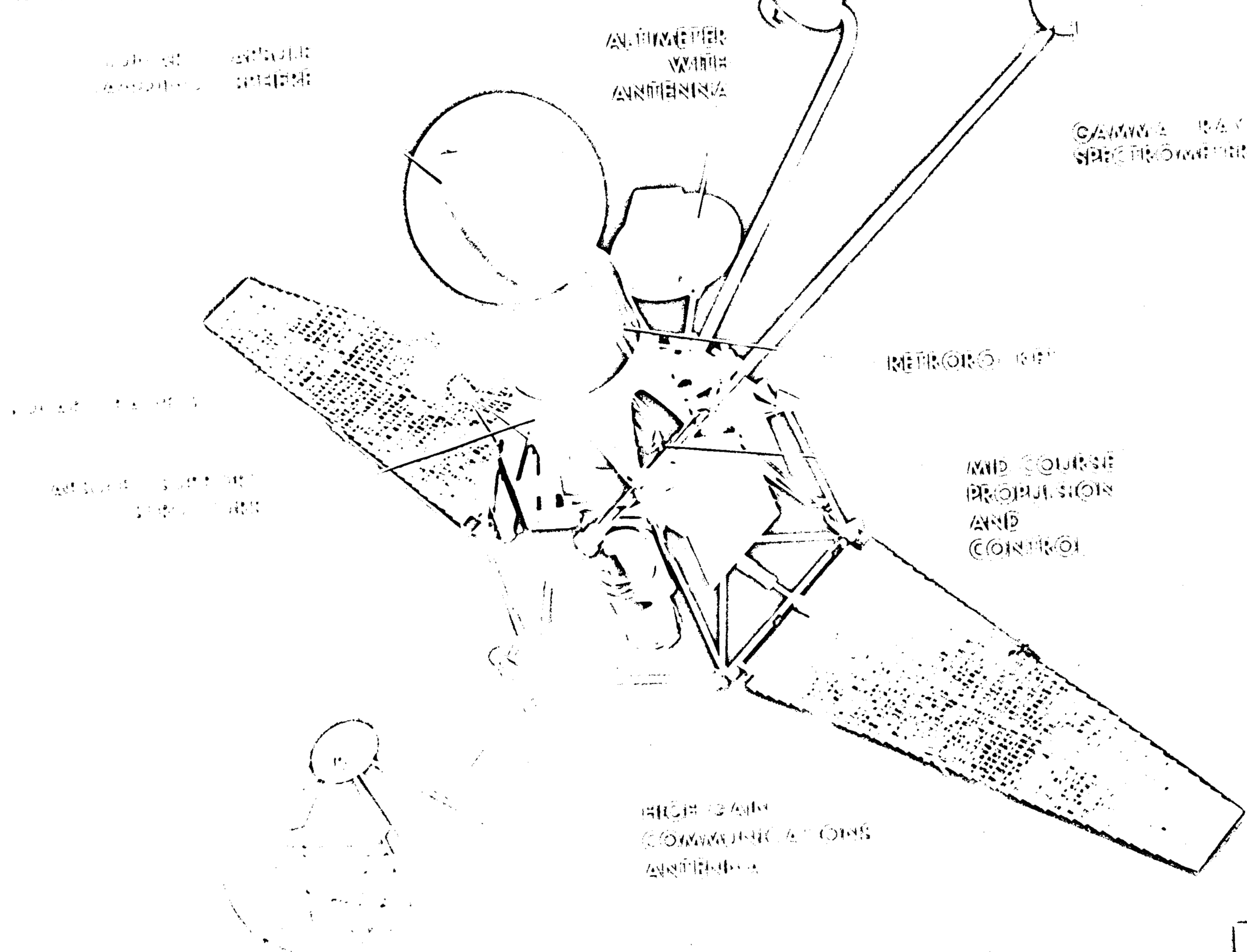
RANGER SPACECRAFT WITH LUNAR CAPSULE



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SURVEYOR SPACECRAFT