NEWS

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WASHINGTON, D.C. 20546

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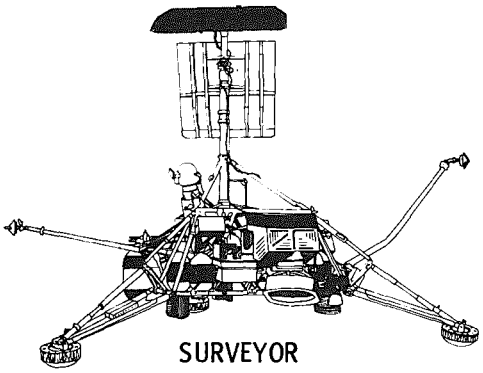
January 4, 1968



SURVEYOR

PROJECT: SURVEYOR G

(To be launched no earlier than Jan. 7)

PRESS KIT

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LAST SURVEYOR SERIES MISSION

The seventh and final Surveyor soft-landing spacecraft is being prepared for launch to the Moon by an Atlas-Centaur launch vehicle from Cape Kennedy, Fla., no earlier than Jan. 7.

Previous Surveyor spacecraft (Surveyors II, III, V and VI) have accomplished their missions of returning detailed on-surface data in four widely separated mare regions in the Moon's equatorial zone. They have shown the surface terrain is suitable for manned landings, thereby satisfying all Surveyor obligations in support of the Apollo program and provided a wealth of new information on the properties of the lunar surface.

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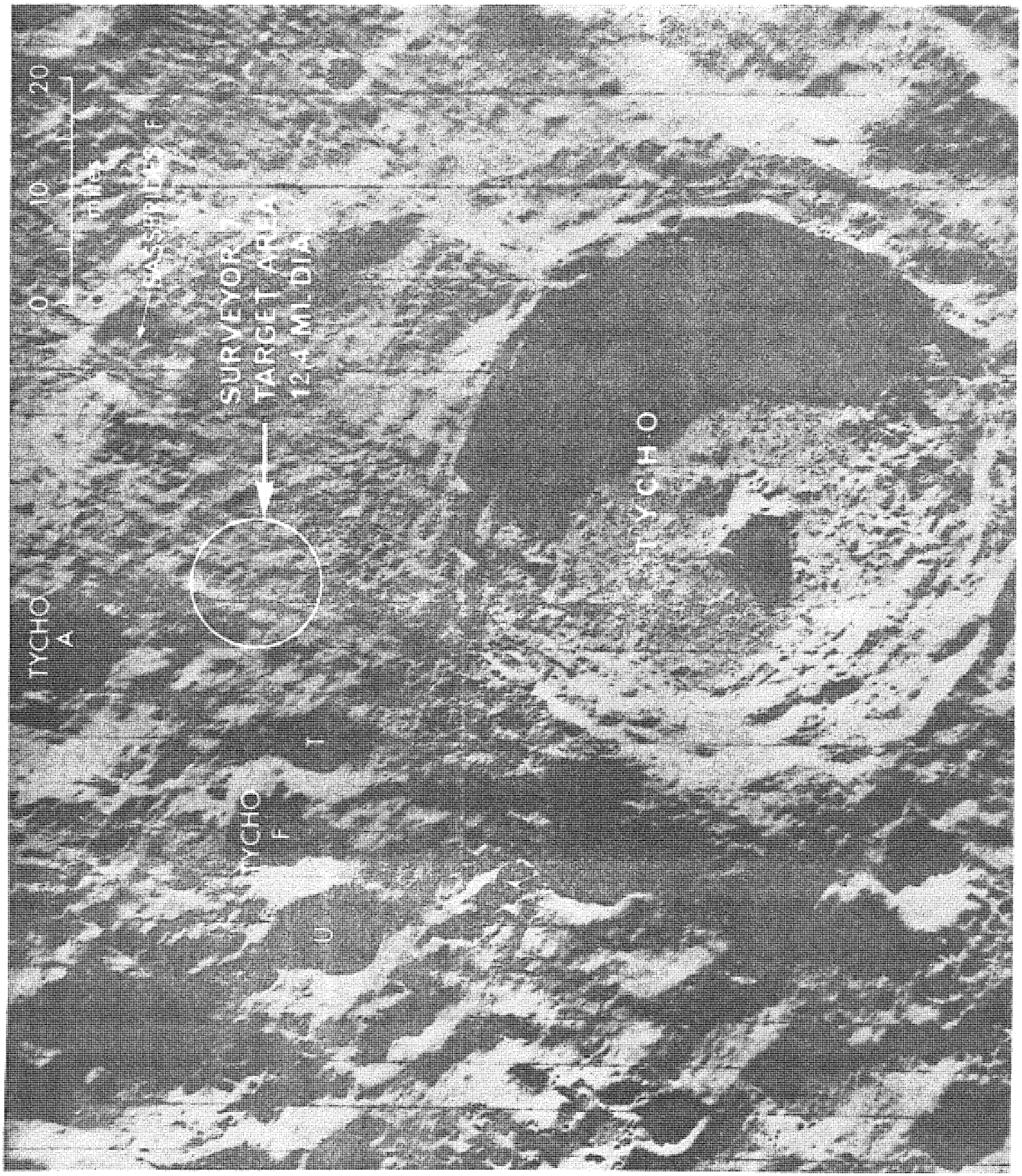
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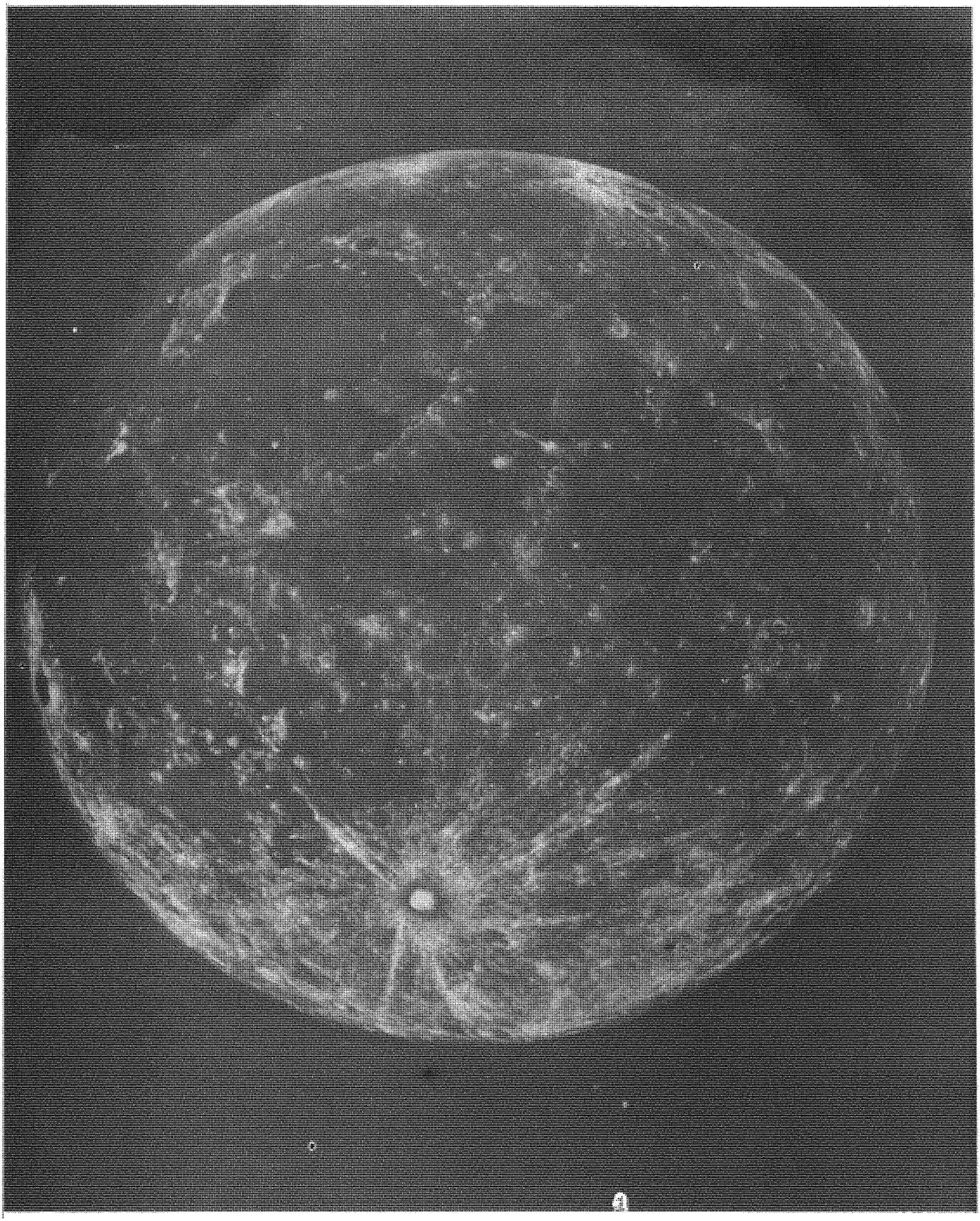
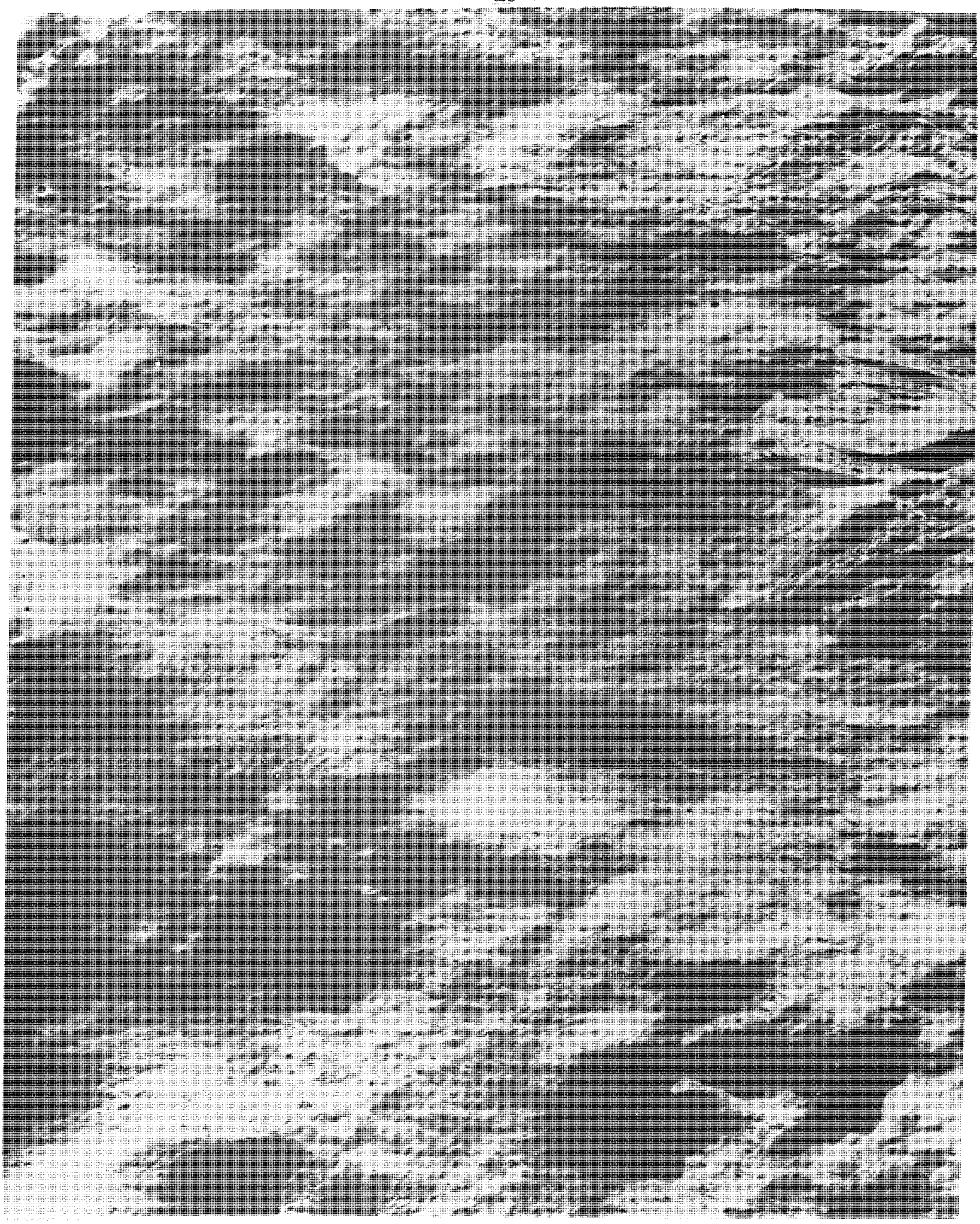




Surveyor G is thus available to examine a lunar site primarily of interest to scientists. In order to gain the utmost in scientific value from the last Surveyor in the series, NASA established a working group of lunar scientists to study possible landing sites and recommend those having the greatest scientific potential.

The group considered that the most important objective should now be to land in a location as geologically different as possible from the maria which previous Surveyors had investigated, preferably one offering the greatest probability of being chemically different from the previous maria.

As first choice, the group recommended a highland site on the "ejecta" blanket near the Crater Tycho. As second choice, they named a site on the Moon's Fra Mauro formation (a topographic feature not to be confused with the Fra Mauro Crater).

The Tycho site at 40.87 degrees South latitude and 11.37 degrees West longitude will permit examining the ejecta or throw-out produced when the Crater Tycho was first formed. This material, which was excavated from beneath the former surface of the highlands, forms the prominent system of rays which radiates out from Tycho on page 1-b.

The Tycho ejecta blanket is particularly attractive to scientists for several reasons:

Tycho is the youngest large crater and its throw-out should, therefore, be less contaminated by ejecta from other parts of the Moon and by meteoritic material. It is an outstanding anomaly in radar and in infrared reflection.

The features which make the ejecta blanket important, however, also make it a risky landing site. The terrain is very rugged. The most desirable landing site lies within a target area 12.4 miles in diameter, north of the Tycho crater.

Closer to the crater the terrain becomes virtually impossible as a landing site. Farther away there is no high resolution Lunar Orbiter photography available.

Page 1-c is an enlarged sample of Lunar Orbiter photography, providing a closer view of the terrain within the target circle. The surface has a swept appearance and is covered with grooves, gullies and ridges, many with steep slopes. Relatively few craters are visible but scientists suspect that there may be many below the five-meter resolution limit of the pictures.

This is obviously not an ideal landing site. The risk in landing will be higher than at any of the previous Surveyor sites. However, after careful consideration, scientists have concluded that the large scientific gains to be achieved are worth the added risk, provided Surveyor G actually lands within the designated region.

This area is smaller than sites normally targeted for Surveyor and will require exceptional performance from both the launch vehicle and the spacecraft itself.

For this reason, a site in the Fra Mauro formation at 3.75 degrees South latitude and 17.5 degrees West longitude has been chosen as an alternate target. Should actual inflight trajectories make it unlikely that Surveyor G will be able to land within the target, it will be diverted by means of a mid-course maneuver to the Fra Mauro formation site.

The Fra Mauro formation, second choice of the scientists, is the name given to an extensive geological unit which forms a belt around the Imbrium Basin. The particular area chosen as the alternate target is just north of the Crater Fra Mauro, in rolling terrain.

The Fra Mauro formation is believed to be composed largely of throw-out material which was ejected and deposited on the surface when Mare Imbrium was formed. If this is true, this area may provide a sample of material excavated from many tens of miles beneath the lunar surface, possibly of sub-crustal material.

The landing site is a circle 37 miles in diameter, a considerably larger target than the Tycho site. Lunar Orbiter photography indicates that there is a high density of craters in the area.

The surface texture is expected to be similar to the maria, but the chemistry should be significantly different. However, the Fra Mauro formation is a rather old unit and the surface may be contaminated by more recently ejected material from other areas.

If the launch occurs Jan. 7, and Tycho remains the objective, Surveyor G's soft landing will require a gravity turn of 36 degrees from the vertical during the crucial terminal descent sequence. For the succeeding days of the launch period, the angle of approach is a few less degrees away from the vertical.

Atlas-Centaur 15 has a two-burn capability in its second stage, like the two-burn Centaur which launched Surveyors V and VI into parking orbits from which they were sent to the Moon.

Surveyor G will carry a more extensive payload than previous Surveyors. Besides their television cameras, some of the earlier Surveyors carried either the surface sampler digging device or the Alpha Scattering experiment for chemical analysis of the lunar surface.

Surveyor G will carry all three of these, television, the Alphs Scattering device and the digger. It will also carry a large number of minor payload items such as magnets on two footpads and on the surface sampler scoop, mirrors for viewing under the spacecraft, plus stereo mirrors and special dust detection mirrors, and the usual instrumentation carried by previous Surveyors.

During the Surveyor G mission the surface sampler and the Alpha Scatter devices will be operated as a team, but not simultaneously since, along with the camera, they are operated via the same radio channel and hence cannot be commanded to operate at the same time.

The Alpha Scattering instrument will first make a chemical analysis on the lunar surface. Then the Surface Sampler will be ordered to dig. Later the sampler equipment will pick up and reposition the Alpha Scattering instrument, placing it over portions of the surface stirred by the sampler.

Surveyor G's flight will last 65 hours from liftoff to touchdown. A large solid propellant retrorocket and three small vernier rocket engines under radar control will slow Surveyor from a lunar approach speed of 6,000 miles-per-hour to about three miles-per-hour. The engines will cut off at the 13-foot mark and the spacecraft will drop to the lunar surface, touching down at a 10 mile-per-hour speed.

Because of the need to consider both the prime and alternate targets, the launch window has been established so as to permit a daylight landing at either site. The window will open at 12:43 a.m. EST, Jan. 7, closing at 3:12 a.m.

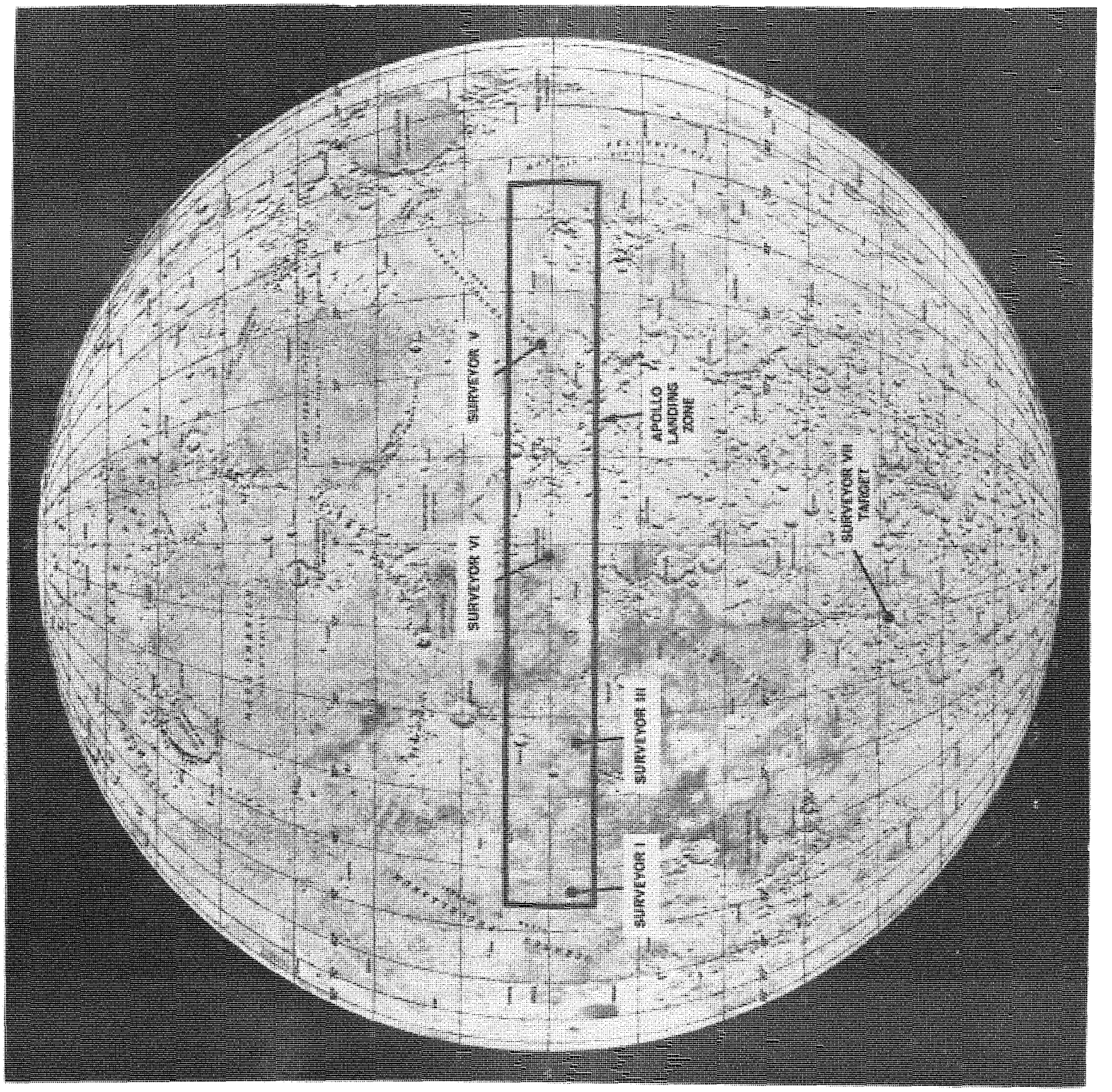
At launch, Surveyor G will weigh 3,288 pounds. The fueled retro motor, which is jettisoned after burnout, weighs 1,442.5 pounds. After expenditure of liquid propellants and attitude control gas, Surveyor G will land on the Moon weighing an estimated 637 pounds or more.

In addition to data provided by the TV camera, Soil Sampler, and the Alpha Scattering instrument, Surveyor G will also provide data on the radar reflectivity, magnetic properties, and thermal conditions of the lunar surface.

Surveyor I soft-landed on the Moon June 2, 1966, and returned 11,150 high-quality photographs of the lunar surface.

Surveyor II was launched Sept. 20, 1966, but the mission failed when one of the three vernier engines failed to ignite during an attempted midcourse maneuver.

Surveyor III soft-landed on the Moon April 19, 1967, returned 6,319 photographs and provided 18 hours of operation of the surface sampler.


SURVEYOR VII
TARGET
APOLLO
LANDING
ZONE
SURVEYOR III
SURVEYOR I
SURVEYOR VI
SURVEYOR V

Surveyor IV, launched July 14, 1967, performed well until the last few seconds of burn of the retromotor when all communications with the spacecraft were lost. An engineering team which studied the failure was unable to pin-point its cause.

Surveyor V, launched Sept. 8, 1967, soft-landed Sept. 10, 1967, on the Moon at a site in the Sea of Tranquility at 1.45 degrees North latitude and 23.25 degrees East longitude.

In the 14 days prior to the first lunar sunset, Surveyor V's camera returned 18,006 photographs of the Moon's surface in its vicinity, of the magnet experiment aboard, and of the operation of the Alpha Scatter device. The Alpha Scattering instrument provided the first on-location chemical analysis of an extra-terrestrial body, a feat hailed as a historic achievement in the scientific world.

Logging the most nearly flawless lunar mission to date, Surveyor VI was launched Nov. 7 and landed Nov. 9, in Sinus Medii or Central Bay in the center of the Moon's visible face at 0.47 degrees North latitude and 1.48 degrees West longitude.

After eight days on the Moon's surface, Surveyor VI was ordered to lift off and successfully completed the first take-off from the surface to a new position eight feet away from its first location.

In its first location the spacecraft's camera took more than 14,500 pictures and logged 27 hours of chemical analysis of the surface on its Alpha Scatter instrument.

After the hop, another 15,000 pictures were taken for a total of more than 30,000.

From its new position the Surveyor VI television camera was able to examine the imprints made in the lunar surface by the spacecraft during its initial touchdown, as well as the blast effects of the spacecraft's rocket motors as it lifted off during the hop maneuver. The before-and-after-hop pictures taken from two different locations permit scientists to produce three-dimensional stereo photographs of nearby lunar festures and, using photogrammetry, to make detailed topographic maps of the landing site.

The Surveyor program is directed by NASA's Office of Space Science and Applications. Project management is assigned to NASA's Jet Propulsion Laboratory, Pasadena, Calif.

Hughes Aircraft Co., under contract to JPL, designed and built the Surveyor spacecraft and the Surface-Sampler instrument.

The University of Chicago provides the Alpha Scattering experiment.

NASA's Lewis Research Center, Cleveland, is responsible for the Atlas first stage booster and for the second stage Centaur, both developed by General Dynamics/Convair.

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SURVEYOR BACKGROUND

Surveyor I performed the first fully-controlled soft landing on the Moon June 1, 1966, after a 63-hour, 36-minute flight from Cape Kennedy. Surveyor I landed at a velocity of about 7.5 miles per hour at 2.45 degrees South of the lunar equator and 43.21 degrees West longitude in the southwest portion of Oceanus Procellarum (Ocean of Storms).

During the six weeks following the perfect, three-point landing, the spacecraft's survey television camera took 11,150 high-resolution pictures of the lunar surface for transmission to Earth receiving stations. Resolution in some of the closeups was one-half millimeter or about one-fiftieth of an inch.

The television pictures showed that the spacecraft came to rest on a smooth, nearly level site on the floor of a ghost crater.

By July 13, Surveyor I's 42nd day on the Moon, the spacecraft had survived the intense heat of the lunar day (250 degrees F), the cold of the two-week-long lunar night (minus 260 degrees F) and a second full lunar day. Total picture count was: first lunar day -- June 1 to June 14 -- 10,338; second day -- July 7 to July 13 -- 812. The total operating time of Surveyor I (time during which signals were received from the spacecraft) was 612 hours.

Although the spacecraft was not designed to endure the rigors of the lunar environment over an extended period, it continued to accept Earth commands and transmit TV pictures through the second lunar sunset. Communications with Surveyor I were reestablished at intervals through January 1967 but no TV pictures were obtained after the July 1966 activity.

Surveyor II was launched Sept. 20, 1966, toward Sinus Medii in the center of the Moon. An attempt to perform the midcourse maneuver was unsuccessful when one of the three liquid fuel vernier engines failed to fire. The thrust imbalance caused the spacecraft to begin tumbling. The spacecraft impacted the Moon southeast of the crater Copernicus at a velocity of nearly 6,000 miles-per-hour.

A thorough investigation did not result in the identification of the exact cause of the failure.

Surveyor III was launched April 17, 1967, and successfully soft-landed on the Moon April 19, 1967, on the east wall of a 650-foot-diameter crater in the Ocean of Storms. The spacecraft touched down three times in the landing when its vernier engines did not cut off at the prescribed 14-foot mark but continued firing to the surface. A command from Earth shut down the engines after the second touchdown at 2.94 degrees South latitude and 23.34 degrees West longitude. Surveyor III was equipped with a surface sampler instrument to provide data on lunar soil characteristics. The device dug four trenches, made seven bearing strength tests and 13 penetration tests.

Operation of the television camera yielded 6,315 pictures. Attempts to reactivate the spacecraft during the second lunar day were unsuccessful.

Surveyor IV was launched July 14, 1967, again toward Sinus Medii in the center of the Moon. The mission proceeded normally until the last few seconds of burn of the retromotor when there was an abrupt loss of communications with the spacecraft. Repeated efforts to reestablish communications failed.

The third successful soft-landing on the Moon's surface by a United States spacecraft was accomplished by Surveyor V on Sept. 10, 1967, despite a critical helium leak problem and a hazardous emergency landing procedure.

Surveyor V, launched Sept. 8, 1967, landed in a small lunar crater (Sept 10, 1967). Resting on a slope of about 19 degrees, two of the spacecraft's feet are positioned on the wall near the floor of the 30-foot diameter crater, and the third is perched on the crater rim. The crater is approximately four feet deep and the camera is a foot above its rim.

During the flight, an irreparable helium gas leak in the spacecraft's vernier propulsion system developed just prior to the midcourse maneuver on Sept. 8.

After a reprogramming of the lunar landing sequence, required to allow for most efficient use of the remaining gas, the precision soft-landing was accomplished. Surveyor V landed about 18 miles from the target site at 1.33 degrees West longitude and 0.42 degrees North latitude. Of the 19,049 pictures taken, 1,043 were taken during the second lunar day.

The Surveyor V Alpha Scatter experiment made scientific history by conducting an on-location chemical analysis of the material on the surface of an extra-terrestrial body for the first time. This device determined the chemical composition of the lunar surface at the landing site to be similar to basalt rock found on Earth. The elements oxygen, silicon and aluminum, plus others, have also been identified in a preliminary review of Surveyor data.

Surveyor VI was launched Nov. 7, 1967, and landed Nov. 9 on a virtually level site in Sinus Medii or Central Bay in the center of the Moon's visible face at 0.47 degrees North latitude and 1.48 degrees West longitude.

After a flawless flight and soft landing, the operation of the spacecraft on the lunar surface was almost perfect in every respect. During its first eight days on the Moon, Surveyor VI acquired more than 14,000 pictures and logged 27 hours of certified on-surface with its Alpha Scatter instrument, thus completing the requirements of the chemical experiment.

Almost eight days after landing on the Moon, Surveyor VI's vernier engines were restarted (Nov. 17) and the spacecraft was lifted off the lunar surface and moved laterally about eight feet to a new location. This historic first such maneuver on the Moon not only provided a demonstration of a new technological capability but significantly enhanced the scientific value of the Surveyor VI mission by providing the means for examining the imprints made in the lunar surface by the spacecraft during its initial touchdown.

Scientists were able to study the effects of the vernier engine blast on the lunar material as well as its interaction with spacecraft surfaces. The lateral maneuver also provided an extended base-line for stereoscopic photography and photogrammetric mapping of the landing site and surface features.

Photographs taken after the hop maneuver showed that the exhaust of the spacecraft's vernier engines eroded and further excavated the imprint made in the lunar surface by one of the crushable landing blocks. Vernier blasts showed less effect on portions of the surface undisturbed by the spacecraft in landing, moving more soil from areas loosened or stirred by the impact of the footpads and crush blocks.

Ejected materials show as fine rays and clumps, darker in color than the remainder of the surface.

Because it could not be retracted to its stowed position, the Alpha Scatter instrument was overturned during the second landing, an event which had been anticipated. The hop maneuver was ordered only after chemical analysis requirements in the initial spacecraft location had been satisfied.

Subsequent to the hop, another 15,000 pictures were taken by Surveyor VI, for a total of more than 30,000 during the first lunar day.

SURVEYOR G SPACECRAFT

The Surveyor G spacecraft is basically identical to Surveyors V and VI with the exception of some payload items.

Television

The Surveyor spacecraft carries one survey television camera. The camera is mounted nearly vertically, pointed at a movable mirror. The mounting containing the mirror can swivel 360 degrees, and the mirror can tilt either down to view a landing leg or up above the horizon.

The camera can be focused, by Earth command, from four feet to infinity. Its iris setting, which controls the amount of light entering the camera, can adjust automatically to the light level or can be commanded from Earth. The camera has a variable focal length lens which can be adjusted to narrow angle, 6.4 x 6.4 field of view, to wide angle, 25.4 x 25.4 field of view.

A focal plane shutter provides an exposure time of 150 milliseconds. The shutter can also be commanded open for an indefinite length of time. A sensing device coupled to the shutter will keep it from opening if the light level is too intense. A too-high light level could occur from changes in the area of coverage by the camera, a change in the angle of mirror, in the lens aperture, or by changes in Sun angle. The same sensor controls the automatic iris setting. The sensing device can be overridden by ground command.

The camera system can provide 200 or 600-line pictures. The 600-line pictures require that the high gain directional antenna and the high power level of the transmitter are both operating. The 600-line mode provides a picture each 3.6 seconds and the 200-line mode every 61.8 seconds.

A filter wheel can be commanded to one of four positions providing clear, colored or polarizing filters.

Mirrors

Two convex beryllium mirrors are mounted on the spacecraft frame near leg number one to provide additional coverage of the area under the spacecraft for the television camera. The larger mirror is 10 inches x 9 inches; the smaller is $3\frac{1}{2}$ inches x $9\frac{1}{2}$ inches.

The large mirror provides a view of the lower portion of crushable block number three and the area under vernier engine number three. The small mirror provides a view of the area that will be covered by the alpha-scattering instrument when the latter is deployed to the lunar surface.

In addition to the curved mirrors positioned on the underside of the spacecraft frame which enables the TV camera to view areas otherwise hidden from view, a flat mirror of beryllium aluminum, $9\frac{1}{2}$ by $3\frac{1}{2}$ inches, has been mounted just below the upper collar of the masting holding the solar panel and planar array antenna.

This mirror will provide photographs of the surface sampler work area on the lunar surface at a different angle then by direct view of the TV camera. Its purpose when used with TV direct viewing is to provide a stereoscopic view of trenching and digging operations.

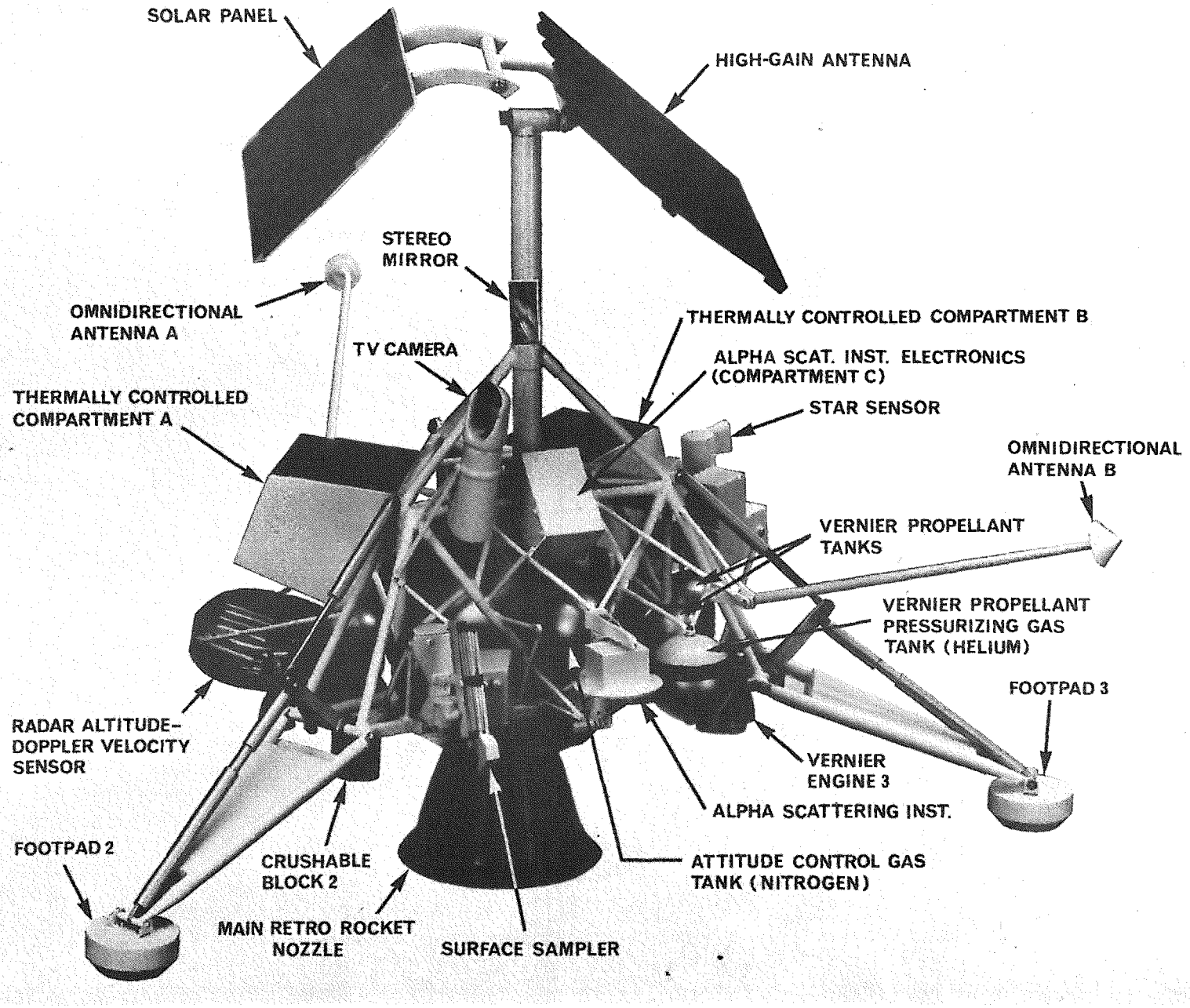
Seven flat one-centimeter-square mirrors are positioned in view of the TV camera at various heights above the lunar surface to measure dust accumulation during post-landing operations.

These mirrors are roughly the size of a 10-cent piece, hexagonal in shape (six-sided square) with about one-half inch between parallel sides. One of the mirrors will be fastened against the side of Compartment A while another will be fastened to omnidirectional antenna B. One each will be fastened to spacecraft legs No. 2 and 3 and one each will also be fastened to footpads No. 2 and 3. A seventh mirror will be attached to one of the struts holding the RADVS.

The mirrors are polished aluminum coated with silicone monoxide to give a highly polished surface. The mirrors are positioned to reflect only lunar sky or lunar surface and will not reflect any portions of the spacecraft when viewed by the TV camera. This will permit easy observation of any accumulations of dust that may settle on the polished surfaces.

Principal television investigator is Dr. Eugene Shoemaker, U. S. Geological Survey.

SURVEYOR



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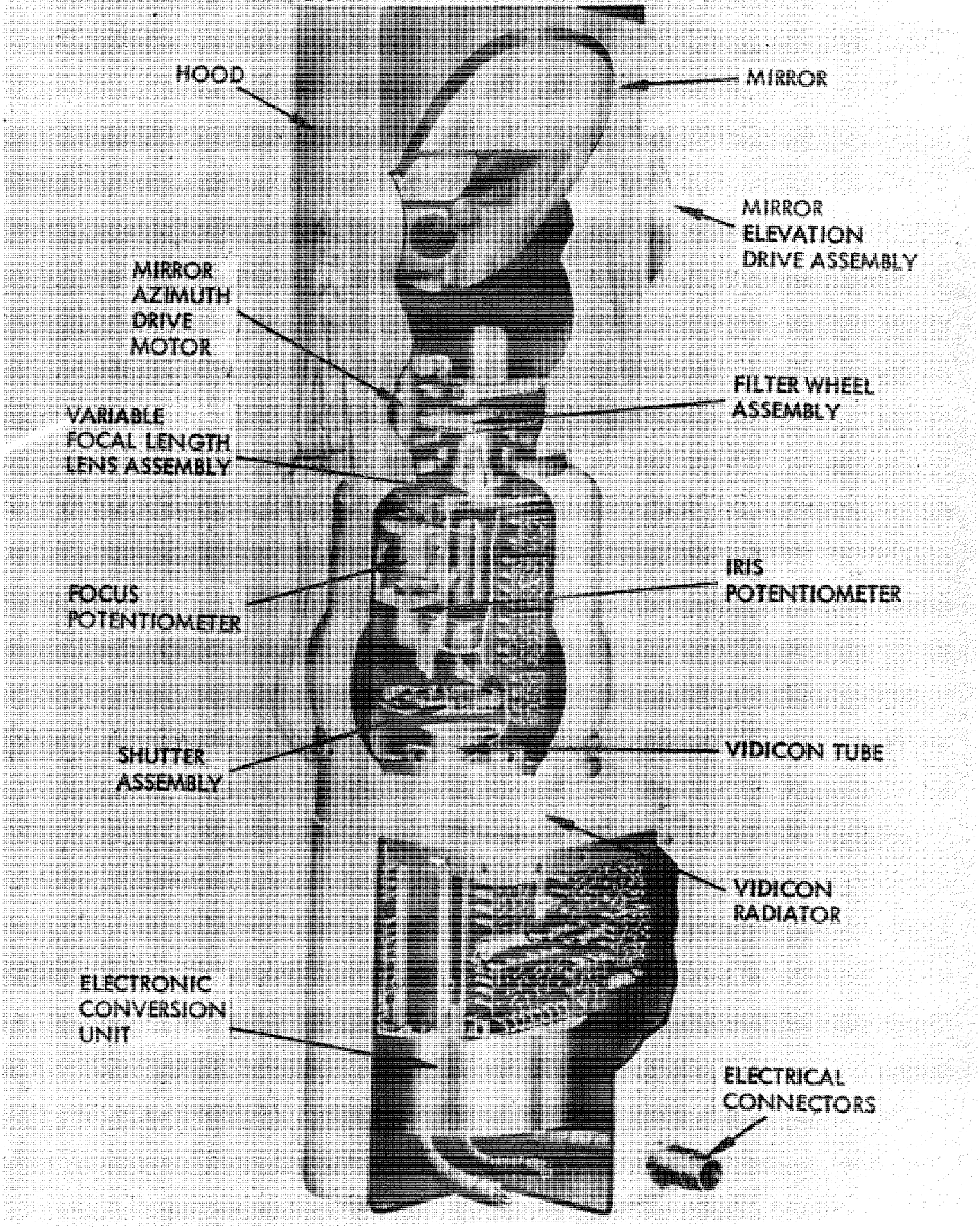
SURVEYOR TV CAMERA



Surface Sampler Experiment

Payload of the Surveyor G spacecraft will include both the Surface Sampler and Alpha Scatter experiments previously flown on separate spacecraft in the Surveyor series. These devices will be operated as a team on the Surveyor G mission.

The Alpha Scatter instrument will make a chemical analysis at the lunar surface. The Surface Sampler will dig into the surface, then pick up and reposition the Alpha Scattering instrument for a second subsurface analysis.

The sampler or metal claw digger, first flown on Surveyor III, enabled scientists to analyze the Moon's bearing strength by digging furrows and moving small amounts of lunar soil from one place to another.

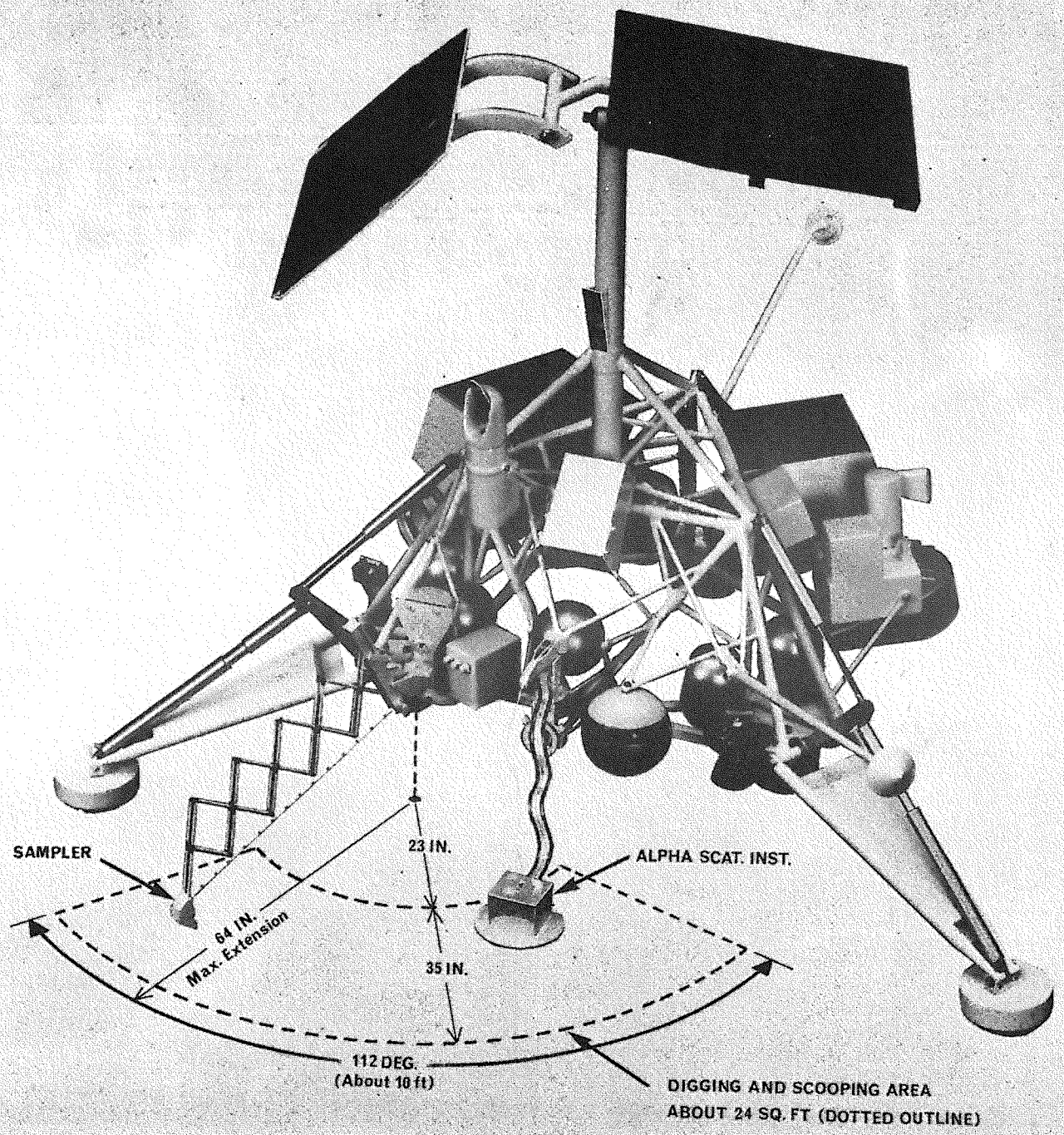
The device is a scoop about five inches long and two inches wide attached to an extendable arm hinged horizontally and vertically to the spacecraft.

The flexible arm, to which the scoop is rigidly attached, is made up of tubular aluminum cross members which operate mechanically in a scissor fashion to extend or retract the scoop. The arm is spring-loaded and is held in its retracted or partially retracted position by a metal tape, one end attached to the scoop and the other wound on a motor spindle at the base. Extension and retraction of the arm is controlled by commands to the motor to reel or unreel the tape. Maximum extension is about five feet from the spaceframe.

Two other motors, which can be operated in either direction, will allow the arm to pivot 112 degrees in a horizontal arc and to elevate or lower the scoop over a range of some 40 inches above to about 18 inches below a level lunar surface. Surface area available to the sampler totals about 24 square feet.

A fourth motor, located in the scoop, opens and closes a two-by-four-inch door on the scoop.

SURVEYOR SURFACE SAMPLER WORKING AREA



All four motors operate on 22 volts of unregulated direct current from the spacecraft battery. They operate for either of two time periods, a single command pulsing the motor for one-tenth of a second or for two seconds. Selection of the motor to be operated, motor direction and the time period is made by ground command.

The instrument will be used in conjunction with both the survey TV camera and the Alpha Scatter experiment. The scoop will be positioned in view of the camera, then activated to perform picking, digging or trenching operations. Visual data combined with a determination of the force developed during the digging will indicate strength, texture and cohesive characteristics of the soil.

The Alpha Scatter device can be moved, to chemically analyze the soil stirred by the Surface Sampler. By engaging a knob on the sensor head, the sampler claw can pick up the Alpha Scatter experiment and move it from one point on the lunar surface to another.

A single telemetry channel from the Surveyor will monitor the electric current being drawn by the Surface Sampler motor in operation. By using pre-flight calibration data, this measurement can be used in analyzing the force necessary to scrape or dig the surface and break small rocks or clods.

In the event of a camera failure, where the Surface Sampler must be used in the blind, the force measurements will be of some, but less value, in analyzing the operation of the instrument. For maximum success of the experiment, the Surface Sampler is dependent upon visual data from the TV camera.

Two U-shaped magnets are imbedded in the scoop door to provide analysis of the magnetic properties of the lunar soil.

The scoop, arm, motors, and housing for the device total about 8.4 pounds. The instrument's electronics unit, located in a separate thermal-control compartment, weighs about 6.3 pounds.

Principal scientific investigator for the Surface Sampler experiment is Dr. Ronald F. Scott of the California Institute of Technology. The instrument was designed and built by the Hughes Aircraft Company.

Alpha Scattering Experiment

The purpose of this experiment is to provide an analysis of the constituents of lunar soil.

The chemical composition of an extraterrestrial body is one of the basic scientific findings that can be determined about that body. Chemical analysis of the Moon can provide a clue to the history and present stage of development of the Moon.

The analysis might determine if any of the meteorites falling on the Earth are of lunar origin.

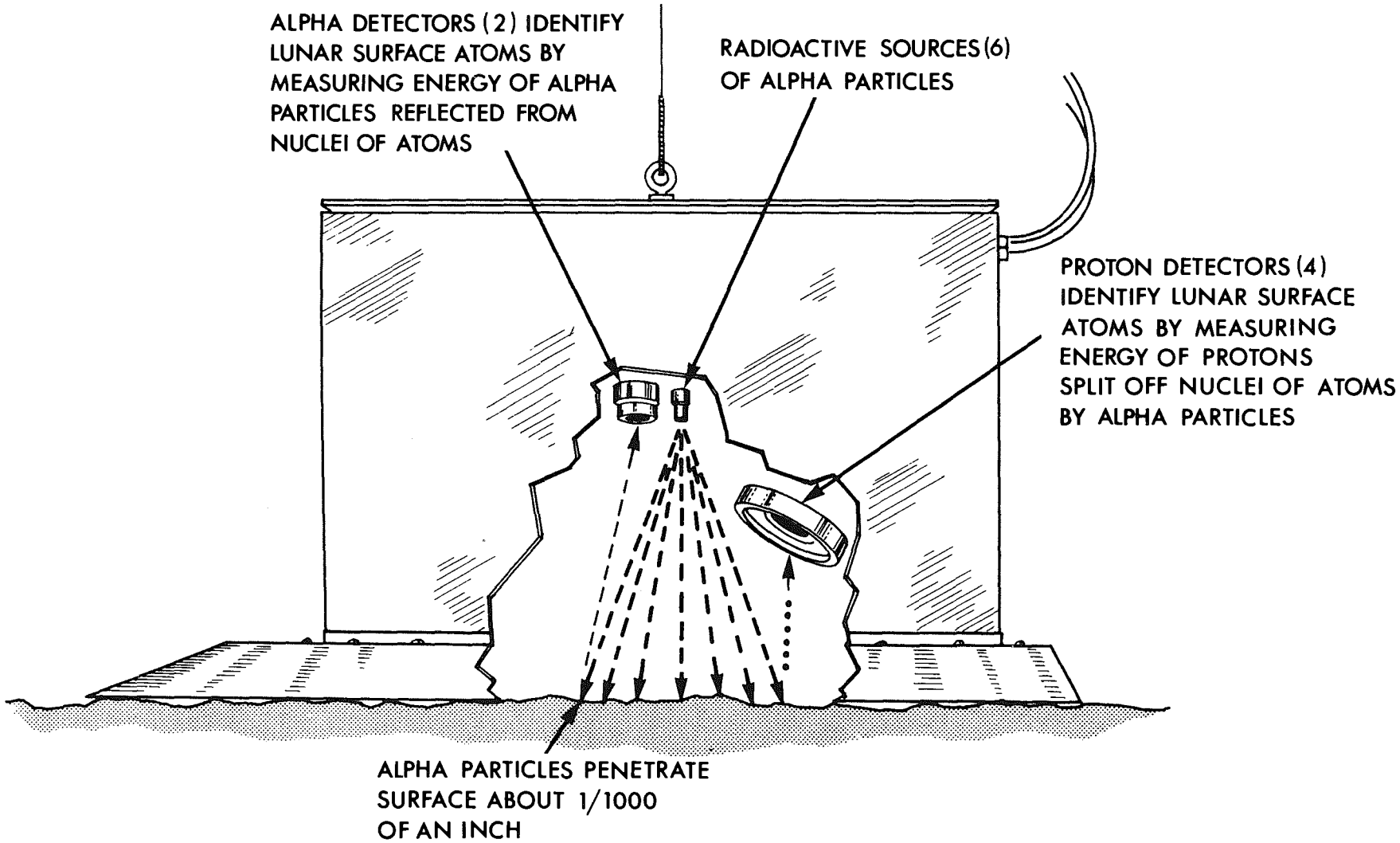
The alpha particle scattering experiment is a new technique for chemical analysis, which detects the interaction of alpha particles with the atomic nuclei of elements present in the lunar surface. Alpha particles striking these nuclei are scattered in a known manner depending on the type of nuclei. Some nuclei when struck by alpha particles also emit protons with known characteristics.

The instrument is designed to bombard the lunar surface with alpha particles from a radio-active source, Curium 242. Two types of detectors in the instrument, two for alpha particles and four for protons, provide a measurement of the energies of the scattered alpha particles and protons and the number of scattered alpha particles and protons.

The energy and number of scattered alpha particles and protons will vary depending on the type of atoms encountered in the lunar soil by the alpha particles emitted by the radio-active source. The alpha scattering detector-analyzer system detects scattered alpha particles from all elements except hydrogen, helium and lithium. The proton detector system detects protons from boron, nitrogen, fluorine, sodium, magnesium, aluminum, silicon, phosphorus, sulfur, chlorine and potassium. Sensitivity of the measurement varies from one element to another.

The instrument is carried in-flight folded up against the spacecraft. After landing the system is checked by analysis of an onboard material of known composition. The instrument is then partially deployed to obtain a background measurement and then lowered by a nylon line to contact the lunar surface. The alpha particles will penetrate a thin, top layer of lunar soil to a depth of about one-thousandth of an inch.

SURVEYOR ALPHA SCATTERING INSTRUMENT



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The instrument is packaged in two parts, the sensor head, which is deployed to the lunar surface, and the digital electronics package. The sensor head contains the radioactive source, alpha detectors, proton-detectors, sensor head electronics and a heater.

The electronics package contains command decoder logic circuitry, power supply, and the logic circuitry required to convert the various values detected into binary data for transmission. The electronics package is contained in a special thermal compartment on the spacecraft. Each binary word will contain nine bits, one sync bit, seven data bits and a parity check bit.

The instrument is attached to the spacecraft by a bracket and metal arm. The checking sequence is performed without deploying the instrument. The instrument is deployed by lowering it to the lunar surface by a nylon cord attached to an eye-bolt on the sensor head. The cord is wrapped around a geared cylinder that unwinds under the pull of lunar gravity and allows the device to drop to the lunar surface in a series of controlled steps. However, during the partial deployment sequence the cord is restrained from unwinding by a lock mechanism. Sufficient slack is provided in the cord for the partial deployment. The lock is released by firing an explosive squib on Earth command, for full deployment.

The sensor head has been fitted with a small lifting knob attached to the top where the nylon cord attaches to the instrument. The lifting knob will enable the surface sampler scoop to pick up and move the sensor head to provide analysis of a different area.

The sensor head, electronic compartment and deployment device total 28 pounds.

Principal investigator for the Experiment is Dr. A. Turkevich, University of Chicago; co-investigators are Ernest Franzgrots, JPL, and James H. Patterson, Argonne National Laboratory.

Magnetic Test

The purpose of this test, utilizing small magnets attached to two footpads, is to determine whether magnetic particles are present in the surface layer of lunar soil.

The magnets are bars, two inches long by ½ inch wide by 1/8 inch thick, mounted vertically on footpads #2 and #3 in view of the television camera. Photographs of the bars taken at various Sun angles would show magnetic particles attracted to the magnets if there are any on the lunar surface.

Second bars -- nonmagnetic -- are also mounted on the footpads to serve as a control for the test by permitting a comparison of the amount of material adhering to the non-magnetic bars, if any, with the amount adhering to the magnetic bars.

Two U-shaped magnets are also mounted on the surface sampler scoop where they can be brought into contact with the lunar surface material at will and in a controlled manner.

The strength of all the magnets, including those on the surface sampler, is approximately 700 gauss.

Engineering Instrumentation

Engineering evaluation of the Surveyor flight will be augmented by an engineering payload including an auxiliary processor for engineering information, and instrumentation consisting of extra temperature sensors, strain gauges for gross measurements of vernier engine response to flight control commands and shock absorber loading at touchdown, and extra accelerometers for measurements of vernier engine response to flight control commands and shock absorber loading at touchdown, and extra accelerometers for measuring structural vibration during main retro burn.

ATLAS-CENTAUR LAUNCH VEHICLE

Atlas-Centaur 15 will boost the seventh and last Surveyor spacecraft on its way to the Moon. Surveyor was the first operational payload for the Centaur vehicle. Centaur, which was developed under the direction of NASA's Lewis Research Center, was the nation's first vehicle to use the liquid hydrogen-liquid oxygen propellant combination.

Despite some growing pains during the development flight program, Centaur has gone on to prove an exceptionally capable and accurate rocket system through near flawless flights on each of its six operational missions to date.

LAUNCH VEHICLE CHARACTERISTICS

(All figures approximate)

Liftoff weight:	322,300 lbs.
Liftoff height:	117 feet
Launch Complex:	36-A
Launch Azimuth:	Variable: 97-115 degrees

	SLV-3C Booster	Centaur Stage
Weight:	287,340 lbs.	37,880 lbs.
Height:	79 feet (including interstage adapter)	48 feet (with payload fairing)
Thrust:	395,000 lbs. (sea level)	30,000 lbs. (vacuum)
Propellants:	Liquid oxygen and RP-1	Liquid hydrogen and liquid oxygen
Propulsion:	MA-5 system (2 - 168,000-lb. thrust engines, 1 - 58,000, 2 - 670)	Two 15,000-lb. thrust RL-10 engines

Velocity:	5,800 mph at BECO 8,200 mph at SECO	23,600 mph at injection
Guidance:	Pre-programmed auto-pilot through BECO Switch to inertial guidance for sustainer phase.	Inertial guidance

AC-15 consists of an SLV-3C booster combined with a Centaur second stage. Both stages are 10 feet in diameter and are connected by an interstage adapter. Both the Atlas and Centaur stages rely on pressurization for structural integrity.

The Atlas SLV-3C Atlas booster is 51 inches longer than its predecessor and develops 395,000 pounds of thrust at liftoff. The increased booster length provides an additional 21,000 pounds of propellants and results in about 10 seconds added booster flight. The increase of 7,000 pounds in Atlas booster thrust was achieved by resetting the engine regulators to provide maximum performance.

The Centaur second stage including the nose fairing is 48 feet long. It is powered by two improved RL-10 hydrogen-oxygen engines, designated RL-10 A-3-3. The RL-10 was the first hydrogen-fueled engine developed for the space program.

ATLAS-CENTAUR FLIGHT SEQUENCE*

EVENT	NOMINAL TIME, SECONDS	ALTITUDE, STATUTE MILES	SURFACE RANGE, STATUTE MILES	VELOCITY, MPH
Liftoff	0	0	0	0
Booster Engine Cutoff	153	37	55	5,807
Booster Jettison	156	39	60	5,877
Jettison Insulation Panels	198	61	129	6,718
Jettison Nose Fairing	228	75	185	7,521
Sustainer Engine Cutoff	248	84	227	8,178
Atlas Separation	250	84	231	8,174
Centaur Engine Start	260	88	252	8,141
Centaur Engine Cutoff	580	106	1,254	16,502
Centaur Second Burn	2,045	103	7,813	16,554
Centaur Engine Cutoff	2,158	113	8,412	23,613
Spacecraft Separation	2,221	143	8,813	23,529
Start Centaur Reorientation	2,226	146	8,844	23,519
Start Centaur Retrothrust	2,461	446	10,228	22,631

*Nominal times of events are directly influenced by the time of launch which determines the parking orbit duration. Nominal times given are for a launch azimuth of 99 degrees and parking orbit coast time of 25 minutes.

TRACKING AND COMMUNICATION

The flight of the Surveyor spacecraft from injection to the end of the mission will be monitored and controlled by NASA's Deep Space Network (DSN) which includes the Space Flight Operations Facility (SFOF) operated by the Jet Propulsion Laboratory.

Some 300 persons will be involved in Surveyor flight monitoring and control during peak times in the mission. On the Surveyor I flight more than 100,000 ground commands were received and acted on by the spacecraft during flight and after the soft landing.

The Deep Space Network consists of the SFOF and five permanent space communications stations in Australia, Spain, South Africa and California; and a spacecraft monitoring station at Cape Kennedy. The two Australia stations are at Woomera and Canberra; the Spanish station near Madird comprises two antenna facilities; the California station comprises three facilities. One facility is at Johannesburg, South Africa.

Of the DSN facilities those assigned to the Surveyor G Mission are Pioneer at Goldstone, Calif.; Robledo, Spain; Tidbinbilla in the Canberra complex, Australia; and Johannesburg, South Africa and the SFOF.

The Goldstone facility is operated by JPL with the assistance of the Bendix Field Engineering Corp. which provides the technical staff and maintenance personnel. The Tidbinbilla facility is operated by the Australian Department of Supply. The Robledo facility is operated by JPL under an agreement with the Spanish government and with the support of Instituto Nacional de Tecnica Aeroespacial (INTA) and the Bendix Field Corp.

The DNS uses a ground communications system for operational control and data transmission between these stations. The ground communications system is a part of a larger net (NASCOM) which links all of the NASA stations around the world. This net is under the technical direction of NASA's Goddard Space Flight Center, Greenbelt, Md.

The DNS supports the Surveyor flight in tracking the spacecraft, receiving telemetry from the spacecraft, and sending it commands. The DNS renders this support to all of NASA's unmanned lunar and planetary spacecraft from the time they are injected into planetary orbit until they complete their mission.

Stations of the DSN receive the spacecraft radio signals, amplify them, process them to separate the data from the carrier wave and transmit required portions of the data to the control center via high-speed data lines, radio links, and teletype. The stations are also linked with the center by voice lines. All incoming data are recorded on magnetic tape.

The information transmitted from the stations to the SFOF is fed into large scale computer systems which translate the digital code into engineering units, separate information pertinent to a given subsystem on the spacecraft, and drive display equipment in the SFOF to present the information to the engineers on the project. All incoming data are again recorded in the computer memory system and are available on demand.

Equipment for monitoring television reception from Surveyor is located in the SFOF.

Some of the equipment is designed to provide quick-look information for decisions on commanding the camera to change iris settings, change the field of view from narrow angle to wide angle, change focus, or to move the camera either horizontally or vertically. Television monitors display the picture being received. The pictures are received line by line and each line is held on a long persistence television tube until the picture is complete. A special camera system produces prints of the pictures for quick-look analysis.

Other equipment will produce better quality pictures from negatives produced by a precision film recorder.

Commands to operate the camera will be prepared in advance on punched paper tape and forwarded to the stations of the DSN. They will be transmitted to the spacecraft from the DSN station on orders from the SFOF.

Three technical teams support the Surveyor mission in the SFOF: one is responsible for determining the trajectory of the spacecraft including determination of launch periods and launch requirements, generation of commands for the midcourse and terminal maneuvers; the second is responsible for continuous evaluation of the condition of the spacecraft from engineering data radioed to Earth; the third is responsible for evaluation of data regarding the spacecraft and for generating commands controlling the spacecraft operations.

TRAJECTORY

The determination of possible launch days, specific times during each day and the Earth-Moon trajectories for the Surveyor spacecraft are based on a number of factors, or constraints.

A primary constraint is the time span during each day Surveyor G can be launched -- the launch window -- which is determined by the requirement that the launch site at launch time and the Moon at arrival time be contained in the Earth-Moon transfer orbit plane. With the launch site moving eastward as the Earth revolves, acceptable conditions occur only once each day for a given plane.

The launch azimuth constraint of 97 to 115 degrees is imposed by the range safety consideration of allowing the initial launch phase only over the ocean, not over land masses.

The time of flight, or the time to landing, about 61-65 hours, is determined by the constraint placed upon the trajectory engineer that Surveyor must reach the Moon during the viewing period of the prime Deep Space Net station at Goldstone in the California Mojave Desert.

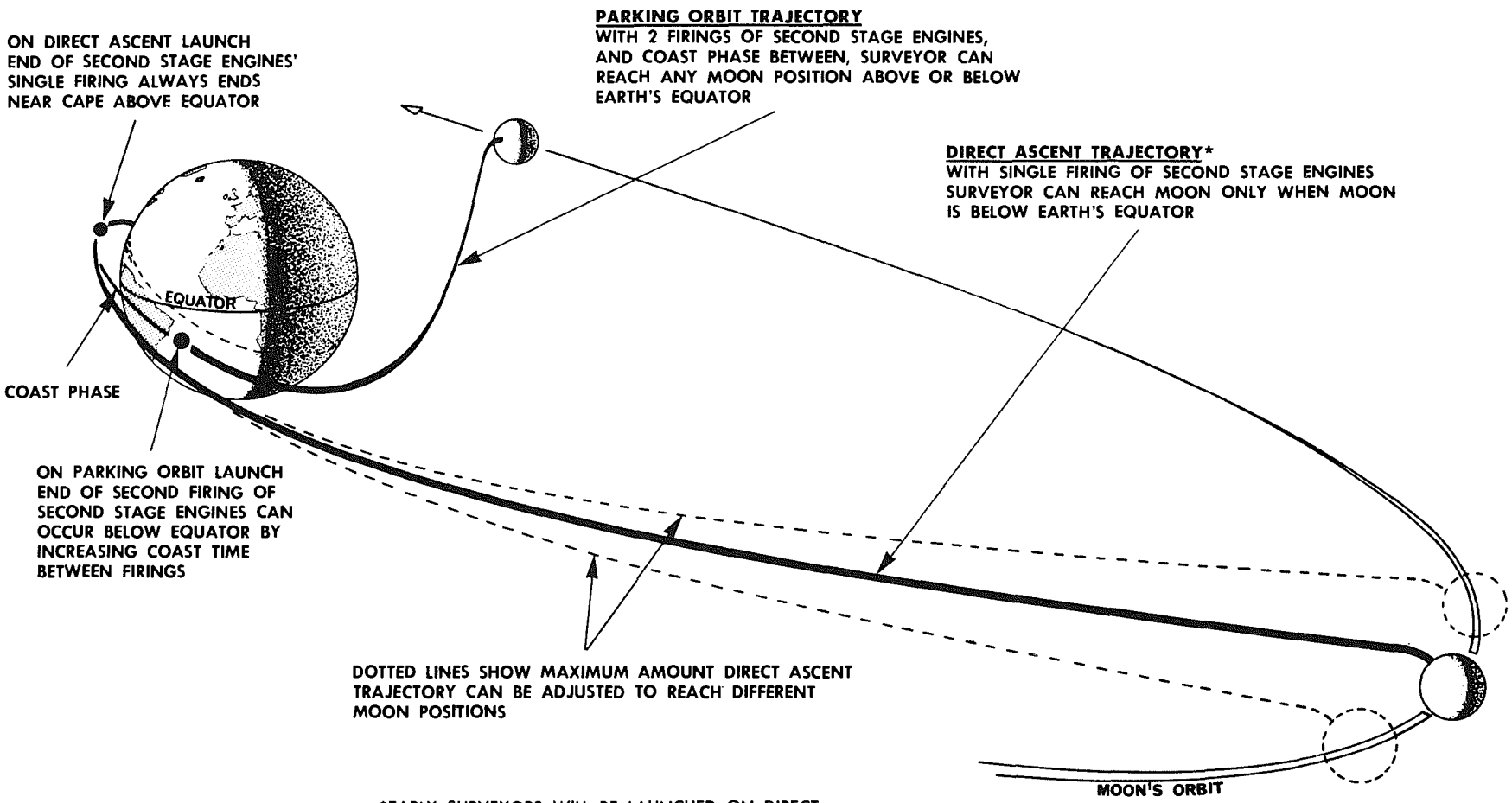
Landing sites are further limited by the curvature of the Moon. The trajectory engineer cannot pick a site, even if it falls within the acceptable band, if the curvature of the Moon will interfere with a direct communication line between the spacecraft and the Earth.

Two other factors in landing site selection are smoothness of terrain and a requirement for Surveyor to land, in areas selected for the Apollo manned lunar mission.

Thus the trajectory engineer must tie together the launch characteristics, the landing site location, the declination of the Moon and flight time, in determining when to launch, in which direction, and at what velocity.

His chosen trajectory also must not violate constraints on the time allowable that the Surveyor can remain in the Earth's shadow. Too long a period can result in malfunction of components or subsystems. In addition, the Surveyor must not remain in the shadow of the Moon beyond given limits.

SURVEYOR TRAJECTORIES TO THE MOON



*EARLY SURVEYORS WILL BE LAUNCHED ON DIRECT ASCENT TRAJECTORIES

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The velocity of the spacecraft when it arrives at the Moon must also fall within defined limits. These limits are defined by the retrorocket capability. The velocity relative to the Moon is primarily correlated with the flight time and the Earth-Moon distance for each launch day.

So, a further requirement on the trajectory engineer is the amount of fuel available to slow the Surveyor from its lunar approach speed of 6,000 mph to nearly zero velocity, 13 feet above the Moon's surface. The chosen trajectory must not yield velocities that are beyond the designed capabilities of the spacecraft propulsion system.

Also included in trajectory computation is the influence on the flight path and velocity of the spacecraft of the gravitational attraction of primarily the Earth and Moon, and to a lesser degree the Sun, Mercury, Venus, Mars, and Jupiter.

It is not expected that the launching can be performed with sufficient accuracy to impact the Moon in exactly the desired area. The uncertainties involved in a launch usually yield a trajectory or an injection velocity that vary slightly from the desired values. The uncertainties are due to inherent limitations in the guidance system of the launch vehicle. To compensate, lunar and deep space spacecraft have the capability of performing a midcourse maneuver or trajectory correction. To alter the trajectory of a spacecraft it is necessary to apply thrust, or energy, in a specific direction to change its velocity, the trajectory of a body at a point in space being basically determined by its velocity.

For example, a simple midcourse might involve correcting a too high injection velocity. To correct for this the spacecraft would be commanded to turn in space until its midcourse engines were pointing in its direction of travel. Thrust from the engines would slow the craft. However, in the general case the midcourse is far more complex and will involve changes in speed and direction of travel.

A certain amount of thrust applied in a specific direction can achieve both changes. Surveyor will use its three liquid fuel vernier engines to alter its flight path in the midcourse maneuver. It will be commanded to roll and then to pitch or yaw in order to point the three engines in the required direction. The engines then burn long enough to apply the change in velocity required to alter the trajectory.

The change in the trajectory is very slight at this point and a tracking period of about 20 hours is required to determine the new trajectory. This determination will also provide the data required to predict the spacecraft's angle of approach to the Moon, time of arrival, and its velocity as it approaches the Moon.

ATLAS-CENTAUR 15/SURVEYOR G FLIGHT PLAN

The Atlas-Centaur 15 vehicle must inject the Surveyor G spacecraft on a lunar intercept trajectory with sufficient accuracy so that the midcourse maneuver required of the spacecraft is within its capability. The Centaur stage will execute a retromaneuver after spacecraft separation to ensure that the vehicle and spacecraft are adequately separated.

Surveyor G will be launched toward the Moon following primary boost by an Atlas, injection of the Centaur stage and spacecraft into a 100-statute mile Earth parking orbit, and final injection of the spacecraft to the Moon following a variable-length coast phase. Depending on time of launch, the coast phase will vary from 2 to 15 minutes.

Launch Periods
(EST)

Launch Window

Date	Open	Close	Open Azimuth
Jan. 7	12:43 a.m.	3:12 a.m.	97.750
Jan. 8	1:36 a.m.	3:28 a.m.	103.068
Jan. 9	2:29 a.m.	3:51 a.m.	106.963
Jan. 10	3:24 a.m.	4:26 a.m.	109.368
Jan. 11	4:19 a.m.	5:16 a.m.	109.992
Jan. 12	5:11 a.m.	6:24 a.m.	108.456

Atlas Phase

After liftoff AC-15 will rise vertically for the first 15 seconds, during which it is rolled to the desired flight plane azimuth between 97 and 108 degrees. During booster engine flight, the vehicle is steered by the Atlas autopilot.

After 153 seconds of booster flight, the booster engines are shut down (BECO) and jettisoned. The Centaur guidance system then takes over flight control. The Atlas sustainer engine continues to propel the AC-15 vehicle to an altitude of about 84 miles. Prior to sustainer engine shutdown, the second stage insulation panels are jettisoned, followed by the nose fairings.

The Atlas and Centaur stages are then separated by an explosive shaped charge and retrorockets mounted on the Atlas.

Centaur Phase

Centaur's hydrogen engines are then ignited for a planned 320-second burn. This will place Centaur and the Surveyor spacecraft into an approximate 100-mile Earth parking orbit.

As Centaur's engines are shut down and the coast phase begins, two 50-pound-thrust hydrogen-peroxide rockets are fired to settle the propellants.

Two hydrogen-peroxide ullage rockets, each with three pounds thrust, are then fired continuously during the coast period (which varies from 17 to 25 minutes) to retain the propellants in the lower part of the tanks.

About 40 seconds before Centaur's second burn, the two 50-pound thrusters are again used to insure proper propellant settling.

Once Centaur is in the proper position to inject the Surveyor toward the Moon, the hydrogen-fueled main engines are ignited for an approximate 113-second burn. The second-burn command and duration of the burn are determined by Centaur's inertial guidance system, as are all command and steering functions following Atlas booster engine cutoff and jettison.

Separation

The Surveyor spacecraft is separated from Centaur and injected toward the Moon.

Following spacecraft separation, the Centaur vehicle will perform a 180-degree reorientation maneuver, using its attitude control system.

Centaur's velocity is then changed by retro-thrusting. The thrust for this maneuver is produced by two 50-pound hydrogen-peroxide thrusters as well as by "blowing" residual, or unused, propellants through Centaur's main engines.

As a result of this retromaneuver the Centaur and the spacecraft will be separated by at least 200 statute miles, five hours after launch.

The Centaur vehicle will continue in a highly-elliptical Earth orbit with a period ranging from 10 to 13 days.

First Surveyor Events

Shortly after Centaur engine shutdown, the programmer commands Surveyor's legs and two omnidirectional antennas to extend and orders the spacecraft's transmitter to high power.

After Surveyor separates from the Centaur, an automatic command is given by the spacecraft to fire explosive bolts to unlock the solar panel. A stepping motor then moves the panel to a prescribed position. Solar panel deployment can also be commanded from the ground if the automatic sequence fails.

Surveyor will then perform an automatic Sun-seeking maneuver to stabilize the pitch and yaw axes and to align its solar panel with the Sun for conversion of sunlight to electricity to power the spacecraft. Prior to this event the spacecraft main battery is providing power.

The Sun acquisition sequence begins immediately after separation from Centaur and simultaneously with the solar panel deployment. The nitrogen gas jet system, which is activated at separation, will first eliminate random pitch, roll and yaw motions resulting from separation from Centaur. Then a sequence of controlled roll and yaw turning maneuvers is commanded for Sun acquisition.

Sun sensors aboard Surveyor will provide signals to the attitude control gas jets to stop the spacecraft when it is pointed at the Sun. Once locked on the Sun, the gas jets will fire intermittently to control pitch and yaw attitude. Pairs of attitude control jets are located on each of the three landing legs of the spacecraft.

In the event the spacecraft does not perform the Sun seeking maneuver automatically, this sequence can be commanded from the ground.

The next critical step for Surveyor is acquisition of its radio signal by the Deep Space Net tracking stations at Ascension Island and Johannesburg, South Africa, the first DSN stations to see Surveyor after launch.

It is critical at this point to establish the communications link with the spacecraft to receive telemetry to quickly determine the condition of the spacecraft, for command capability to assure control, and for Doppler measurements from which velocity and trajectory are computed.

The transmitter can only operate at high power for approximately one hour without overheating. It is expected, however, that the ground station will lock on to the spacecraft's radio signal within 40 minutes after launch and if overheating is indicated, the transmitter can be commanded to low power.

The next major spacecraft event after the Sun has been acquired is Canopus acquisition. Locking on the star Canopus provides a fixed inertial reference for the roll orientation.

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Canopus Acquisition

Canopus acquisition will be commanded from the ground about six hours after launch. The gas jets will fire to roll the spacecraft at 0.5 degree per second. When the sensor sees the predicted brightness of Canopus (the brightest star in the Southern Hemisphere) it will order the roll to stop and lock on the star. The brightness of the light source it is seeing will be telemetered to Earth to verify that it is locked on Canopus.

Verification can also be provided by a ground command ordering a 360 degree roll and the plotting of each light source the sensor sees that is in the sensitivity range of the sensor. (The sensor will ignore light levels above and below given intensities.) This star map can be compared with a map prepared before launch to verify that the spacecraft is locked on Canopus.

Now properly oriented on the Sun and on Canopus, Surveyor is in the coast phase of the transit to the Moon. Surveyor is transmitting engineering data to Earth and receiving commands via one of its omnidirectional antennas. Tracking data is obtained from the pointing direction of ground antenna and observed frequency change (Doppler).

The solar panel is providing electrical power and additional power for peak demands is being provided by one of two batteries aboard. The gas jets are firing intermittently to keep the craft aligned on the Sun and Canopus.

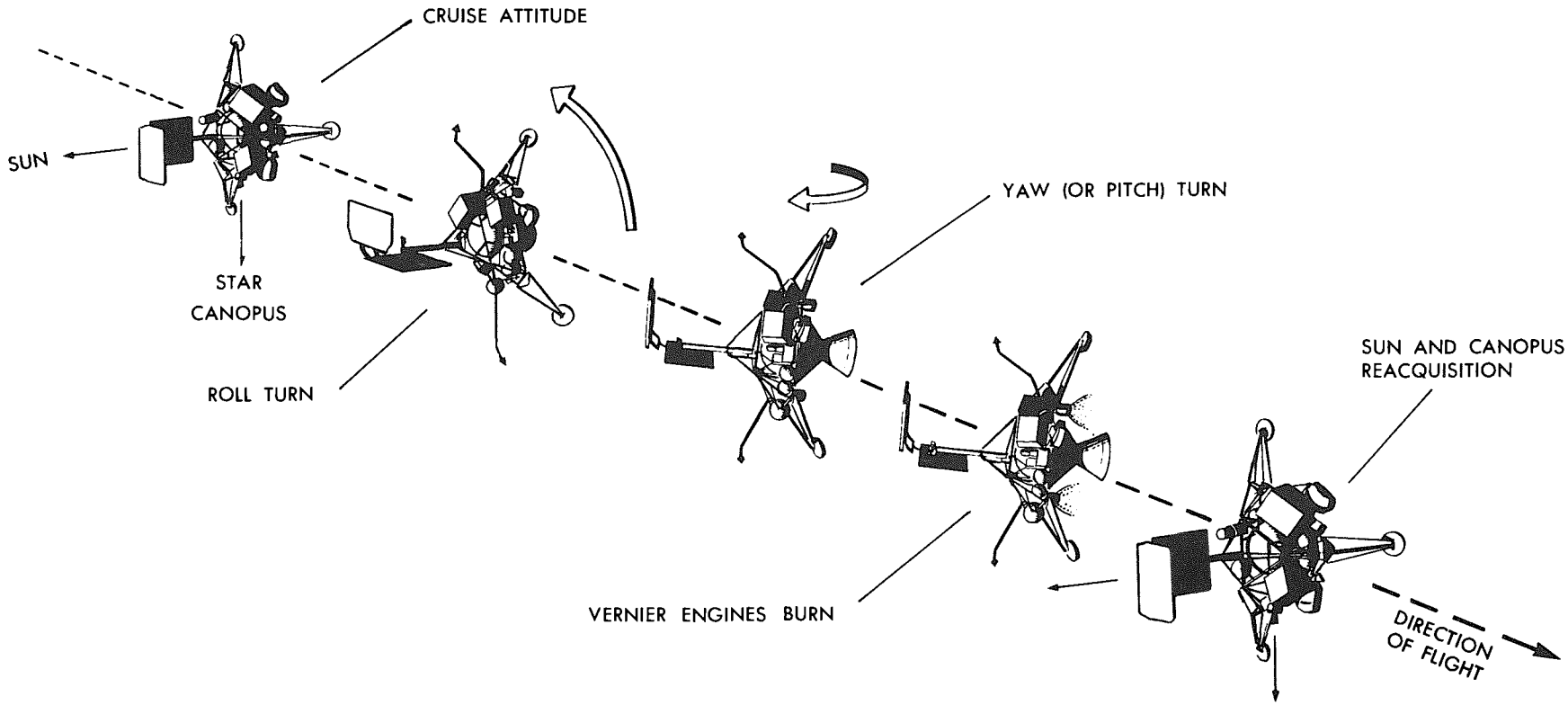
The engineering and tracking information is received from Surveyor at one of the stations of the Deep Space Net. The data is communicated to the Space Flight Operations Facility (SFOF) at the Jet Propulsion Laboratory in Pasadena where the flight path of the spacecraft is carefully calculated and the condition of the spacecraft continuously monitored.

Midcourse Maneuver

Tracking data will be used to determine how large a trajectory correction must be made to land Surveyor in the given target area. This trajectory correction, called the midcourse maneuver, is required because of many uncertainties in the launch operation that prevent absolute accuracy in placing a spacecraft on a trajectory that will intercept the Moon precisely at the desired landing point.

The midcourse maneuver is timed to occur over the Goldstone station of the DSN in the Mojave Desert, the tracking station nearest the SFOF at JPL.

SURVEYOR MIDCOURSE CORRECTION



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The thrust for the midcourse maneuver will be provided by the spacecraft's three liquid fuel vernier engines. Total thrust level is controlled by an accelerometer at a constant acceleration equal to 0.1 Earth g (3.2 ft/sec/sec). Pointing errors are sensed by gyros which can cause the individual engines to change thrust level to correct pitch and yaw errors and swivel one engine to correct roll errors.

Flight controllers determine the required trajectory change to be accomplished by the midcourse maneuver. In order to align the engines in the proper direction to apply thrust to change the trajectory, or flight path, Surveyor will be commanded to roll, then pitch or yaw to achieve this alignment. Normally, two maneuvers are required, a roll-pitch or a roll-yaw.

The duration of the first maneuver is radioed to the spacecraft, stored aboard and re-transmitted back to Earth for verification. Assured that Surveyor has received the proper information, it is then commanded to perform the first maneuver. When completed, the second maneuver is handled in the same fashion. With the spacecraft now aligned properly in space, the number of seconds of required thrust is transmitted to the spacecraft, stored, verified and then executed.

In the event of a failure of the automatic timer aboard the spacecraft which checks out the duration of each maneuver turn and firing period, each step in the sequence can be performed by carefully timed ground commands.

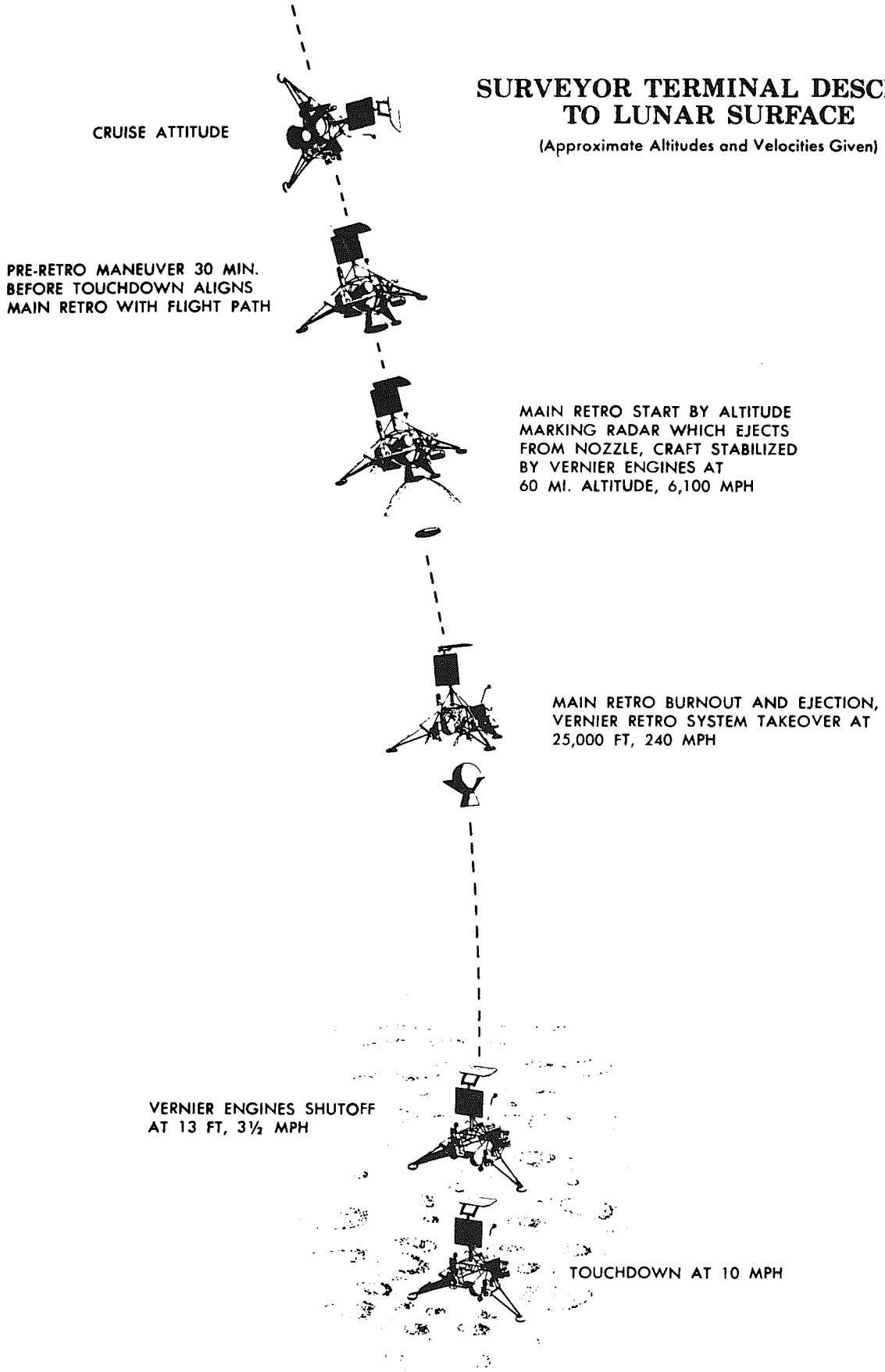
After completion of the midcourse maneuver, Surveyor reacquires the Sun and Canopus. Again Surveyor is in the cruise mode and the next critical event will be the terminal maneuver.

Terminal Sequence

The first step starts at about 1,000 miles above the Moon's surface. The exact descent maneuvers will depend on the flight path and orientation of the Surveyor with respect to the Moon and the target area. Normally they will be a roll followed by a yaw or a pitch turn. As in the midcourse maneuver, the duration times of the maneuvers are radioed to the spacecraft and the gas jets fire to execute the required roll and pitch and yaw. The object of the maneuver is to align the main retro solid rocket with the descent path. To perform the maneuvers, the spacecraft will break its lock on the Sun and Canopus. Attitude control will be maintained by inertial sensors. Gyros will sense changes in the attitude and order the gas jets to fire to maintain the correct attitude until the retrorocket is ignited.

SURVEYOR TERMINAL DESCENT TO LUNAR SURFACE

(Approximate Altitudes and Velocities Given)



With the spacecraft properly aligned, the altitude marking radar will be activated, by ground command, at approximately 200 miles above the Moon's surface. All subsequent terminal events will be automatically controlled by radars and the flight control programmer.

At approximately 60 miles' slant range from the Moon's surface, the marking radar starts the flight control programmer clock which then counts down a previously-stored delay time and then commands ignition of the solid propellant main retro and the three liquid fueled, throttleable vernier engines. The vernier engines maintain a constant spacecraft attitude during main retro firing in the same manner as during midcourse thrusting.

The spacecraft will be traveling at approximately 6,000 miles-per-hour. The main retro will burn out in 40 seconds at about 25,000 feet above the surface after reducing the velocity to about 250 miles-per-hour. The casing of the main retro is separated from the spacecraft, on command from the programmer 12 seconds after burnout, by explosive bolts and falls free.

After burnout the flight control programmer will control the thrust level of the vernier engines until the Radar Altimeter and Doppler Velocity Sensor (RADVS) locks up on its return signals from the Moon's surface.

Descent will then be controlled by the RADVS and the vernier engines. Signals from RADVS will be processed by the flight control electronics to throttle the three vernier engines reducing velocity as the altitude decreases. At 13 feet above the surface, Surveyor will have been slowed to three miles per hour. At this point the engines are shut off and the spacecraft free falls to the surface.

Immediately after landing, flight control power is turned off to conserve battery power.

Post-landing Events

Touchdown will be followed by periods of engineering telemetry to determine the condition of the spacecraft. Then a series of wide angle, 200-line television pictures will be taken.

The solar panel and high-gain planar array antenna will then be aligned with the Sun and Earth, respectively. If the high-gain antenna is successfully operated to lock on Earth, transmission of 600-line television pictures will begin. If it is necessary to operate through one of the low-gain, omnidirectional antennas, additional 200-line pictures will be transmitted.

The lifetime of Surveyor on the surface will be determined by a number of factors such as the power remaining in the batteries in the event that the Sun is not acquired by the solar panel and spacecraft reaction to the intense heat of the lunar day and the deep cold of the lunar night.

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ATLAS-CENTAUR AND SURVEYOR TEAMS

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Oran W. Nicks	Deputy Associate Administrator for Space Science and Applications
Donald P. Hearth	Director, Lunar and Planetary Programs
Lee R. Scherer	Assistant Director for Lunar Flight Programs
Benjamin Milwitzky	Surveyor Program Manager
V. L. Johnson	Director, Launch Vehicle and Propulsion Programs
T. B. Norris	Centaur Program Manager

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Robert J. Parks	Deputy Director
Howard H. Haglund	Surveyor Project Manager
Kermit S. Watkins	Assistant Project Manager for Surveyor Operations
Robert G. Forney	Surveyor Spacecraft System Manager
Dr. Leonard Jaffe	Project Scientists

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Dr. Nicholas A. Renzetti	Surveyor Tracking and Data Systems Manager, JPL

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J. Buckley	Pioneer Station Manager, Goldstone
R. J. Fahnestock	JPL DSN Resident in Australia
R. A. Leslie	Tidbinbilla Station Manager
Phil Tardani	JPL DSN Resident in Spain
Donald Meyer	Robledo Station Manager
Avron Bryan	Ascension Station Manager

LEWIS RESEARCH CENTER, CLEVELAND, O.

Dr. Abe Silverstein	Director
Dr. S. C. Himmel	Assistant Director for Launch Vehicles
Edmund R. Jonash	Centaur Project Manager

KENNEDY SPACE CENTER, FLA.

Dr. Kurt R. Debus	Director
Robert H. Gray	Director of Unmanned Launch Operations
John D. Gossett	Chief, Centaur Operations

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Dr. Anthony L. Turkevich University of Chicago	Alpha Scattering Experiment

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Richard R. Gunter	Assistant Program Manager
James D. Cloud	Assistant Program Manager

GENERAL DYNAMICS/CONVAIR, SAN DIEGO, CALIF.

Grant L. Hansen	Vice President, Launch Vehicle Programs

PRATT AND WHITNEY AIRCRAFT DIVISION OF UNITED AIRCRAFT CO., WEST PALM BEACH, FLA.

Richard Anchutze	RL-10 Engine Project Manager

HONEYWELL, INC., ST. PETERSBURG, FLA.

Paul V. Yingst	Centaur Guidance Program Manager

SURVEYOR/ATLAS-CENTAUR SUBCONTRACTORS

Surveyor

AiResearch Division Garrett Corp. Torrance, Calif.	Ground Support Equipment
Airite El Segundo, Calif.	Nitrogen Tanks
Airtek Fansteel Metallurgical Corp. Compton, Calif.	Propellant Tanks
Ampex Redwood City, Calif.	Tape Recorder
Astrodata Anaheim, Calif.	Decommutators and Subcarrier Discriminator Systems
Bell & Howell Co. Chicago, Ill.	Camera Lens
Bendix Corp. Products Aerospace Division South Bend, Ind.	Landing Dynamics Stability Study
Borg-Warner Santa Ana, Calif.	Tape Recorder
Brunson Kansas City, Kan.	Optical Alignment Equipment
Carleton Controls Buffalo, N. Y.	Helium Regulator

Eagle-Picher Co. Joplin, Mo.	Auxiliary Batteries
Electric Storage Battery Raleigh, N.C.	Main Batteries
Electro-Development Corp. Seattle, Wash.	Strain Gage Electronics
Electro-Mechanical Research Sarasota, Fla.	Decommutators
Electro-Optical Systems, Inc. Pasadena, Calif.	Solar Panel Assembly and Testing
Endevco Corp. Pasadena, Calif.	Accelerometers
General Electro Dynamics Garland, Tex.	Vidicon Tubes
General Precision, Inc. Advanced Products Division Link Group Sunnyvale, Calif.	Spacecraft TV Ground Data Handling System
Heliotek Sylmar, Calif.	Solar Modules
Hi-Shear Corp. Torrance, Calif.	Separation Device
C. G. Hokanson Santa Monica, Calif.	Mob. Temperature Control Unit
Holex Hollister, Calif.	Squibs
Honeywell Los Angeles, Calif.	Tape Recorder/Reproducer
General Precision, Inc. Kearfott Systems Division Wayne, N.J.	Floated Rate Integrated Gyros
Kinetics Solana Beach, Calif.	Main Power Switch
Lear Siegler Santa Monica, Calif.	T.V. Photo Recorder
Menasco Los Angeles, Calif.	Gas Tanks

Metcom Salem, Mass.	Magnetron Assembly
Motorola, Inc. Military Electronics Division Scottsdale, Ariz.	Subcarrier Oscillators
National Water Lift Co. Kalamazoo, Mich.	Landing Shock Absorber
Northrop/Norair Hawthorne, Calif.	Landing Gear
Ryan Aeronautical Co. San Diego, Calif.	Radar Altitude Doppler Velocity Sensor
Sanborn Waltham, Mass.	L. F. Oscillograph
Scientific-Atlanta Atlanta, Ga.	System Test Stand
Singer-Metrics Bridgeport, Conn.	F. M. Calibrator
Telemetrics Santa Ana, Calif.	Simulator
Thiokol Chemical Corp. Elkton Division Elkton, Md.	Main Retro Engine
Thiokol Chemical Corp. Reaction Motors Division Denville, N. J.	Vernier Propulsion System
Tinsley Laboratories, Inc. Berkeley, Calif.	Spacecraft Mirrors
United Aircraft Corp. Norden Division Southhampton, Pa.	Subcarrier Oscillator
Vector Southhampton, Pa.	Subcarrier Oscillator

Atlas-Centaur

Rocketdyne Division of North American Aviation, Inc. Canoga Park, Calif.	MA-5 Propulsion System

Thiokol Chemical Corp. Reaction Motors Division Denville, N. J.	LOX and Fuel Staging Valves
Hadley Co., Inc.	Valves, Regulators and Disconnect Coupling
Fluidgenics, Inc.	Regulators
General Precision, Inc. Kearfott Division Wayne, N. J.	Displacement Gyros
Honeywell, Inc. Aeronautical Division	Rate Gyros
Fifth Dimension, Inc.	Commutators
Bendix Corp. Bendix Pacific Division	Telepaks and Oscillators
Fairchild-Hiller Stratos Western Division	LOX Fuel and Drain Valves
Bourns, Inc.	Transducers and Potentiometers
Washington Steel Co. Washington, Pa.	Stainless Steel
General Dynamics Fort Worth Division Fort Worth, Tex.	Insulation Panels and Nose Fairing
Pesco Products Division of Borg-Warner Corp. Bedford, O.	Boost Pumps for RL-10 Engines
Bell Aerosystems Co. of Bell Aerospace Corp. Buffalo, N. Y.	Attitude Control System
Liquidometer Aerospace Division Simmonds Precision Products, Inc. Long Island, N. Y.	Propellant Utilization System
General Precision, Inc. Kearfott Division San Marcos, Calif.	Computer for Inertial Guidance System

Goodyear Aerospace Division Goodyear Tire and Rubber Co. Akron, O.	Handling Trailer
Systems and Instruments Div. Bulova Watch Co. Flushing, N. Y.	Destructors
Consolidated Controls Corp. El Segundo, Calif.	Safe and Arm Initiator
Borg-Warner Controls Division Borg-Warner Corp. Santa Ana, Calif.	Inverter
Sippican Corp. Marion, Mass.	Modules for Propellant Utilization System
General Electric Co. Lynn, Mass.	Turbine
Vickers Division of Sperry Rand Corp. Troy, Mich.	Hydraulic Pumps
Edcliff Instruments, Inc. Monrovia, Calif.	Transducers and Switches
Rosemount Engineering Co. Minneapolis, Minn.	Tranducers
Scientific Data Systems Santa Monica, Calif.	Computers
W. O. Leonard, Inc. Pasadena, Calif.	Hydrogen and Oxygen Vent Valves

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