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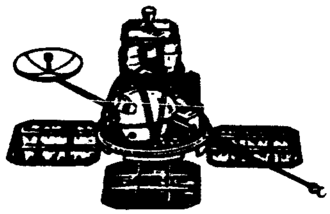

PROJECT: LUNAR ORBITER B

(To be launched no earlier than November 6, 1966)

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SECOND ORBITER
LAUNCH SCHEDULED
IN NOV. 6-11 PERIOD

The United States is preparing to launch the second in a series of photographic laboratory spacecraft to orbit the Moon.

Lunar Orbiter B is scheduled for launch by the National Aeronautics and Space Administration from Cape Kennedy, Fla., within a Nov. 6 through 11 period.

Lunar Orbiter spacecraft are flown to continue the efforts of Ranger and Surveyor to acquire knowledge of the Moon's surface to support the Apollo manned lunar landing program and to enlarge scientific understanding of the Moon.

The 850-pound Orbiter will be launched by an Atlas-Agena D vehicle on a flight to the vicinity of the Moon which takes about 92 hours. If successfully injected on its lunar trajectory, this second of five spacecraft will be designated Lunar Orbiter II.

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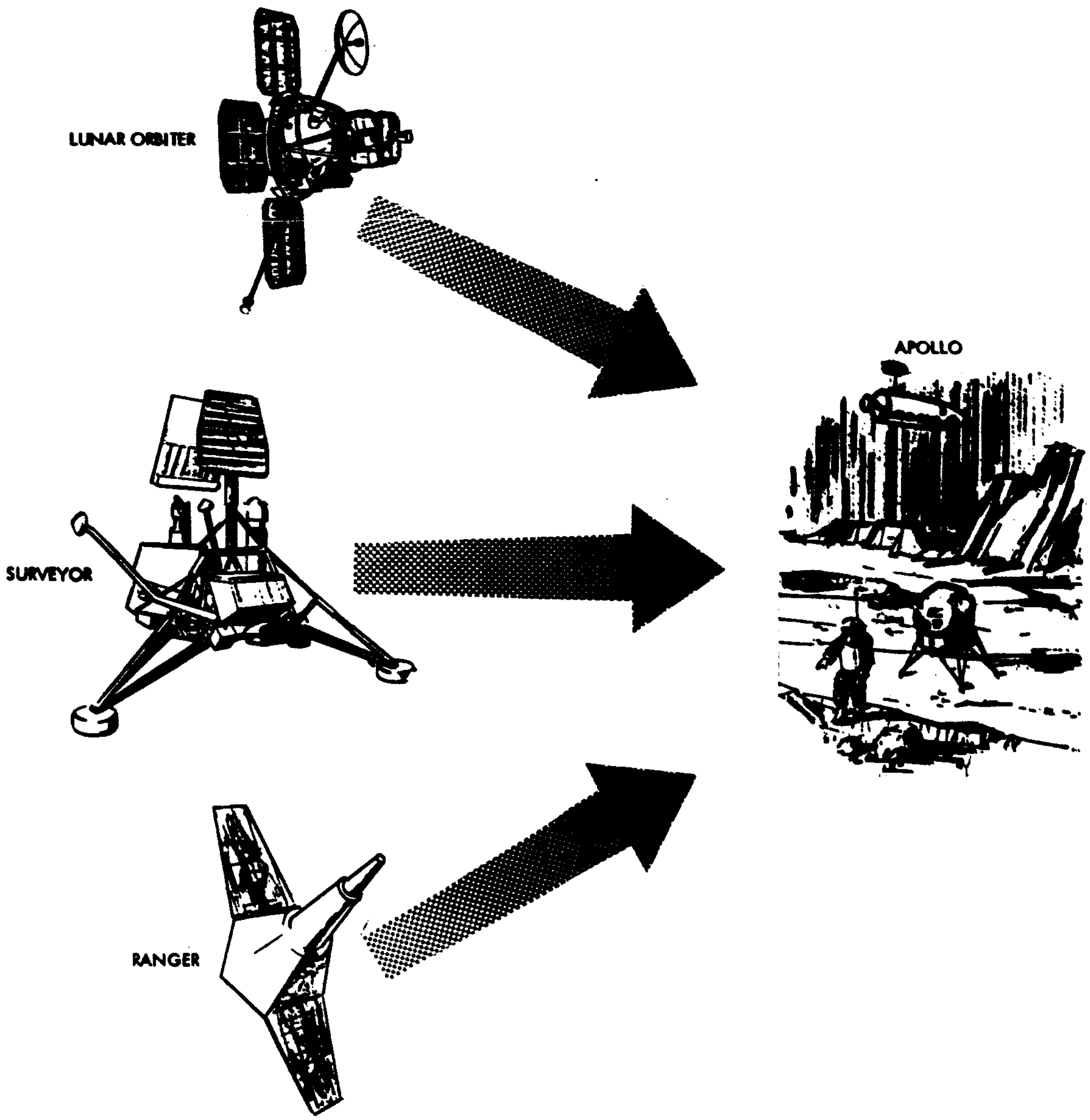


THE LUNAR EXPLORATION PROGRAM

The basic task of this Lunar Orbiter is to expand the findings of Lunar Orbiter I by obtaining detailed photographic information on various areas on the Moon's surface to assess their suitability as landing sites for Apollo and Surveyor spacecraft.

Orbiter B has been assigned 13 primary target sites, located generally within the northern half of the Apollo zone of interest on the Moon's front face. Other areas of the Moon on both the front and hidden sides may also be photographed.

This spacecraft also will attempt to photograph the impact point of Ranger VIII although, unlike Lunar Orbiter I, it will not have the Surveyor I landing site as a target.

The photographic flight plan is an ambitious one and assumes that all spacecraft systems, ground support systems, and the operations team will be able to operate at maximum efficiency. Covering the 13 primary sites requires photography on a great many of the orbits; thus there will be fewer priority readouts -- the radioing back to Earth of pictures between picture-taking sessions -- than on Lunar Orbiter I. In addition, the full photographic flight plan requires about 40 photographic maneuvers by Orbiter B where only 11 were required for the Lunar Orbiter I photographic flight plan.

In addition to its photographic task, Lunar Orbiter B will monitor micrometeoroids and radiation intensity in the vicinity of the Moon. After more than two months in orbit, Lunar Orbiter I had not experienced any micrometeoroid punctures in its detecting instruments. Its radiation counters clearly reflected the effects of a series of solar flares which took place after its photography was complete.

Both micrometeoroid and radiation measurements are used primarily for spacecraft performance analysis since the hermetically-sealed camera package potentially could suffer damage from a micrometeoroid hit or from space radiation.

Orbiter B like Orbiter I will add to and refine the definition of the Moon's gravitational field.

On the first day of the planned launch period, Nov. 6, Orbiter's launch window is between 5:58 p.m. to 8:35 p.m., EST. On each succeeding day of the period, the window opens about 30 minutes later.

During its journey to the Moon the spacecraft will be oriented to the Sun and the Southern hemisphere star Canopus, except when it is executing one or possibly two mid-course correction maneuvers.

At a point ranging from 730 miles to 215 miles from the Moon's surface, depending on the actual launch date, a liquid fuel retro engine will fire to slow the spacecraft so it will be captured by the Moon's gravitational field. As a satellite of the Moon, Lunar Orbiter will enter an initial elliptical orbit about 1,150 by 125 miles.

Orbiter will be tracked precisely by the Deep Space Network for seven to 11 days -- depending on the day of launch -- before its retro rocket will be fired again on Nov. 17 to place it in its ultimate photographic orbit. It is desired to adjust the lowest point of the final orbit (perilune) to 28 miles above the lunar surface. The highest point of the orbit (apolune) will remain at 1,150 miles.

Then, for a period of eight days, as the Moon revolves beneath it, the spacecraft's camera will record on film, views of the 13 primary and selected secondary target sites in far greater detail then they have been observed through Earth-based telescopes. Lunar Orbiter B is scheduled to begin photography Nov. 18 and to take its final picture Nov. 25.

As many as six exposures from a site will be transmitted to Earth by radio in a priority photographic readout sequence which is scheduled whenever photographic targets are spaced sufficiently apart to permit it.

All of Lunar Orbiter's photographs will be transmitted to NASA Deep Space Network stations after site photography is finished. They will be received in reverse order from which the pictures were taken. Lunar Orbiter B is scheduled to complete final picture transmission on Dec. 13.

NASA will disseminate lunar site photographs to members of the scientific community for interpretive studies. The U.S. Geological Survey will employ the Lunar Orbiter photographs as basic material in its efforts to derive a more detailed understanding of the physical processes which played a part in the formation of the lunar surface as it exists today.

The Lunar Orbiter program is directed by NASA's Office of Space Science and Applications. The project is managed by the agency's Langley Research Center, Hampton, Va. The spacecraft are built and operated by The Boeing Co., Seattle, Wash., as prime contractor. Eastman Kodak Co., Rochester, N.Y., (camera system) and Radio Corporation of America, Camden, N.J., (power and communication systems) are the principal subcontractors to Boeing. NASA's Lewis Research Center, Cleveland, is responsible for the launch vehicle and the Kennedy Space Center will supervise the launch operation. Prime vehicle contractors are General Dynamics/Convair, San Diego, Cal., for the Atlas and Lockheed Missiles and Space Co., Sunnyvale, Cal., for the Agena.

Tracking and communications for the Lunar Orbiter program are the responsibility of the NASA Deep Space Network (DSN), operated by the Jet Propulsion Laboratory, Pasadena, Cal. DSN stations at Goldstone, Cal.; Madrid, Spain; and Woomera, Australia, will participate in the mission. Photographic data gathered by Lunar Orbiter will flow from each DSN station to the Eastman Kodak Co., for reassembly processing, thence to the Langley Research Center, for preliminary evaluation.

END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS

LUNAR ORBITER SPACECRAFT

The Lunar Orbiter program was announced by NASA in August, 1963, as one of three major projects for unmanned exploration of the Moon in advance of Project Apollo.

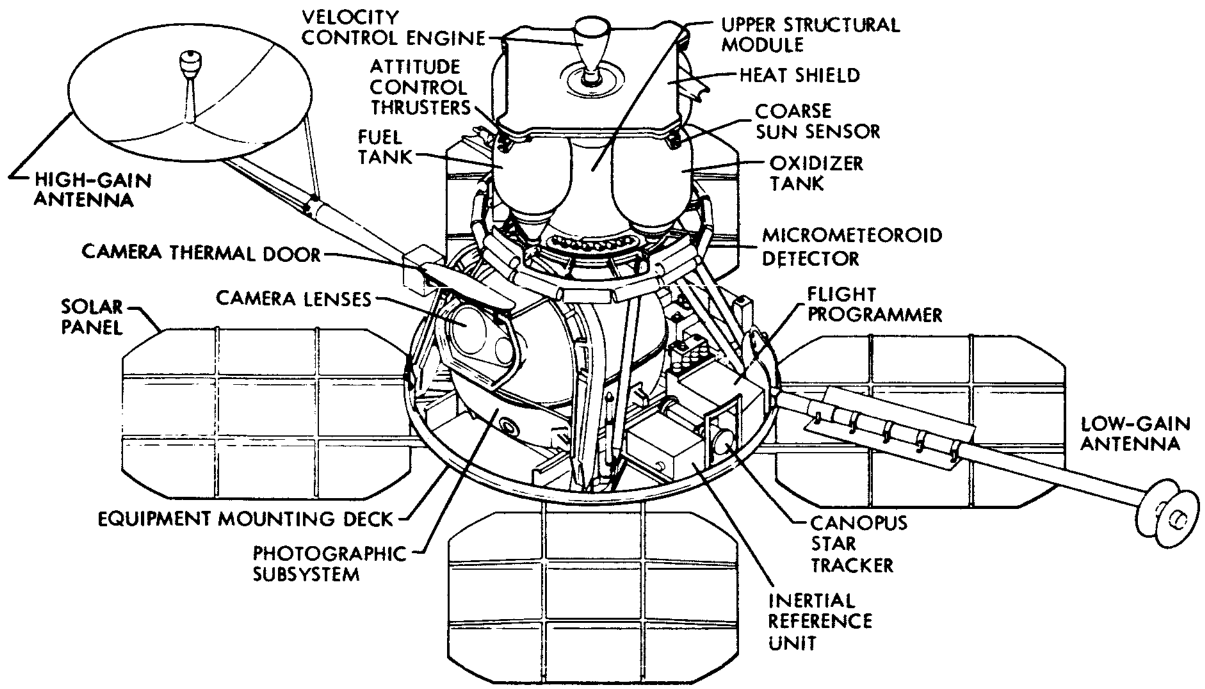
In the following two years, three Ranger spacecraft, carrying television cameras, returned a total of 17,259 close-up photographs of the lunar surface en route to crash landing and destruction on the Moon.

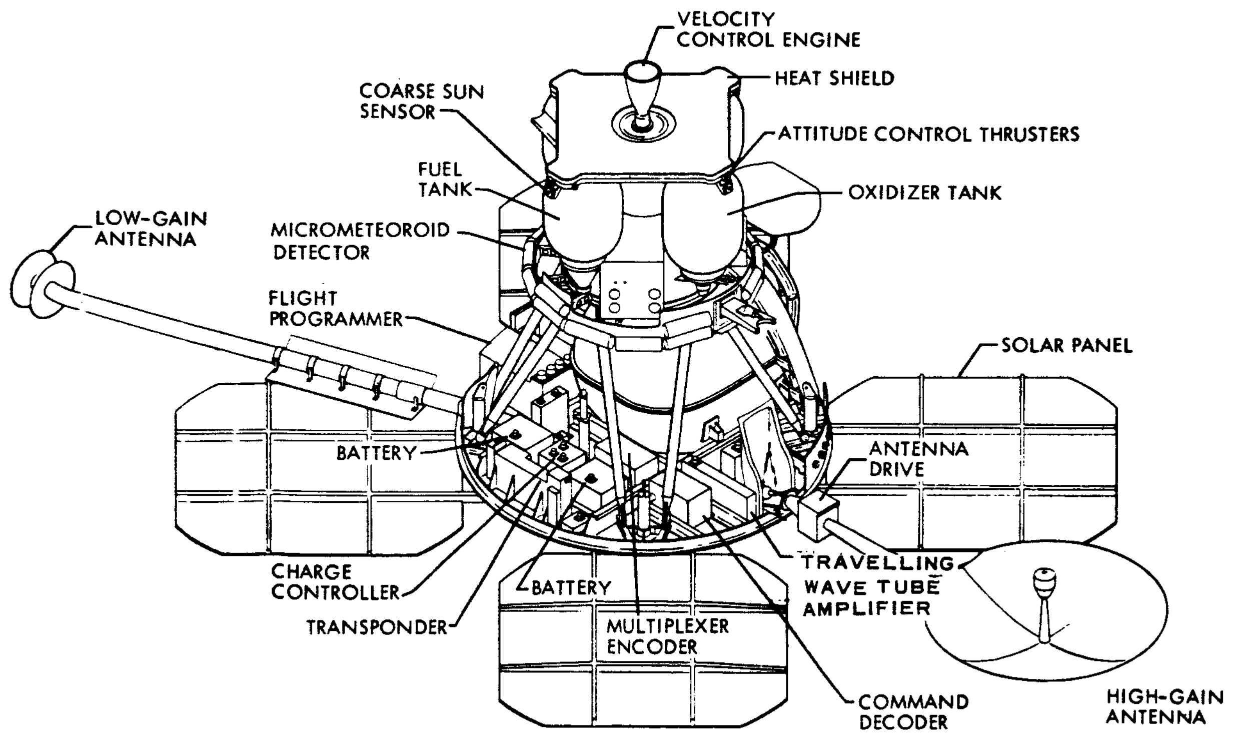
Surveyor I, launched last May 30, went on to achieve successful soft-landing on the Moon's surface. It has since measured important surface properties -- for example, how much weight the lunar crust will support -- and transmitted 11,150 close-ups of the Moon's surface from its position in the Sea of Storms.

On August 10, Lunar Orbiter I was launched on its maiden voyage to the Moon, and during the succeeding days, demonstrated its remarkable versatility as a flying photographic laboratory. Final tallies show that it photographed about two million square miles of lunar surface, including 16,000 square miles over prime target sites in the Apollo zone of interest on the front face of the Moon. It provided the first detailed scientific knowledge of the lunar gravitational field and topographic and geoligical information of direct benefit to the Apollo program and to scientific knowledge of the Moon.

On Oct. 29, after making 527 revolutions in 77 days of orbiting the Moon, Lunar Orbiter I was ordered to fire its velocity control engine for 97 seconds. At 9:30 a.m., EDT, it impacted the hidden side of the Moon. This was done to eliminate any possibility that Orbiter I could interfere with the Orbiter B mission by inadvertantly turning on its radio transmitter.

Lunar Orbiter and Surveyor spacecraft are being used as a team to obtain specific kinds of information about selected areas of the lunar surface in order to make a safe manned landing possible.





LUNAR ORBITER SPACECRAFT

Lunar Orbiter will examine such areas so that Surveyor's findings can be applied over a full-sized landing site with all topographic features of significant size located and measured. Since Lunar Orbiter can obtain more than 3,000 square miles of high resolution (three feet) photographs on each mission, formidable demands are placed on the spacecraft's capability to gather information.

In December 1963 NASA selected The Boeing Co., Seattle, to be prime contractor for the program, and a contract was negotiated in May 1964.

SPACECRAFT CONFIGURATION

The Lunar Orbiter spacecraft is a flying photographic laboratory, equipped with the necessary controls to position the camera correctly over the site to be viewed, and the means to extract the information contained in each photograph and send it back to Earth.

In flight configuration, Lunar Orbiter is a truncated cone from whose base project four solar cell panels. It carries two antennas on rods extended from opposite sides of the spacecraft, and is covered with an aluminized mylar reflective thermal blanket.

Lunar Orbiter weighs 850 pounds, and when folded for launch measures five feet in diameter by five and one-half feet tall. During launch the solar panels are folded against the base of the spacecraft and the antennas are held against the sides of the structure. A nose shroud only five feet, five inches in diameter encloses the entire spacecraft.

When the solar panels and antennas are deployed in space, the maximum span becomes 18½ feet across the antenna booms and 12 feet, 2 inches across the solar panels.

The primary structure consists of the main equipment mounting deck and an upper section supported by trusses and an arch.

In the upper section are located the velocity control engine with its tankage for oxidizer, fuel and pressurization, and the attitude control thrusters. The nozzle of the engine extends through an upper heat shield.

The lower section houses the camera, communications and electrical system equipment, the inertial reference unit, the Sun sensor, and the Canopus star tracker.

Camera System

The technological ability to compress a complete photographic laboratory within an egg-shaped pressure shell with all parts weighing no more than 150 pounds makes the Lunar Orbiter mission possible. The package itself includes two cameras--one for medium and the other for high resolution photography. The cameras will view the Moon through a protective window of quartz, which in turn is protected by a mechanical flap in the thermal blanket which covers most of the spacecraft. The flap, or camera thermal door, is opened and closed by command at the beginning and end of every photographic pass over a section of lunar surface.

The medium resolution lens is an 80-mm Xenotar, manufactured by the West German firm of Schneider-Kreuznach. It is fitted with a fixed aperture stop of f/5.6 and a between-lens shutter to provide exposure speed selections of 1/25, 1/50 and 1/100 second.

The high resolution lens is a 24-inch f/5.6 Paxoramic, specially designed and built by Pacific Optical Company. The lens weighs less than 16 pounds and operates through a focal plane shutter adjustable on ground command to the same speed selections as the 80-mm lens.

Relatively low shutter speeds are required by the exposure index of the film, which is Kodak Special High Definition Aerial Film, Type SO-243. Although its aerial exposure index of 1.6 is slow in comparison with other films, it has extremely fine grain and exceptionally high resolving power. It is relatively immune to fogging at the levels of radiation normally measured in space.

Lunar Orbiter will carry a 200 foot roll of 70-mm SO-243 unperforated film, sufficient for at least 194 dual exposure frames. The supply spool is shielded against ionizing radiation from solar flares.

Along one edge of the film is a band of pre-exposed data, primarily resolving power charts and densitometric gray scales, which will be read out along with the lunar images captured by the spacecraft.

The gray scales are very important because they contain the key to correct interpretation of the Lunar Orbiter's photographs. Specifically, they provide the photometric calibration which will make it possible to estimate slopes on the Moon's surface by measuring film densities.

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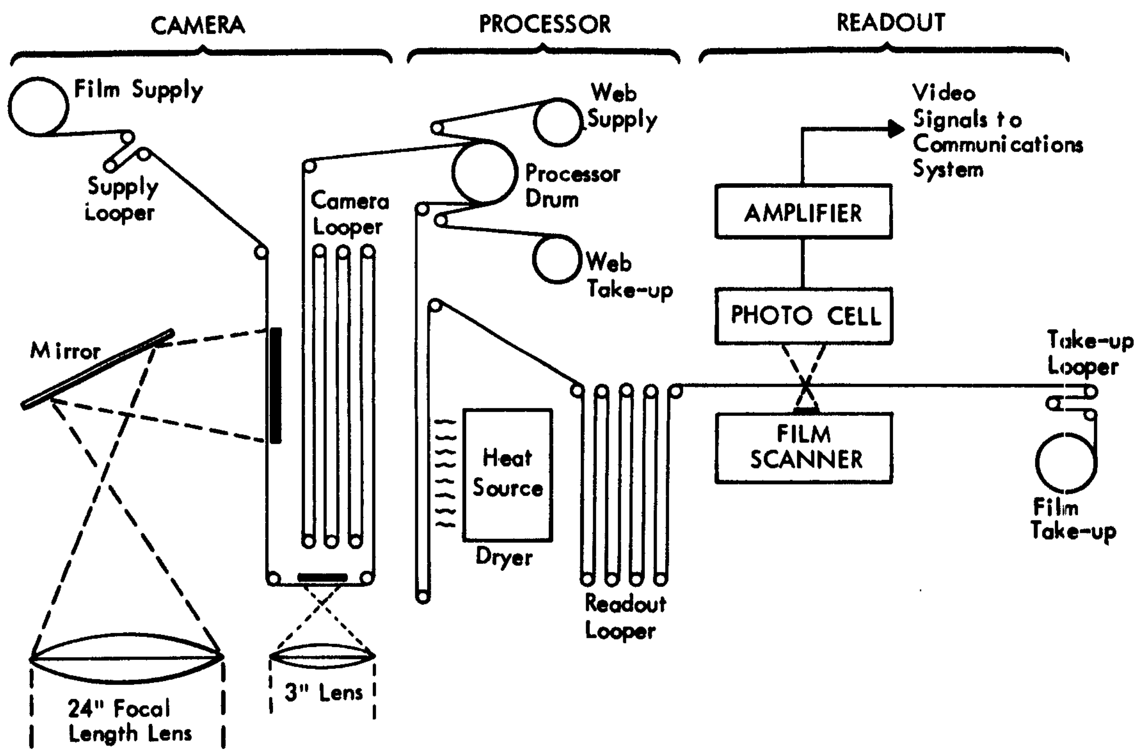


PHOTOGRAPHIC SUBSYSTEM

Photo Taking Process

Light gathered by the 24-inch lens is turned through a right angle by a mirror before it reaches the film, while the medium resolution lens passes light directly to the film. Because of the camera's mechanical design, the two simultaneous images are not placed side by side on the film, but are interspersed with other exposures.

Because the spacecraft will be moving at 4,500 mph at perilune (or lowest point in orbit about the Moon) and in view of the relatively low film exposure speeds, the camera system has been provided with a device to eliminate blurring of the image. This image motion compensation is performed by a special sensor and a mechanical drive to move the film platen slightly while an exposure occurs.

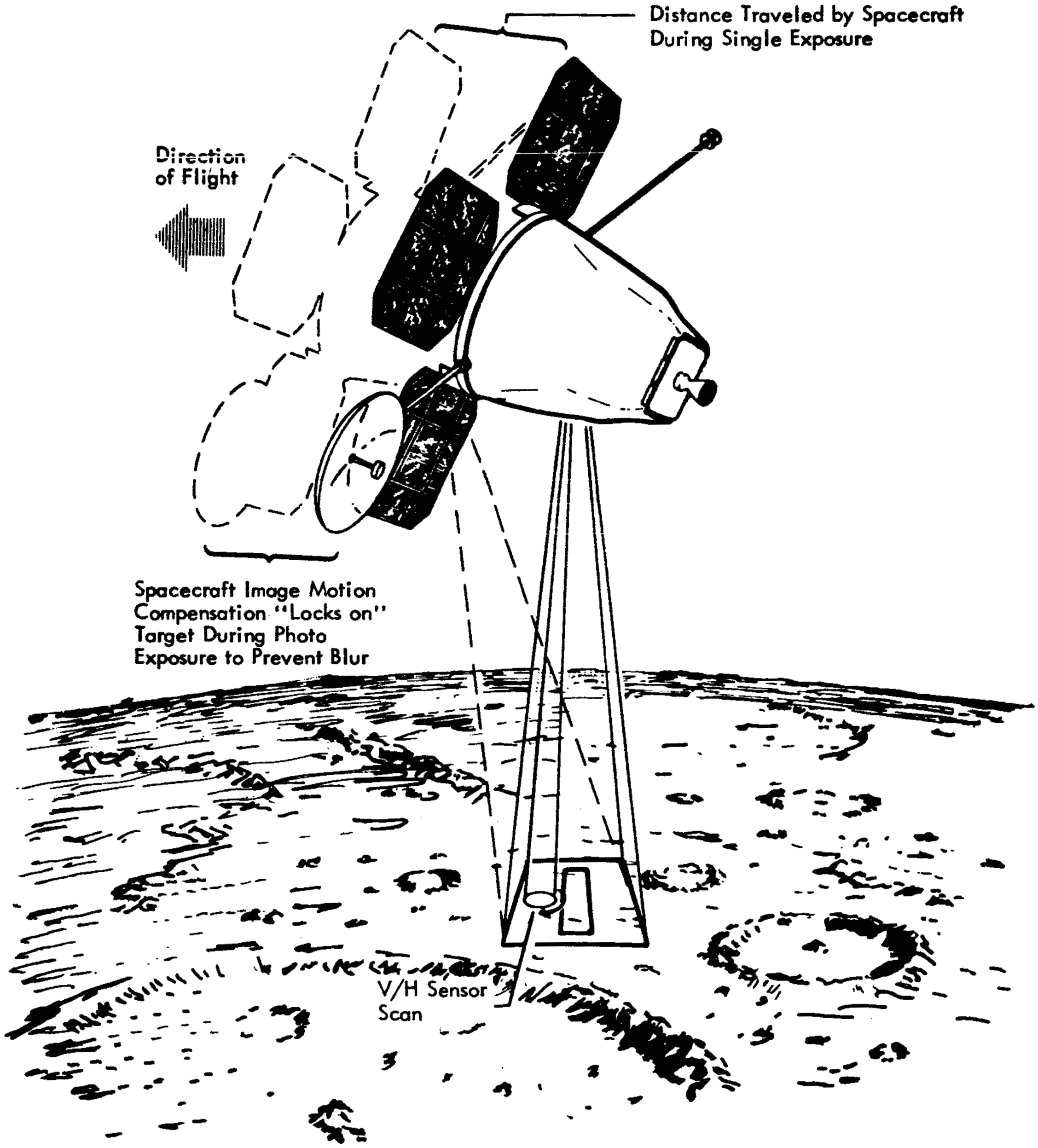
The special sensor is a vital component of the camera system. Called a V/H sensor (velocity divided by height), it electronically scans a portion of the image formed by the high resolution lens.

The tracker compares successive circular scans of a portion of the image and generates a signal proportional to the rate and direction of the motion it senses. The rate signal in turn governs the action of the image motion compensation servomechanism and the exposure interval controller, while the direction information is used to control spacecraft yaw attitude.

Special platens have been built into the camera to grip the film and hold it flat by means of vacuum while an exposure is made. The platens are mechanically driven as required by the signal sent from the V/H sensor, and their motion, although very slight, matches the speed of the spacecraft and minimizes any blur or smearing of the image.

After each exposure, the platens return to their original positions and are ready for the next picture.

During the flight of Lunar Orbiter I, difficulty was experienced with the high resolution portion of the camera system. Photographs made through the high resolution lens were blurred, indicating that the shutter had been opened at a time when the film was being advanced through the system or when the film platens were not properly compensating for motion of the spacecraft across the lunar surface.



The velocity/height (V/H) sensor provides the spacecraft with velocity and height information by sampling a ring of lunar surface through the high resolution lens and comparing successive scans. The angular position change of consecutive scans with respect to time gives the velocity/height change ratio. This ratio is used for image motion compensation to "lock on" a ground target during each exposure to reduce image smear or blur. The V/H data is also used to control time between exposures, to control spacecraft yaw angle during photography, and is telemetered to aid in photograph analysis.

VELOCITY HEIGHT SENSOR

High resolution photographs made when the V/H sensor was turned off were of excellent quality, and the source of the problem was traced to the electronic circuits controlling shutter timing and operation.

Because it was believed that the system was over-sensitive to stray electronic signals, the shutter triggering circuits in the camera system aboard Lunar Orbiter B have been changed to make them less sensitive.

After exposure, the film moves forward to a storage or buffer area between the camera and processor. The buffer region or looper is provided to take up the slack between the camera -- which can make up to 20 exposures on a single orbital pass -- and the processor. The looper is a system of pulley blocks which can be separated to store exposed film without slack. The looper can hold as many as 20 frames.

Photo Processing System

Next phase of the Lunar Orbiter's photographic system is a processor, in which the exposed film is chemically developed by the Eastman Kodak "Bimat" process.

The Bimat method uses a processing film or web whose gelatin layer has been soaked in a single developer-fixer solution of photographic chemicals. The film is slightly damp to the touch but little free liquid can be squeezed from it.

When the exposed film passes onto the processor drum and is mechanically pressed against the Bimat web, the chemical processes of negative development begin. Silver halide is reduced to silver in a few minutes, and undeveloped silver ions pass into the Bimat web material by a diffusion-transfer process. The Bimat web thereby acquires a positive image of the exposed view.

After processing is complete, the two films are separated and the used web material is reeled onto a take-up spool. No use is made of the positive images on the web.

The negative film, fully processed, passes between two chemically treated pads which remove much of its moisture, and is then fully dried by a small electric heater. When dry, the negative film is stored on a take-up reel until the electronic read-out process is to begin.

Photo Readout Process

Read-out is one of the most exacting tasks the Lunar Orbiter photographic system is required to perform.

There is no proved way of storing information which can compare in compactness with an image composed of silver grains in a gelatin emulsion on photographic film.

The read-out method used by Orbiter must capture as much as possible of the film's densely-packed information and change it into a stream of electronic signals which can be transmitted to Earth.

A film scanner, in which a flying spot of light and suitable optical elements are linked with a photomultiplier, is the heart of the read-out equipment.

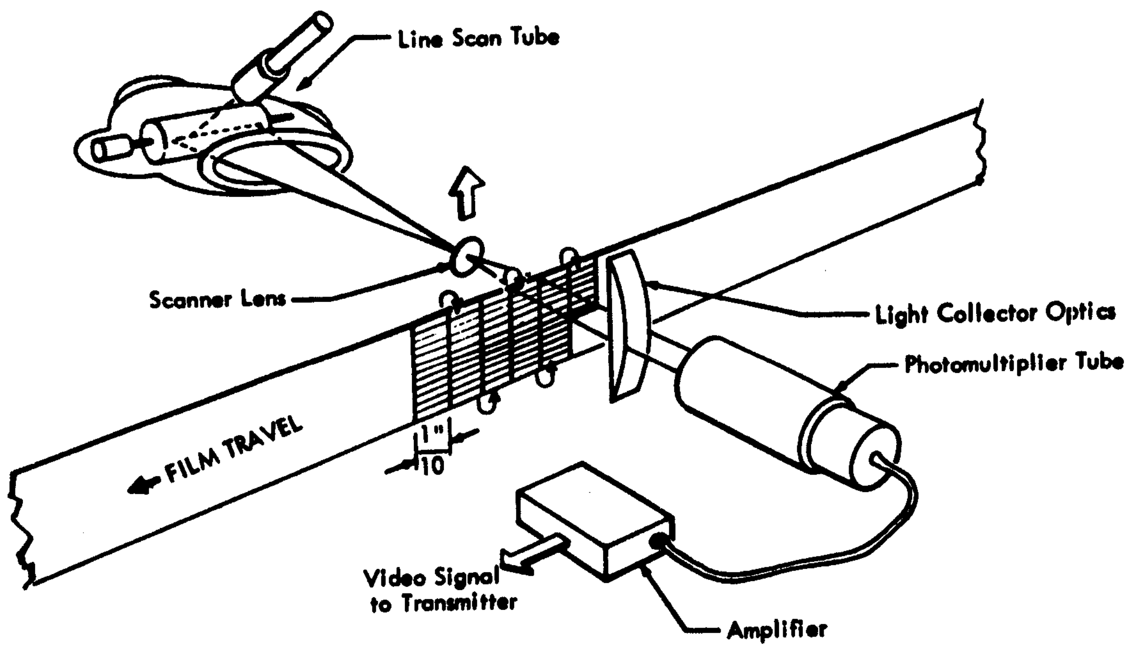
Light source for the flying spot is a Line Scan Tube developed by CBS Laboratories for film scanning applications. The tube contains an electron beam generator and a revolving drum whose surface is coated with a phosphorescent chemical.

As the electron beam moves across the surface of the phosphor, a thin spot of light is produced. The drum must be rotated to avoid burning at the electron intensities used.

The light generated by the tube is focused on the film through a scanning lens to a spot diameter of only five microns (a micron is one-thousandth of a millimeter or about 0.000039 of an inch).

The scanning lens moves the spot of light in a regular pattern across a small segment of the developed film, covering the 2.4-inch width of the image on the negative with 17,000 horizontal scans of the beam, each one-tenth of an inch long. A complete scan across the film takes 20 seconds, and when it is ended, the film advances one-tenth of an inch and the scanning lens travels over the next segment in the opposite direction.

By the process used, the Lunar Orbiter will require 40 minutes to scan the 11.6 inches of film which correspond to a single exposure by the two lenses.



FILM SCANNER

As the spot of light passes through the image on the negative, it is modulated by the density of the image, that is, the denser portions transmit less light than sections of lower density.

After passing through the film, the light is sensed by a photomultiplier tube which generates an electronic signal proportional to the intensity of the transmitted light. The signal is amplified, timing and synchronization pulses are added, and the result is fed into the communications link as the Lunar Orbiter's composite video signal for transmission to Earth.

The flow of film through the Bimat processor cannot be reversed once started because the dry film would stick to the Bimat, so a complete readout of Lunar Orbiter photographs will not begin until the final picture is taken.

Capability for earlier partial readout is provided by the looper built into the photographic system between the processor and film scanner. The priority readout looper holds four frames, which can be sent through the scanner upon ground command. Current plans call for some partial readouts during the course of the mission, when there is sufficient time between orbits on which photography is scheduled.

Before the final film readout is begun, the Bimat web film used in processing is cut so that the finished negative can be pulled backward through the processor and gradually returned to the original film supply reel. After the Bimat web is cut, the Lunar Orbiter is no longer able to obtain photographs, and the remaining portion of its photographic mission will be occupied with readout.

Readout will occur in reverse order from that in which the pictures were taken because of the inherent design of the photographic system. There is provision for repeated readout if required.

Electrical Power System

Lunar Orbiter carries a conventional solar panel-storage battery type of power system, with provisions for voltage regulation and charge control.

Primary source of power is an array of four solar panels, each slightly more than 13 square feet in area. There are 10,856 solar cells on the spacecraft panels--2,714 per panel. Each is an N-on-P silicon solar cell, 0.8-in. square, protected by a blue reflecting filter.

In full sunlight, the Lunar Orbiter solar panels will produce about 375 watts of power. Total weight of the array, including the stowage and deployment mechanisms, is 70 pounds.

Energy produced by the solar panels is stored for use while the Lunar Orbiter is in shadow in a 20-cell nickel-cadmium battery rated at 12 ampere hours. The battery consists of two identical 10-cell modules; overall weight is 30 pounds.

Orbiter's electrical system voltage can vary from 22 volts when the batteries are supplying the load to a peak of 31 volts when the solar panels are operating.

The spacecraft power system includes a charge controller to prevent overloading the batteries while they are being recharged, and a shunt regulator to keep the solar array output from exceeding a safe maximum voltage.

Critical power system quantities are measured by sensors at various points, and the instrument readings will be included in the engineering and performance items telemetered to Earth.

Attitude Control System

During the course of its mission, Lunar Oribter will be called on to perform accurately a larger number of attitude changes than previous lunar spacecraft missions have required.

From launch through final photographic readout, Lunar Orbiter I acted correctly upon 4,446 commands and performed 347 separate attitude maneuvers, a technological achievement without precedent for an unmanned spacecraft.

Its attitude control subsystem has been designed to accomplish these spacecraft events precisely and repeatedly, while retaining enough flexibility to respond to changes ordered by ground command.

Principal elements of the attitude system are the programmer, inertial reference unit, Sun sensors, Canopus (star) tracker, an electronic control and switching assembly, and a set of reaction control thrusters.

The programmer is a low-speed digital data processing machine with a memory capacity large enough to provide 16 hours of control over a photographic mission from stored commands. It contains redundant clocks for timing mission events, and is designed to operate primarily in the stored program mode to accomplish the major mission objectives.

The programmer executes a stored program by bringing commands sequentially from its memory, completing them, and continuing to measure time until the next scheduled event. It is intended that the programmer memory will be periodically brought up to date by ground control, but the device can be operated in a real-time command mode if required.

In view of the many precise maneuvers which Lunar Orbiter must perform, the inertial reference unit is a particularly important element in the attitude control system. It has five main functions:

During an attitude maneuver, it reports the rate at which the spacecraft's attitude is changing, so that the flight programmer can send correct instructions to the reaction control jets which position the vehicle.

When photographs are being made or when the velocity control engine is in use, the inertial reference unit measures attitude errors so that the attitude control system can be directed to maintain the attitude required.

At times when the velocity control engine is firing, an accelerometer in the inertial reference unit furnishes a measurement which permits the programmer to cut off the engine at the proper instant.

While Lunar Orbiter is in cruise or coasting flight, the inertial reference unit keeps track of small oscillations which can be expected to occur and provides signals to the attitude control jets for corrective action when needed

In lunar orbit, the inertial reference unit furnishes a memory of the positions of the Sun or Canopus whenever the spacecraft is in a position from which its sensors cannot see either one or both of the basic celestial reference bodies. Occultation is the technical term describing that condition, and it will occur during a portion of every lunar orbit. The Sun, for example, is expected to be occulted about one-fourth of the time. Inertial reference unit accuracy is important to permit rapid re-acquisition of the Sun or Canopus when the spacecraft emerges from the shadow region.

The inertial reference unit is contained in a package 7 by 10 by 7 inches, and weighs about 13 pounds. In its beryllium main frame are mounted three single-degree-of-freedom, floated, rate-integrating gyroscopes and one pulsed integrating pendulum-type accelerometer. The remaining space in the container is filled with the six electronic modules required to operate the unit and relay its measurements to the Lunar Orbiter programmer. Its power requirements are low, never exceeding 30 watts at any point in the mission.

Five Sun sensors are carried on Lunar Orbiter to provide the celestial references needed for attitude control in pitch and yaw. Four are coarse sensors, mounted under the corners of the heat shield between the propellant tanks and the velocity control engine. The fifth, a combination coarse and fine Sun sensor, views through the equipment mounting deck which forms the bottom surface of the spacecraft.

All solar sensors measure the angle of spacecraft deviation from a direct line to the Sun and generate an electronic signal in proportion to the deviation. The signal can then be used by the attitude control system to adjust the attitude of the spacecraft.

The star tracker or Canopus sensor furnishes the celestial reference for the spacecraft's roll axis. Like the Sun sensors, it measures any angle of deviation of the Lunar Orbiter from a direct line to Canopus, and provides the necessary signal to begin a corrective maneuver when needed.

The star tracker is designed to produce a series of recognition signals from which a star map can be constructed by ground controllers. The map permits a positive determination that the tracker has locked onto Canopus rather than some other star within its field of view.

In flight, the Canopus tracker is used for the first time after the Lunar Orbiter has passed through the Van Allen radiation belts -- some six hours after launch. It is located on the Lunar Orbiter's main equipment mounting deck, and looks outward through an opening in the thermal blanket.

During the flight of Lunar Oribter I, signals from the Canopus tracker were intermittently masked by interference, particularly when the spacecraft was in full sunlight. When it passed into the shadow of the Moon, the interference disappeared and the tracker furnished a direct and positive lock on Canopus.

Subsequent ground experiments have identified the interference as light reflected from the low gain antenna and solar panel edges.

To prevent such undesirable reflections, Lunar Orbiter B and all subsequent spacecraft in the series will have the outer end of the low gain antenna and the edges and backs of the four solar panels coated with black anti-reflective paint.

All parts of the attitude control system are interlinked by a flight electronics control assembly. It contains the reaction jet valve drivers, signal summing amplifiers and limiters, Sun sensor amplifiers and limiters, signal generators, switching arrangements and other electronic circuitry required by the system.

Eight reaction control thrusters use nitrogen gas in a titanium sphere directly beneath the velocity control engine to generate the torques needed to move Lunar Orbiter in roll, pitch or yaw. Gas expelled through the thrusters is distributed through a pressure reducing valve and plumbing system according to commands issued by the programmer.

The nitrogen storage bottle, pressurized to 3500 psi, will contain just over 14½ pounds of gas at the beginning of the mission. Ten pounds of the total are budgeted for use in attitude control changes regulated at 19 psi; four remaining pounds are assigned to the velocity control system to be used in pushing fuel and oxidizer from storage tanks into the velocity control engine. The remainder takes care of leakage and a small residue.

Velocity Control System

In a typical Lunar Orbiter mission, at least three and perhaps four changes in spacecraft velocity will be required after the launch vehicle has completed its work.

Plans call for one and possibly two mid-course corrections, if necessary, but the most critical velocity changes will have to be made in the vicinity of the Moon.

There the spacecraft's velocity control engine must execute a precision firing maneuver to slow Orbiter just enough to allow it to enter an orbit around the Moon.

After several days of careful orbit tracking and computation, another firing will reduce the perilune (lowest point of orbit) to the final height from which lunar surface photographs will be taken.

To make the necessary changes and to provide a small margin of extra capability, the Lunar Orbiter carries a 100-pound thrust engine and sufficient fuel and oxidizer to make velocity adjustments totaling about 3,280 feet per second.

Lunar Orbiter's velocity control engine was developed for Project Apollo, where it will be used in the Service Module and Lunar Module for attitude control.

Nitrogen tetroxide is the oxidizer and Aerozine 50 the fuel. Aerozine 50 is a 50-50 blend of hydrazine and un-unsymmetrical dimethyl-hydrazine (UDMH).

Both fuel and oxidizer are storable and hypergolic; that is, when mixed together the two liquids burn without the need for auxiliary ignition. Lunar Orbiter's four tanks divide the fuel and oxidizer to minimize changes in the spacecraft's center of gravity as propellants are consumed. About 265 pounds of usable propellants will be carried in the spacecraft tanks.

The same source of gaseous nitrogen used for the attitude control thrusters provides a positive method to push the propellants from their tanks into the velocity control engine when required. Each tank has within it a teflon bladder which exerts a positive pressure against the liquid when nitrogen is admitted to the opposite face. The tanks are pressurized to about 200 pounds per square inch.

Tank pressurization will be commanded a short time before the first midcourse maneuver. When the maneuver is to begin, the attitude control system places the spacecraft in an attitude based on ground computations and the programmer transmits an opening signal to solenoid valves on the fuel and oxidizer lines. Thrusting begins when the fuel and oxidizer mix and burn in the engine's combustion chamber.

While thrusting, the accelerometer in the inertial reference unit constantly measures the change in velocity as it occurs, and when the desired increment is achieved, the solenoid valves are commanded to close and the engine stops firing.

The velocity control system is capable of as much as 710 seconds of operation and at least four engine operating cycles.

Communications System

The Lunar Orbiter communication system is an S-band system compatible with the existing NASA Deep Space Network and capable of operating in a variety of modes.

It enables the spacecraft to:

Receive, decode and verify commands sent to the spacecraft from Earth;

Transmit photographic data, information on the lunar environment gathered by the radiation and micrometeoroid detectors, as well as information on the performance of the spacecraft;

Operate in a high power mode when photographic information is being transmitted,and a low power mode at other times;

Provide by ground command the ability to choose the transmitting power mode and to turn the transmitter off and on.

The heart of the Lunar Orbiter's communication system is a transponder basically similar to the type flown on Mariner IV.

The transponder receives a transmitted command from Earth and passes it to a decoder where it is stored temporarily. The command is then re-transmitted to Earth through the transponder to verify that it has been correctly received. When verification is confirmed, an execute signal is sent from Earth causing the decoder to pass the command along to the programmer for immediate or later use as required. The command transmission rate is 20 bits per second.

In the tracking and ranging mode, the transmitting frequency of the transponder is locked to the frequency of the signal being received from Earth in a precise ratio. The signals can then be used to determine the radial velocity of the spacecraft to an accuracy of about one foot per second. When interrogated by the Deep Space Network ranging system, the transponder signal will measure the distance between the Earth and the spacecraft with an accuracy of about 100 feet.

A low power operating mode delivers spacecraft performance telemetry and data from the lunar environment experiments (radiation and meteoroids) to Earth at 50 bits per second. Telemetry is in digital form, and has been passed through a signal conditioner, a multiplexer encoder and a modulation selector before transmission.

A high power communication mode is used to transmit photographic data in analog form and brings into use the spacecraft's high gain antenna and a traveling wave tube amplifier. Performance and environmental telemetry will be mixed with the photographic information in the transmission.

During photographic or video data transmission, the spacecraft uses a 10-watt transmitter and a high gain antenna. At other times, a one-half watt transmitter and a low gain antenna are used to conserve battery power.

A low gain antenna is hinge-mounted at the end of an 82-inch boom. It is deployed in space after the heat shield is jettisoned. The hinge is spring loaded and fitted with a positive locking latch to keep the boom in deployed position. The radiation pattern of the low gain antenna is virtually omnidirectional.

By contrast, the high gain antenna which will come into use when pictures are transmitted is quite directional, having a 10-degree beam width. It is therefore equipped with a rotational mechanism so that it can be correctly pointed toward the Earth station receiving its transmissions.

The high gain antenna is a 36-inch parabolic dish of lightweight honeycomb construction. It is mounted on the end of a 52-inch boom and is deployed after heat shield jettison in the same way as the low gain antenna. The antenna dish and feed weigh only two and one-third pounds.

A motor driven gear box at the base of the high gain antenna boom allows the boom to be rotated in one degree steps to point the antenna accurately toward the Earth receiver.

Temperature Control System

Lunar Orbiter is equipped with a passive temperature control system to carry away heat generated by the energy used in its operation and to limit the amount of heat absorbed when the spacecraft is in direct sunlight.

All sides of the spacecraft are insulated except the equipment mounting deck which forms the bottom of Lunar Orbiter. The mounting deck is coated with a special paint similar to that used on Mariner IV. The paint permits the deck surface to radiate heat much more readily than it can absorb heat from the Sun, and it thus forms a heat sink to dissipate heat generated inside the spacecraft.

Some degradation of the special paint covering the equipment mounting deck was noted during the flight of Lunar Orbiter I. Ultraviolet radiation is the suspected cause. As a result, temperatures inside the spacecraft were somewhat higher than predicted, and it became necessary at times to tilt Lunar Orbiter I away from direct sunlight to maintain normal temperature control.

To overcome the problem, a different type of paint, identified as S13G, has been applied to Orbiter B's deck. Laboratory tests simulating solar ultraviolet radiation and space vacuum indicate the additional paint will not degrade as rapidly in space and should provide better temperature control.

In addition, three small metal coupons have been attached to Lunar Orbiter B, each coated with a different type of paint and each instrumented with a thermocouple to measure its temperature changes. In addition, a small mirror also instrumented with a thermocouple is mounted on Orbiter. These samples should provide direct information on the relative efficiency of various paints in the space environment.

On Orbiter's upper surface, the heat shield on which the velocity control engine is mounted is insulated, and the entire surface of the spacecraft within those boundaries is covered with a multilayer thermal blanket composed of alternating layers of aluminized mylar and dacron cloth. The high reflective aluminized mylar will effectively prevent solar heat from reaching the interior of the spacecraft.

During flight from the Earth to the Moon, Lunar Orbiter's temperature inside the thermal blanket will vary between 40 and 100 degrees F. In lunar orbit, the spacecraft internal temperatures will range between 35 and 85 degrees F.

All external parts of the spacecraft are capable of withstanding full sunlight for an indefinite period.

LUNAR ORBITER TASKS

Lunar Orbiter B's primary assignment is to obtain detailed photographs of specified areas of the Moon's surface to assist in the selection of proposed landing sites for Project Apollo and to enlarge the current scientific understanding of Earth's nearest neighbor.

It will contribute to three additional areas of scientific inquiry through the following experiments:

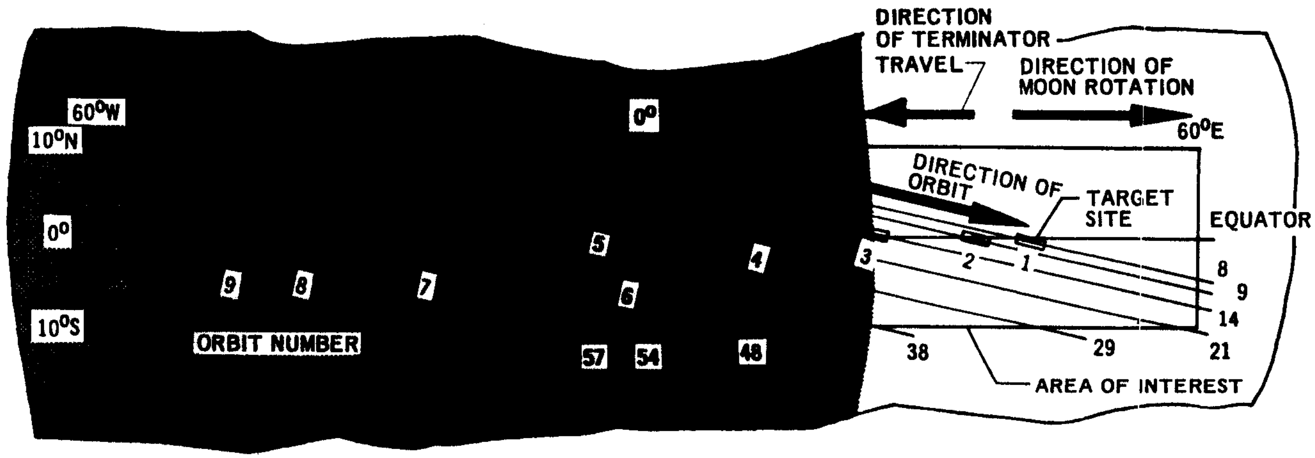
-- Selenodesy, the study of the gravitational field and shape of the Moon;

-- Meteoroid measurements along the translunar trajectory and in orbit near the Moon;

-- Radiation measurements in cislunar and near-lunar space.

Information obtained from the selenodesy experiments will increase knowledge of the Moon's gravitational field obtained through detailed tracking of Lunar Orbiter I. It is now believed, on the basis of the first direct measurement by Lunar Orbiter I, that the Moon is nearly spherical, although it does have irregularities which affect spacecraft orbits about it. To assist Project Apollo mission planners and to expand available scientific knowledge, Lunar Orbiter B will be carefully tracked to refine the existing knowledge of the lunar gravity field.

Results of the Lunar Orbiter I flight have erased a serious unknown which faced NASA scientists and engineers before the first Orbiter mission, and it is now possible to operate spacecraft with confidence in low inclination orbits as close as 20 miles to the lunar surface.



PHOTOGRAPHY OF TARGET SITES

Meteoroid and radiation data are primarily gathered for spacecraft performance analysis but also are of considerable scientific interest.

Lunar Photography

Lunar photography is Orbiter's principal assignment, and the entire project has been built around the requirement to obtain high quality photographs of large areas of the Moon's surface in such fine detail that objects as small as a card table can be distinguished.

From such photographs, in combination with Surveyor data, Project Apollo mission planners can work with confidence toward the selection and certification of suitable landing sites for Apollo's Lunar Module.

Both the spacecraft and Mission B have been designed to yield a maximum of scientific information about the lunar areas to be photographed. The camera system will be employed in several different modes, and the second mission has been carefully calculated to gather the maximum of topographic information from 13 selected primary sites grouped along and slightly north of the lunar equator.

Photography over each of the 13 selected sites has been programmed to produce overlapping pictures of most of the areas photographed by the medium resolution lens. The pictures will form stereo pairs, and well-developed techniques of photographic interpretation will be used to extract the topographic information they will contain.

The high resolution coverage, while not stereoscopic, can be analyzed by photometric methods to yield information on smaller slopes, craters and other small-scale surface features.

To cover the primary mission B sites, 184 frames of the Orbiter's capacity of 211 frames have been bugeted.

The remaining 27 frames represent film that must be moved through the camera system at four to eight hour intervals to prevent the film from developing a permanent set by remaining over the rollers for too long a time or sticking to the bimat developer.

Thus, the position and number of the secondary sites utilizing these remaining 27 frames are subject to the exact conditions of the operational situation that may exist during the photographic phase of the mission. In general, the attempt will be to use these to fill in areas of the hidden side not photographed by Lunar Orbiter I, and to obtain additional coverage of areas on the front side. Some of this additional coverage may include oblique photography similar to that obtained on Lunar Orbiter I.

To make Orbiter's photography as useful as possible, pictures will be taken shortly after local sunrise on the Moon, so that sunlight falls on the lunar surface at a shallow angle. That lighting situation will permit the best use of photometric techniques to obtain the maximum amount of topographic and geological information from the photographs. As the spacecraft continues orbiting, the Moon turns on its axis beneath it, bringing the 13 primary target sites successively into camera view.

At each primary target site, the camera will make at least eight exposures at intervals of about two and one half seconds. Some sites will receive a total of 16 frames of coverage by taking eight frames on each of two successive orbits. One will receive 24 frames of coverage, using eight frame sequences on each of three successive orbits. The first primary site, over which the camera will be operated for the first time, will be photographed with 16 frames on one orbit followed by four additional frames as close to the site as possible. That sequence will fill the camera loopers so that priority readout of frames can begin.

In cases where there is sufficient separation between photographic orbits, Lunar Orbiter will process and transmit to Earth one or more frames of photographic coverage.

After completing photography, which on this mission will consist of 211 frames, a complete readout will begin. Present schedules call for taking the final frame of photography on November 25 with full readout completed by December 13.

Readout of a complete frame -- one medium resolution picture with a high resolution picture centered within it -- takes about 43 minutes. Under the best conditions, Lunar Orbiter I was able to read and transmit up to two frames per orbit. For readout it is necessary to have the spacecraft in sunlight with its high gain antenna pointed at one of the Deep Space Net receiving stations.

Selection of the 13 primary target sites to be photographed by the second Lunar Orbiter was made by a special NASA Surveyor/Orbiter Utilization Committee. The selection was based on a consideration of the Apollo and Surveyor project requirements. The committee worked from recommendations drawn up after extensive consultation among experts from the Lunar Orbiter, Surveyor and Apollo programs, Bellcomm, the U.S. Geological Survey, and NASA Headquarters.

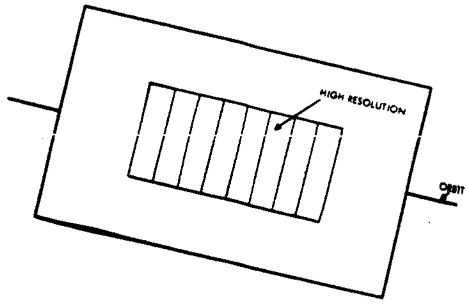
With a single exception, the 13 primary sites are within the northern half of the Apollo zone of interest which is defined as plus or minus five degrees of latitude and plus or minus 45 degrees of longitude. The exception is site IIP-11, whose center is 0° 05 South of the Moon's equator at 19°55' West.

The following table lists the primary target sites scheduled to be photographed by Lunar Orbiter B. Each site is designated by Roman numeral II followed by the letter P (standing for primary) plus the site number from one to 13.

Lunar Orbiter Mission B Primary Site Locations

Orbit No.	Site	Coverage Frames	Mode	Site Center Latitude	Site Center Longitude	General Description
6	IIP-1	16	Fast	$40^{\circ}10'N$	$36^{\circ}55'E$	An average regional mare area in the eastern part of Mare Tranquillitatis with superimposed intersecting rays. These rays are moderately diffuse, with darker inter-ray areas near the deformed crater Maskelyne F.
11	IIP-2	8	Fast	$2^{\circ}45'N$	$34^{\circ}00'E$	This area appears to be a volcanic complex in southeastern Mare Tranquillitatis where craters have been subdued by volcanic material or where craters are generally absent. The general area was photographed in medium resolution by Lunar Orbiter I.
13 14	IIP-3	8 8	Fast	$4^{\circ}20'N$	$21^{\circ}20'E$	An average regional mare area in the western part of Mare Tranquillitatis. Diffuse rays from the crater Arago extend across most of the site, and a north-northeast trending ridge crosses the middle of the area.

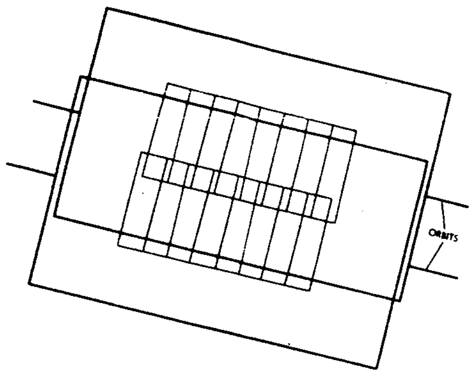
PHOTOGRAPHIC COVERAGE
MISSION B TARGET AREAS



PHOTOGRAPHIC COVERAGE - SEQUENCE OF 8 EXPOSURES ON 1 ORBIT PASS

AREAS 1, 2, 4, 5, 9

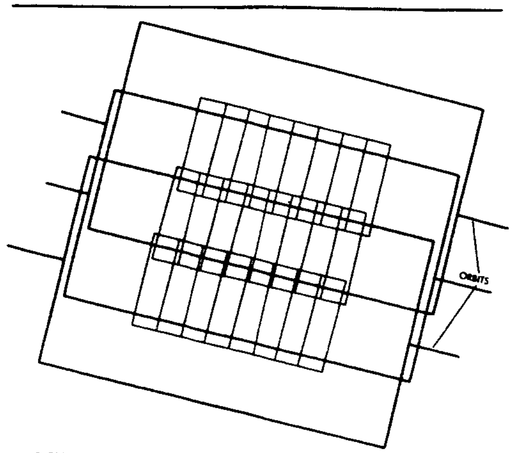
MEDIUM RESOLUTION: 60 km x 36 km
HIGH RESOLUTION: 32 km x 16 km



PHOTOGRAPHIC COVERAGE - SEQUENCE OF 8 EXPOSURES ON 2 CONSECUTIVE ORBIT PASSES.

AREAS 3, 6, 7, 10, 11, 12, 13

MEDIUM RESOLUTION: 60 km x 48 km
HIGH RESOLUTION: 32 km x 28 km

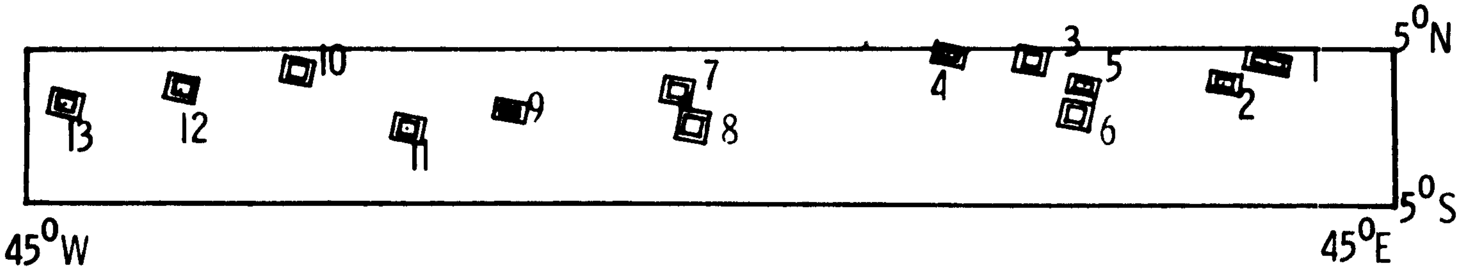


PHOTOGRAPHIC COVERAGE - SEQUENCE OF 8 EXPOSURES ON 3 CONSECUTIVE ORBIT PASSES

AREA 8

MEDIUM RESOLUTION: 60 km x 60 km
HIGH RESOLUTION: 32 km x 40 km

SITES SELECTED FOR LUNAR ORBITER MISSION II



Site No.	Latitude	Longitude	Coverage
1	4°10' N	36°55' E	1 X 16
2	2°45' N	34°00' E	1 X 8
3	4°20' N	21°20' E	2 X 8
4	4°45' N	15°45' E	1 X 8
5	2°36' N	24°48' E	1 X 8
6	0°45' N	24°10' E	2 X 8
7	2°10' N	2°00' W	2 X 8

Site No.	Latitude	Longitude	Coverage
8	0°05' N	1°00' W	3 X 8
9	1°00' N	13°00' W	1 X 8
10	3°28' N	27°10' W	2 X 8
11	0°05' S	19°55' W	2 X 8
12	2°25' N	34°40' W	2 X 8
13	1°30' N	42°20' W	2 X 8

15	IIP-4	8	Fast	4°45'N	15°45'E	Smooth upland plains area north of the crater Dionysius. The area is covered lightly by rays from Dionysius, but slopes and relief appear relatively low for uplands. Low escarpments occur in the eastern portion of the site.
16	IIP-5	8	Fast	2°36'N	24°48'E	Area in the Mare Tranquillitatis containing the impact point of Ranger VIII. If the Ranger impact crater can be located, it may yield useful information on soil mechanics in an average regional mare area.
20 21	IIP-6	8 8	Fast Fast	0°45'N	24°10'E	The western portion of Site A-3 photographed by Lunar Orbiter I. It lies in the southern part of Mare Tranquillitatis near the crater Moltke, and contains the smoothest area found furing preliminary evaluation of lunar Orbiter I photography.
30 31	IIP-7	8 8	Fast Fast	2°10'N	2°00'W	This site is located in the northwestern part of Sinus Medii at the mare-upland contact. A dark area at the contact is of special interest as a potential landing site.
34 35 36	IIP-8	8 8 8	Fast Fast Fast	0°05'N	1°00'W	This site lies in the central portion of Sinus Medii and includes some of Site A-5 photographed by Lunar Orbiter I. Diffuse rays and crater fields appear to cover the central area. Low ridge structures are also present. The darker areas are of particular interest.

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39	IIP-9	8	Fast	1°00'N	13°00'W	The site is centered on a moderately dark area between two large Copernican rays east of Sinus Medii. Positive relief features suggest possible volcanic origin for this dark area or, alternatively, simply the absence of rays.
40 41	IIP-10	8 8	Fast Fast	3°28'N	27°10'W	Diffuse rays extending southwest from the crater Copernicus cover the entire area. Small darker patches may be only moderately cratered or older terrain may be locally subdued by material thrown out of Copernicus
44 45	IIP-11	8 8	Fast Fast	0°05'S	19°55'W	A moderately dark inter-ray area bounded by uplands on both East and West. A small Copernican ray and domical structures are present. A portion of the area was photographed by Lunar Orbiter I.
46 47	IIP-12	8 8	Fast Fast	2°25'N	34°40'W	A ray-covered mare area southeast of the crater Kepler. A dark area at the upland-mare contact in the Western portion is the most interesting section.
52 53	IIP-13	8 8	Fast Fast	1°30'N	42°20'W	Two rays extending southwesterly from the crater Kepler transect the site, but dark mare covers most of the area. It is a northern extension of the Site 9.2 area photographed by Lunar Orbiter I and may have small portions similar to the area in which Surveyor I rests.

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Selenodesy

Major uncertainties about the detailed nature of the Moon's gravitational field were dispelled by the scientific contributions of Lunar Orbiter I, and as a result the flight of Lunar Orbiter B has been designed with considerably more confidence.

Although we now possess enough knowledge of the lunar gravitational field to operate spacecraft freely in lunar orbit, there is a requirement for much more detailed study and Lunar Orbiter B, like its predecessor, will be tracked with care to add to what has already been learned.

The Moon, according to the best existing analysis, is relatively "smooth," that is, its gravitational field does not appear to possess large or unusual variations. It is sufficiently non-uniform to produce small changes in the track of any satellite around it, and these small changes, suitably evaluated by complex computer programs, permit scientists to deduce from tracking data further information about lunar gravity.

Selenodic analysis of the tracking data of Lunar Orbiter I has yielded a description of the lunar gravity field which will be used in making operational lifetime predictions for managing the mission of Lunar Orbiter B. Post flight analysis of the tracking data of Lunar Orbiter B will, in a long range sense, contribute to future manned and unmanned missions near the Moon.

Principal investigator for the Lunar Orbiter selenodesy experiment is William H. Michael, Jr., Head of the Mission Analysis Section, NASA Langley Research Center. Co-investigators are Robert H. Tolson, Langley; and Jack Lorell and Warren Martin of NASA's Jet Propulsion Laboratory.

Meteoroid Measurements

Lunar Orbiter B will carry 20 pressurized-cell detectors to obtain more direct information on the presence of meteoroids in the near-lunar environment.

As the photographic system is enclosed in a thin-walled aluminum container which provides a controlled pressure and humidity environment for the operation of the camera system, a puncture of this container wall by meteoroids could result in performance degradation of this system. If such a degradation occurs, the meteoroid data could give clues to its cause.

Thus, the meteoroid information will guide designers of future spacecraft by determining what hazard, if any, should be expected from meteoroids -- small particles of solid matter which move at very high speeds in space.

Meteoroids are most evident when they penetrate the Earth's atmosphere and produce the streaks of light called meteors as they burn to destruction. NASA's Explorer satellites XIII, XVI and XXIII and the three large Pegasus satellites provided direct measurements of the meteoroid population in orbits near the Earth, but similar measurements near the Moon and in translunar space have been made only by Lunar Orbiter I.

The 20 pressurized cell detectors mounted on Lunar Orbiter were made in the instrument shops of the Langley Research Center. Each is shaped like a half cylinder seven and one-half inches long.

The puncture-sensitive skin of each half cylinder is beryllium copper 1/1,000-inch thick. The detectors are mounted girdle-wise outside the Lunar Orbiter's thermal blanket, on brackets attached to the fuel tank deck of the spacecraft.

A total surface area of three square feet is provided by the 20 cells.

At launch, each cell is pressurized with helium gas. If a meteoroid punctures the thin beryllium copper skin the helium leaks away, and a sensitive metal diaphragm inside the half cylinder detects the loss of pressure and closes a switch to indicate that a puncture has occurred. Periodic sampling of the pressure cell switches by telemetry indicates whether any have been punctured.

Experimenter for the meteoroid measurements is Charles A. Gurtler, Head of the Sensor Development Section of the Langley Research Center's Flight Instrumentation Division. Project Engineer is Gary W. Grew of Langley.

Radiation Measurements

The photographic film aboard Lunar Orbiter is sensitive to radiation exposure and several parts of the photographic system are shielded to reduced the possibility of damage.

To report the actual amounts of radiation to which the spacecraft may be subjected on its way to the Moon and during lunar orbits, two scintillation counters are included among its instruments. One is close to the film supply reel and the other adjacent to the camera shell.

Although their primary job is to report radiation intensities which might be hazardous to the film, they will supply additional information about the radiation found by Lunar Orbiter along its flight path.

Experimenter for the Radiation Measurements is Dr. Trutz Foelsche, Staff Scientist of the Langley Research Center's Space Mechanics Division.

ATLAS-AGENA D LAUNCH VEHICLE

An Atlas/Agena D launch vehicle will boost Lunar Orbiter B from Launch Complex 13 at Cape Kennedy to an approximate 115-mile-high parking orbit before injecting the spacecraft on its lunar trajectory.

The upper-stage Agena must start the spacecraft on its way to the Moon through a narrow "translunar injection point" some 119 miles above the Earth's surface. Injection velocity is 24,400 mph, plus or minus an allowable error of less than 54 mph.

The accuracy required of the launch vehicle is so great that, with no midcourse maneuver, Orbiter must not be more than 10,000 miles off its aiming point after traveling more than 221,000 miles to the Moon.

Lunar encounter conditions during the winter months of November, December and January may require a Northward launch from Cape Kennedy's Launch Complex 13. Even with the time gained on a northerly azimuth, the coast period between Agena's first and second burns will be as short as 260 seconds with the most likely translunar injection point coming over North America. This differs considerably from the Lunar Orbiter I flight in August where spacecraft injection occurred over the Indian Ocean after an extended coast period.

The maximum northward azimuth in November would be 72°, or 18° North of due East. To meet the requirements of this unusual trajectory, the Lunar Orbiter B Atlas booster has a roll capability of 39° compared with 26° on the first Orbiter mission.

NASA's Lewis Research Center, Cleveland, managed development of both the shroud and the spacecraft adapter for the Orbiter vehicle.

The shroud is made of magnesium with a beryllium nose cap. Its over-the-nose design is similar to that which Lewis developed for the successful Mariner IV flight to Mars.

The spacecraft adapter is the mounting structure that supports the spacecraft, the shroud and a sealing diaphragm, and provides a transition from the Orbiter to the Agena. It includes four spring-loaded plungers to push the spacecraft from Agena at separation and a V-band release mechanism with associated pyrotechnic devices. This structure is made of magnesium.

LAUNCH VEHICLE STATISTICS

The Atlas/Agena D Lunar Orbiter launch vehicle is under the direction of NASA's Lewis Research Center, Cleveland, Ohio.

Total Height on pad	105 feet
Total Weight on pad	279,000 pounds

	Atlas	Agena D
Height	68 feet	23 feet
Diameter	10 feet	5 feet
Weight (at liftoff)	261,000 pounds	15,600 pounds
Propellants	RP-1 (11,530 gallons) LOX (8,530 gallons)	unsymetrical di-methyl hydrazine UDMH (585 gallons) and inhibited red fuming nitric acid IRFNA (745 gallons)
Propulsion	2 Rocketdyne boosters, 1 sustainer, and 2 verniers	Bell Aerosystems Engine
Guidance	G.E. Mod III	Lockheed inertial reference package
Prime Contractors	General Dynamics/ Convair, San Diego, Calif.	Lockheed Missiles & Space Co., Sunny-vale, Calif.

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DEEP SPACE NETWORK

The NASA Deep Space Network (DSN) consists of a number of permanent space communications stations strategically placed around the world; a spacecraft monitoring station at Cape Kennedy, and the Space Flight Operations Facility (SFOF) in Pasadena, Cal.

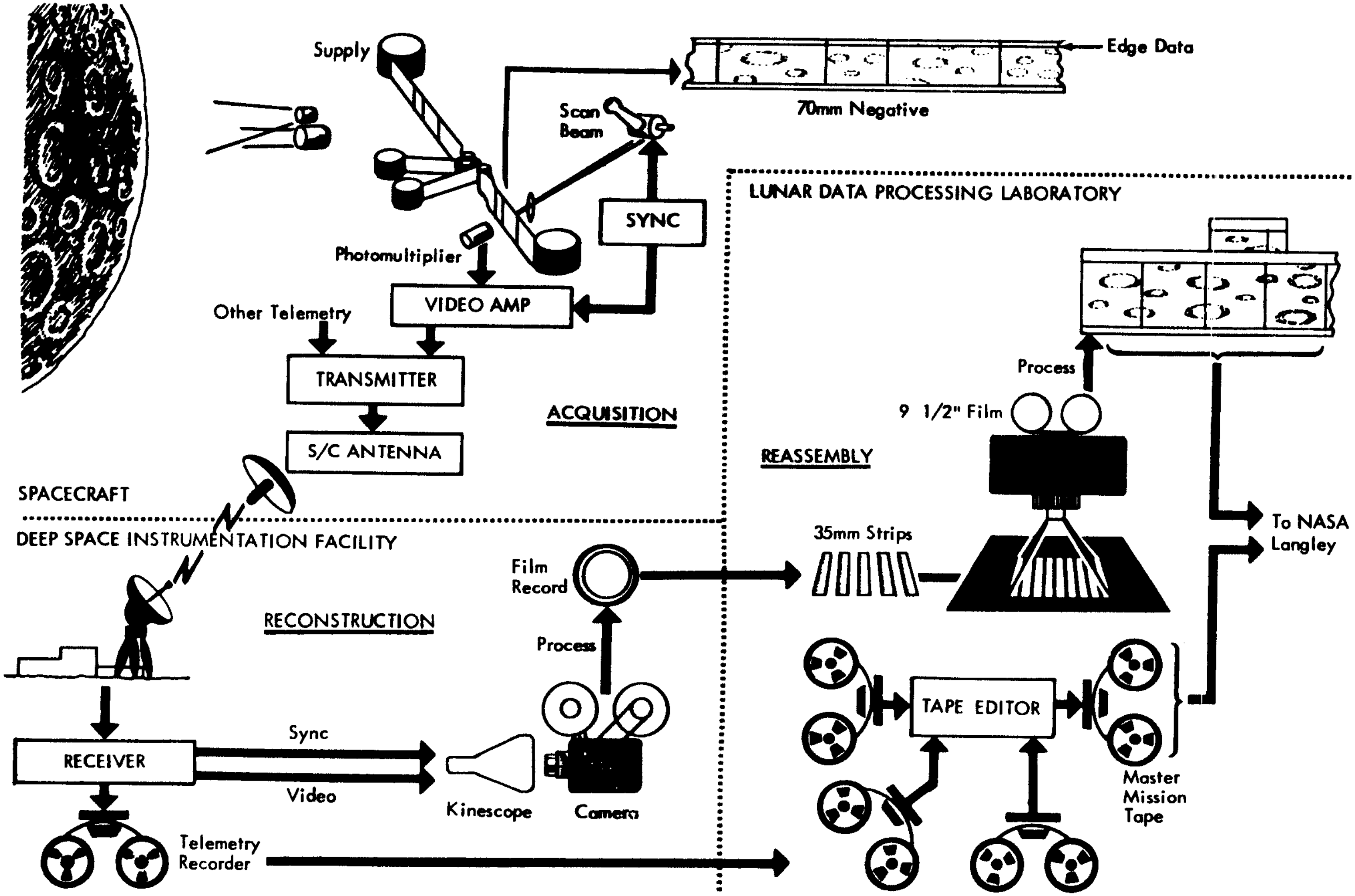
Permanent stations include four sites at Goldstone, in the Mojave Desert, Cal.; two sites in Australia, at Woomera and Tidbinbilla near Canberra; Robledo site, near Madrid, Spain; and Johannesburg, South Africa. All are equipped with 85-foot-diameter antennas except the one at Goldstone which is 210 feet in diameter. One other site, now under construction near Madrid will be known as Cebreros.

The DSN is under the technical direction of the Jet Propulsion Laboratory for NASA's Office of Tracking and Data Acquisition. Its mission is to track, communicate, receive telemetry from and send commands to unmanned lunar and planetary spacecraft from the time they are injected into orbit until they complete their missions.

The DSN uses a Ground Communications System for operational control and data transmission between these stations. The Ground Communications System is part of a larger net (NASCOM) which links all of the NASA stations around the world. This net is under the technical direction of the Goddard Space Flight Center, Greenbelt, Md.

The Goldstone DSN stations are operated by JPL with the assistance of the Bendix Field Corporation. JPL also operates the Robledo site under an agreement with the Spanish government. Technical support is provided by the Bendix Field Corporation.

The Woomera and Tidbinbilla stations are operated by the Australian Department of Supply. The Johannesburg station is operated by the South African government through the Counsel of Scientific and Industrial Research and the National Institute for Telecommunications Research.



PHOTOGRAPHIC DATA ACQUISITION, RECONSTRUCTION, AND REASSEMBLY

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

The DSN stations assigned to the Lunar Orbiter project are the Echo station at Goldstone, Woomera, and Madrid. Equipment has been installed at these stations to enable them to receive picture data from the Lunar Orbiter spacecraft. Since these three stations are located approximately 120 degrees apart around the world, at least one will always be able to communicate with the spacecraft as it travels toward the Moon.

The Space Flight Operations Center (SFOF) at JPL, the command center for the DSN stations, will be the primary mission control point. The overseas stations and Goldstone are linked to the SFOF by a communications network, allowing tracking and telemetry information to be received and displayed in real time. Key personnel for the Lunar Orbiter program will be stationed at SFOF during the spacecraft's flight. Commands will be generated at SFOF and transmitted to the DSN station for relay to the spacecraft.

Data Acquisition

The Lunar Orbiter spacecraft was designed for maximum compatibility with existing equipment installed at DSN stations. Additional equipment installed at the three Deep Space Network stations assigned to the Lunar Orbiter project includes three racks of telemetry and command equipment and four racks of equipment associated with the processing and recording of photographic information from the spacecraft.

Spacecraft tracking and ranging is accomplished by existing DSN equipment at the stations. Telemetry data, including spacecraft housekeeping information and data gathered by meteoroid and radiation sensors is routed to performance telemetry equipment and recorded on magnetic tape. The output from this equipment is fed directly to the SFOF via high speed data lines or teletype.

Video data are routed from the receiver at the DSN Station to photographic ground reconstruction equipment. A video signal is generated on board the spacecraft as the scan beam passes back and forth across the photographic negative. The signal is transmitted to Earth where it is magnetically taped and displayed line by line on a kinescope.

The face of the kinescope is photographed by special 35mm cameras at the DSN stations, converting the video information back to photographic image. Two 35mm film records are made at each DSN station. Portions of this film are processed at the station so that picture quality may be judged and corrections made, if necessary, to the spacecraft camera or readout system to improve the quality of subsequent pictures.

Each of these 35mm framelets measures approximately 3/4-inch wide by 16-3/4 inches long, and represents a portion of the original film on board the spacecraft only 1/10-inch wide and 2.165 inches long. By carefully assembling a series of these framelets, scientists will be able to reconstruct a duplicate about eight times as large as the original negative stored on the spacecraft. This work will be accomplished in the Eastman Kodak Laboratories at Rochester, N.Y.

Fourteen framelets will be edge-matched to form a composite that is photographically reduced to a 9 by 14-inch re-assembled photograph. Seven of the 9 by 14-inch composites constitute one high-resolution frame on the spacecraft negative.

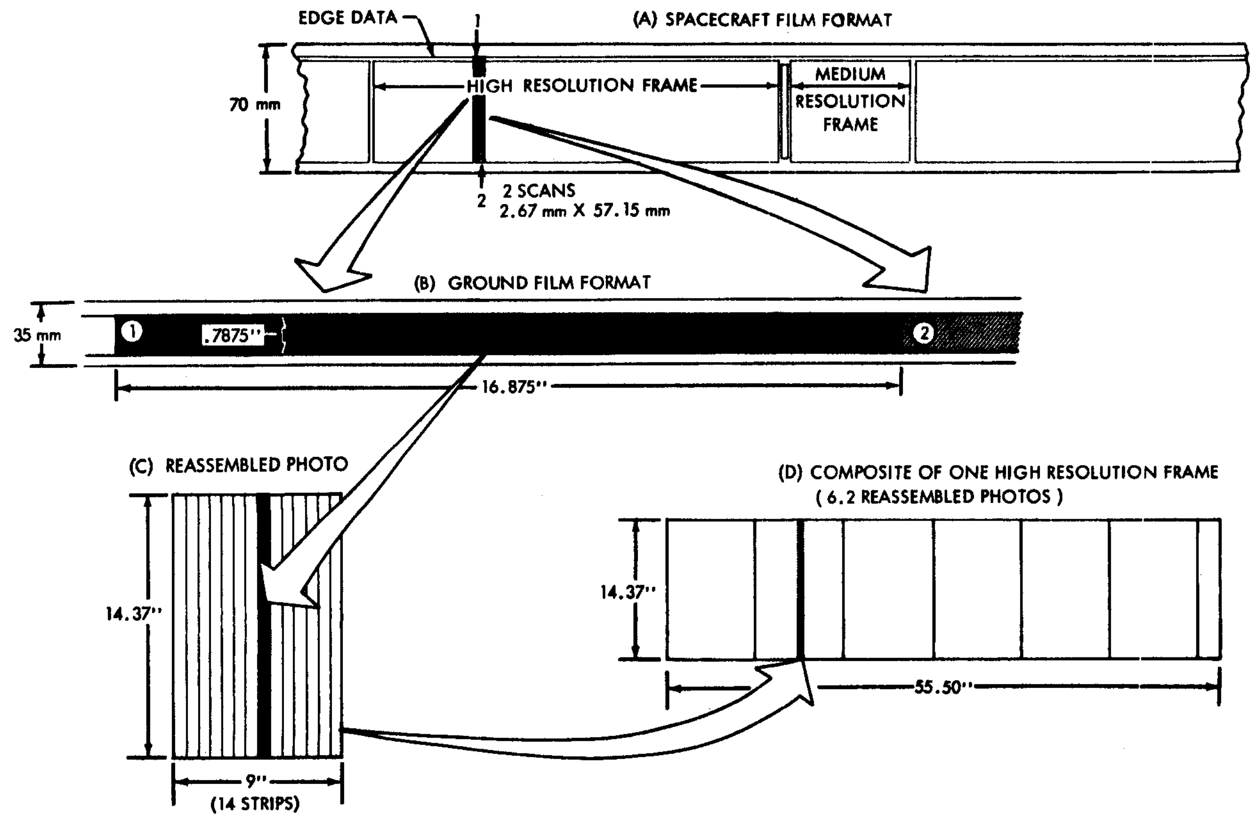


PHOTO REASSEMBLY

Data Evaluation

The photographs produced by the reassembly printer at Eastman Laboratories will be flown to the Langley Research Center, Hampton, Va., where NASA will assemble a group of experts in various areas of lunar science and space technology. Initial screening and a preliminary evaluation of the Lunar Orbiter's photographic results will be made by that group.

The evaluation team will include representatives of the Lunar Orbiter Project; NASA Headquarters; the Manned Spacecraft Center; Bellcomm; the Surveyor Project; the U.S. Geological Survey; and the USAF Aeronautical Chart and Information Service and the Army Map Service, both Department of Defense Agencies.

One primary task of the evaluation group will be a preliminary screening of the photographs to aid in planning future Orbiter missions just as Lunar Orbiter I photographic data was used as the basis for the Orbiter B photographic flight plan. The photographs also will be reviewed as a guide to future Surveyor flights.

Lunar Orbiter photography will be analyzed for slope and profile information useful to Project Apollo, and preliminary terrain maps of sites which appear of interest to Apollo will be prepared.

Statistical analysis of portions of the data will be made as rapidly as possible, to expand general knowledge of lunar surface conditions, and a computer study of terrain information extracted from the Lunar Orbiter photographs will be made at the Manned Spacecraft Center.

Over a longer period of time, Lunar Orbiter photographs will be used in geological and terrain studies directed toward landing site problems, and finally, the photographs will be used for longer-term systematic geologic investigations to obtain a more comprehensive understanding of the Moon itself.

ATLAS-AGENA/LUNAR ORBITER MISSION

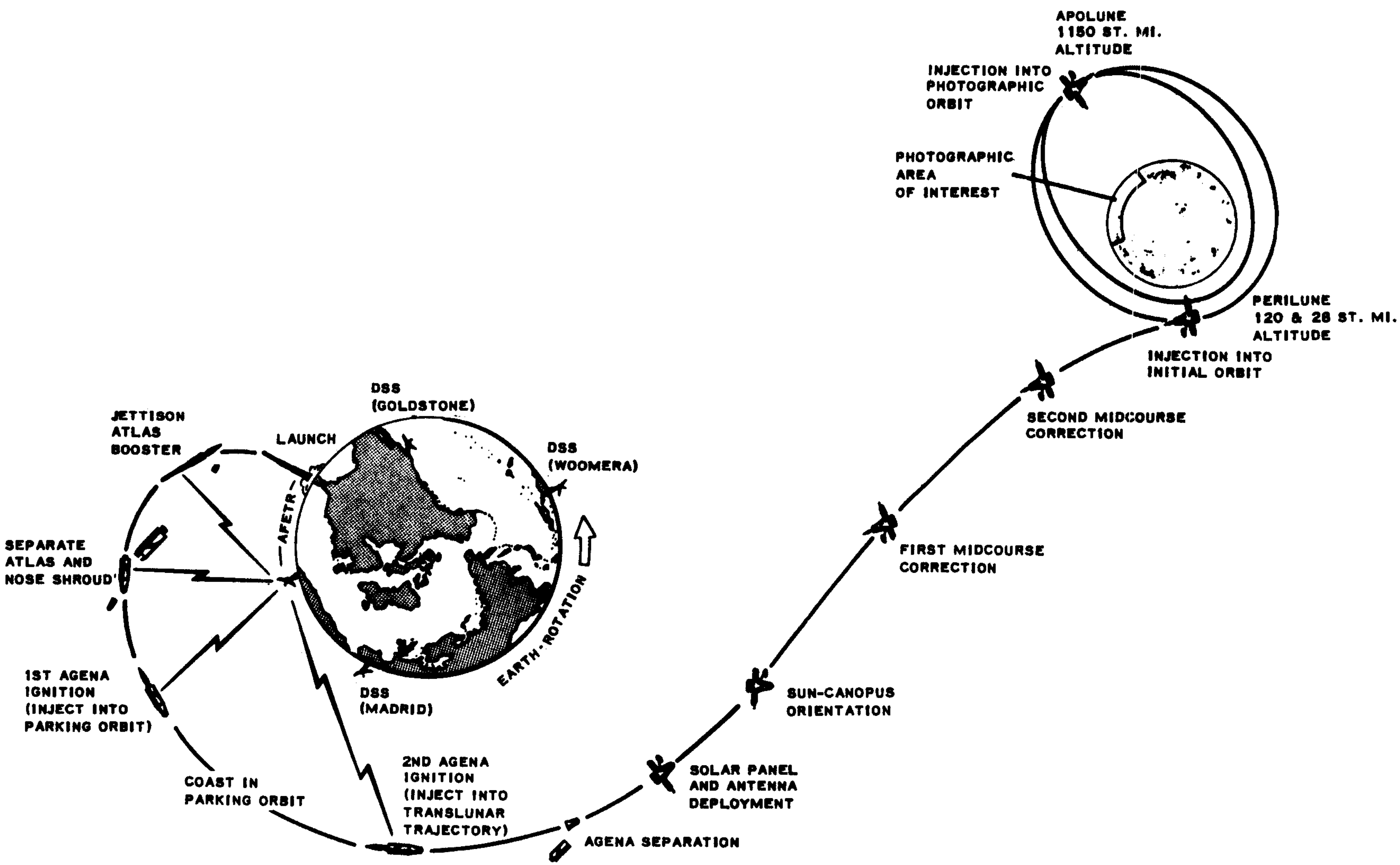
Approximate launch times* for the November period of a Lunar Orbiter B launch are:

Day	Window Opens (EST)	Window Closes (EST)
Nov. 6	5:58 p.m.	8:35 p.m.
Nov. 7	7:23 p.m.	9:59 p.m.
Nov. 8	7:50 p.m.	10:49 p.m.
Nov. 9	8:05 p.m.	11:41 p.m.
Nov. 10	8:58 p.m.	12:40 a.m.

Countdown Events

Event	Minus Time (Minutes)
Start Count	395
Start UDMH Tanking	155
Finish UDMH Tanking	135
Start removal of Gantry	130
Complete Removal of Gantry	100
Start IRFNA Tanking	90
Finish IRFNA Tanking	65
Built-in Hold of 50 minutes (To meet launch window requirements)	60
Start LOX Tanking	45
Built-in Hold of 10 minutes (To meet launch window requirements)	7
Secure LOX Tanking	2
Hold for Automatic Sequencer	18 seconds
Atlas engines to Full Thrust	2 seconds

* Subject to additional tracking and range restrictions



TYPICAL FLIGHT PROFILE

MAJOR FLIGHT EVENTS

Event	Plus Time (seconds)	Velocity	Altitude	Miles Downrange
Booster Engine Cutoff (BECO)	128	6625	33	50
Jettison Booster Section	131		33	50
Sustainer Engine Cutoff (SECO)	289	12655	94	400
Start Agena Primary Timer	294			
Vernier Engine Cutoff (VECO)	309	12630	101	464
Jettison Shroud	311			
Atlas-Agena Separation	313			
Start Agena First Burn	366	12560	112	644
End Agena First Burn	519	17440	115	1211
Start Agena Second Burn	1272	17445	114	4566
End Agena Second Burn	1360	24425	119	5025

Launch Vehicle Flight

The vehicle's time in parking orbit will vary from 544 seconds to as much as 1345 before the sequence is begun to ignite Agena's engine for the second time. Lunar Orbiter must be started on its 90-hour coast to the Moon at a velocity of 24,400 mph plus or mirus a margin for error of only 54 mph. The exact velocity-to-be-gained will be dependent on previous flight events but the figure should be on the order of 7000 mph requiring some 92 seconds of engine operation.

Agena must inject Lunar Orbiter toward the Moon at a point in space which remains relatively fixed. However, the Earth turns under this stationary gateway to the Moon and the actual injection time varies with the day and hour of the launch.

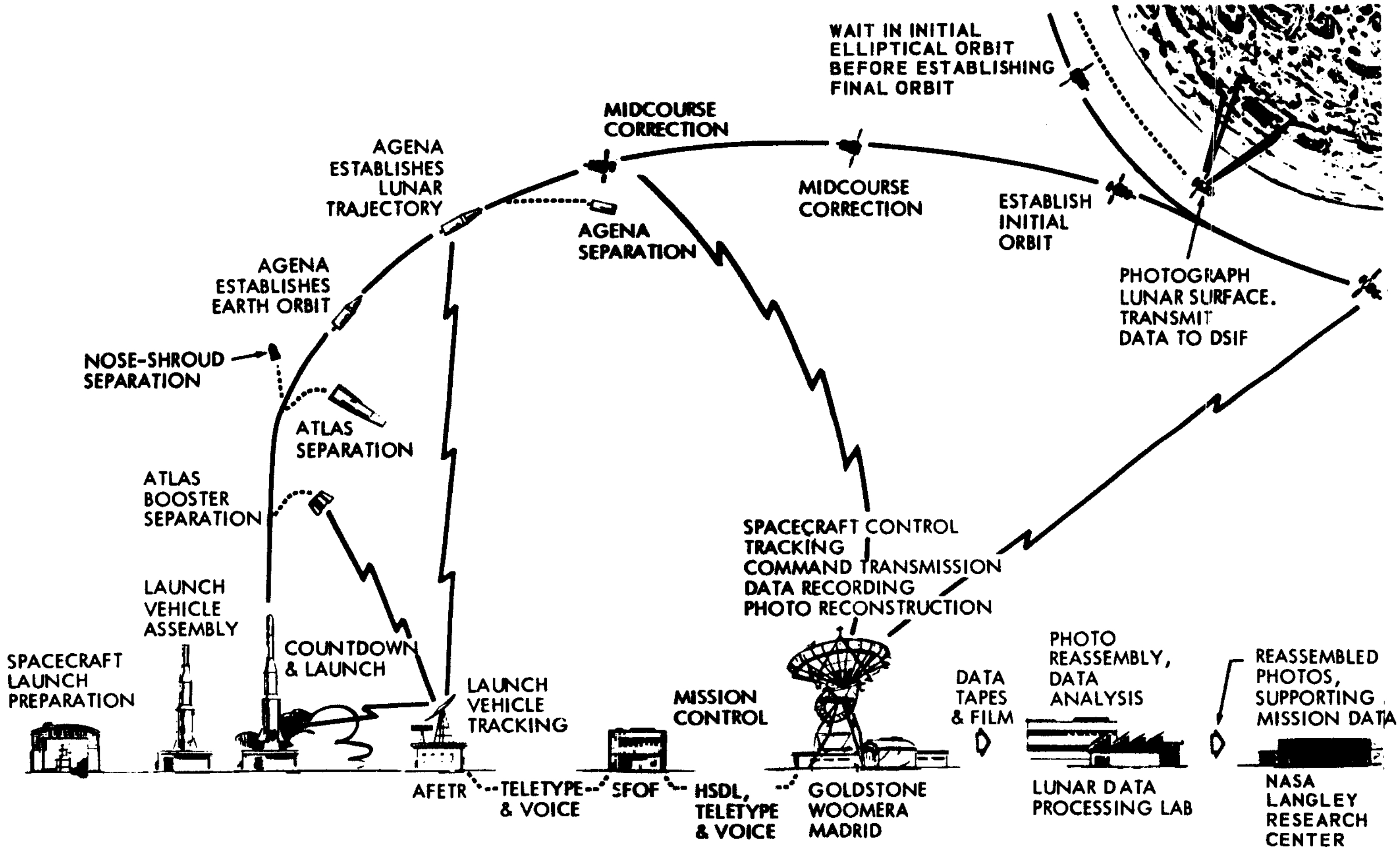
Launch vehicle performance varies somewhat, thus the times of actual flight events are determined during the flight when the desired speed and altitude are acquired.

At the correct point on the ascent trajectory, the radio guidance system starts the Agena primary timer which controls all Agena events except engine shutdown. Both parking orbit and injection conditions are highly influenced by the point on the ascent trajectory at which the Agena primary timer is started.

Agena's velocity meter controls the duration of engine burn. It is preset with the velocity-to-be-gained in each case and, when that velocity is gained, the engine is shut down. That is, should Agena's 16,000-pound-thrust engine burn a little hotter, the time of engine operation will be shorter than that given as nominal but the end effect of the desired vehicle velocity will be the same.

After Agena's engine shuts down for the final time, the spacecraft release assembly bolt squib is fired to release the V-band clamp. Four spring-loaded separation mechanisms push the spacecraft away from the Agena at slightly less than one mile per hour and the Lunar Orbiter spacecraft will be on its trans-lunar trajectory.

Three seconds after spacecraft separation, Agena begins a yaw maneuver which will turn it around 180° in space. Then 10 minutes after separation, a signal from the primary timer fires Agena's retrograde rocket for about 16 seconds. This 137-pound thrust retrograde rocket slows Agena 30 mph to minimize the possibility that the vehicle could interfere with Orbiter or hit the Moon. With its launch job done, Agena will go into a high eccentric Earth orbit.


WAIT IN INITIAL ELLIPTICAL ORBIT BEFORE ESTABLISHING FINAL ORBIT
MIDCOURSE CORRECTION
AGENA ESTABLISHES LUNAR TRAJECTORY
AGENA ESTABLISHES EARTH ORBIT
NOSE-SHROUD SEPARATION
ATLAS SEPARATION
ATLAS BOOSTER SEPARATION
AGENA SEPARATION
MIDCOURSE CORRECTION
ESTABLISH INITIAL ORBIT
PHOTOGRAPH LUNAR SURFACE. TRANSMIT DATA TO DSIF
SPACECRAFT CONTROL
TRACKING
COMMAND TRANSMISSION
DATA RECORDING
PHOTO RECONSTRUCTION
SPACECRAFT LAUNCH PREPARATION
LAUNCH VEHICLE ASSEMBLY
COUNTDOWN & LAUNCH
LAUNCH VEHICLE TRACKING
MISSION CONTROL
DATA TAPES & FILM
PHOTO REASSEMBLY, DATA ANALYSIS
REASSEMBLED PHOTOS, SUPPORTING MISSION DATA
AFETR
TELETYPE & VOICE
SFOF
HSDL, TELETYPE & VOICE
GOLDSTONE WOOMERA MADRID
LUNAR DATA PROCESSING LAB
NASA LANGLEY RESEARCH CENTER

THE MISSION

First Spacecraft Events

Thirty seconds after the Lunar Orbiter leaves Agena, a sequence of spacecraft events is commanded by the programmer, starting with solar panel deployment. Next the two antennas are released and locked in their cruise positions.

The spacecraft is then commanded to begin Sun acquisition, and the attitude control system provides the necessary torque to position Lunar Orbiter correctly. Sun acquisition should be complete about one hour and 15 minutes after lift-off.

Some six and one-half hours into the flight, and after Lunar Orbiter has passed beyond the Van Allen radiation belt, the Canopus sensor will be turned on, and the spacecraft will be commanded to begin Canopus acquisition. The Canopus tracker will view a circular band of the heavens while the spacecraft is making a complete roll, and the resulting "star map" telemetered to Earth will confirm the location of Canopus. The spacecraft will then be commanded to roll to the correct Canopus location and lock on to the stellar reference point it will use throughout its journey.

First midcourse maneuver is scheduled about 15 hours after lift-off, although the precise time for executing it will be based on actual flight events, including launch accuracy and tracking results.

A correct sequence of events derived from ground computers will be stored in the spacecraft programmer and at the selected time, Orbiter's attitude control system will position the spacecraft precisely for the velocity control engine to apply the needed thrust. After thrusting, the attitude control system returns the spacecraft to its initial orientation, reacquiring the Sun and Canopus as references.

Should a second midcourse correction prove necessary, it will be made about 70 hours after launch.

Lunar Orbit Injection

During translunar flights, trajectory information provided by the Deep Space Net tracking stations will be used in the Space Flight Operations Facility to compute the velocity change required to achieve an initial lunar orbit. On a nominal mission, lunar orbit injection will occur after 92 hours of flight.

As the Lunar Orbiter more deeply penetrates the lunar gravitational field, a calculated attitude maneuver will point the rocket engine against the direction of flight. The correct burn time, as computed on the ground, will be placed in the programmer.

Then, at a precise instant, the rocket engine will ignite for a burn time about 10 minutes.if the spacecraft is on its planned trajectory. Small variations from the intended trajectory are probable, and the engine burn time will be adjusted as necessary.

The slowed spacecraft, approaching a minimum altitude of 120 miles above the surface of the Moon, will no longer have sufficient velocity to continue outward against the pull of lunar gravity, and will be captured as a satellite of the Moon. High point of the orbit (apolune) is intended to be 1150 miles. Lunar Orbiter will circle the Moon every three hours and 37 minutes in its initial orbits.

Time in the high orbit will be between three and seven days.

Photographic Orbit Injection

On November 17, the spacecraft will be commanded to make its final planned velocity change.

The maneuver will be similar to those previously performed. Instructions to the attitude control system will assure that the velocity engine is correctly aligned, and a brief engine burn will counteract just enough of Orbiter's velocity to lower the perilune to the intended final altitude of 28 miles. The apolune will remain unchanged.

In its final photographic orbit, the spacecraft will circle the Moon every three hours and 28 minutes. Its speed relative to the Moon will be about 4500 miles per hour at closest approach, or perilune.

When the maneuver is complete, the spacecraft will return to its cruise attitude oriented to the Sun and Canopus. When the Moon comes between it and either of its celestial reference points, the inertial reference unit will furnish the required orientation.

Then Lunar Orbiter will be ready for its main task -- detailed photography of 13 primary locations near the equator of the Moon.

LUNAR ORBITER AND ATLAS-AGENA TEAMS

NASA Headquarters, Washington, D.C.

Dr. Homer E. Newell	Associate Administrator for Space Science and Applications
Oran W. Nicks	Director, Lunar and Planetary Programs
Capt. Lee R. Scherer	Lunar Orbiter Program Manager
Leon J. Kosofsky	Lunar Orbiter Program Engineer
Dr. Martin J. Swetnick	Lunar Orbiter Program Scientist
Vincent L. Johnson	Director, Launch Vehicle and Propulsion Programs
Joseph B. Mahon	Agena Program Manager

Langley Research Center, Hampton, Va.

Dr. Floyd L. Thompson	Director
Charles J. Donlan	Associate Director
Eugene C. Draley	Assistant Director for Flight Projects
Dr. Samuel Katzoff	Chairman, Langley Research Center Lunar Orbiter Advisory Committee
Clifford H. Nelson	Lunar Orbiter Project Mgr.
James S. Martin, Jr.	Assistant Manager, Lunar Orbiter Project
Israel Taback	Spacecraft Manager
William I. Watson	Assembly and Integration
G. Calvin Broome	Photographic Subsystem
J. E. Harris	Power Subsystem
Royce H. Sproull	Velocity and Attitude Control Subsystem
T. W. E. Hankinson	Thermal, Structure and Mechanisms Subsystem
I. W. Ramsey	Spacecraft Testing

William J. Boyer	Operations Manager
Dalton D. Webb	Space Flight Operations Director (SFOD)
Donald H. Ward	Spacecraft Launch Operations
John B. Graham	Operations Integration
Kenneth L. Wadlin	Lunar Orbiter Resident Engineer, Boeing, Seattle
Norman L. Crabill	Mission Integration Manager
A. T. Young	Mission Definition
Edmund A. Brummer	Communications and Tracking Manager
Gerald W. Brewer	Mission Assurance Manager
William L. Ervi	Department of Defense Field Support
I. G. Recant	Data Analysis Manager
Robert L. Girouard	Space Vehicle System Manager
Theodore H. Elder	Technical Administration Manager
F. E. Jennings	Funding and Schedules

<u>Lewis Research Center, Cleveland</u>

Dr. Abe Silverstein	Director
Bruce T. Lundin	Associate Director
Dr. Seymour C. Himmel	Assistant Director
H. Warren Plohr	Manager, Agena Project
Joseph A. Ziemanski	Agena Project Engineer

-more-

Kennedy Space Center, Fla.

Dr. Kurt H. Debus	Director
Robert H. Gray	Director of Unmanned Launch Operations
Harold Zweigbaum	Manager, Atlas Agena Operations

Jet Propulsion Laboratory, Pasadena, Cal.

Dr. William H. Pickering	Director
Gen. A. R. Luedecke	Deputy Director
Dr. Eberhardt Rechtin	Assistant Laboratory Director for Tracking and Data Acquisition
J. R. Hall	Lunar Orbiter DSN Manager
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Howard Olson	Echo Station Manager, Goldstone
Donald Meyer	JPL Station Manager, Robledo site, Madrid, Spain
Phil Tardani	JPL DSN Resident, Madrid
R. J. Fahnestock	JPL DSN Resident, Australia
D. Willshire	Station Manager, Woomera
Robert Terbeck	JPL DSN Resident, Johannesburg
Doug Hogg	JPL Station Manager, Johannesburg

Industrial Team

The Lunar Orbiter prime contractor is The Boeing Co., Seattle, Wash., which designed, built and tested the spacecraft. Major subcontractors to Boeing are the Eastman Kodak Co., Rochester, N. Y., for the camera system and Radio Corporation of America, Camden, N. J., for the power and communications systems.

Prime contractor for the Atlas booster stage is General Dynamics/Convair, San Diego, Calif., and prime contractor for the Agena second stage is Lockheed Missiles and Space Co., Sunnyvale, Calif.

The following is a list of other subcontractors for the Lunar Orbiter spacecraft:

Contractor	Product
Accessory Products Company	Quad Check Valve
Ball Brothers Research Corporation	Sun Sensor
Bell Aerosystems	Fuel Tanks
Bendix Corporation	Crystal Oscillator
Calmec Manufacturing Co.	Relief Valve
J. C. Carter Company	Propellant Fill & Vent Valve
Electronic Memories, Inc.	Programmer Memory
Fairchild Controls	Pressure Transducer
Firewel Company	Fill & Test Valves
General Precision, Inc., Kearfott Division	TVC Actuator
Gerstenslager Company	Van
ITT Federal Laboratories	Star Tracker
Marquardt Corporation	Engine
National Water Lift Co.	Hi Pressure Regulator

Contractor	Product
Ordnance Engineering Associates	Pin Release Mech. N_2 Squib Valve Shut Off Valve Propellant Squib Valve Cartridges
Radiation, Incorporated	Multiplexer Encoder Test Set
Resistoflex Corporation	Propellant Hoses
Sperry Gyroscope Company	Inertial Reference Unit
Standard Manufacturing Company	Servicing Unit - Cart Purge, Dry & Flush Unit
Sterer Engineering and Manufacturing Company	Thrusters Low Pressure Regulator
Texas Instruments, Inc.	Radiation Dosage Measurement System
Vacco Valve Company	N_2 Filter Propellant Filter
Vinson Manufacturing Co.	Linear Actuator

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