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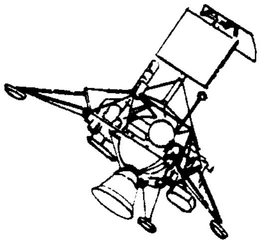

PROJECT: SURVEYOR A

(To be launched no earlier than May 30, 1966)

CONTENTS

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FIRST SURVEYOR
TEST MISSION
SET FOR MAY 30

The United States is preparing to launch the first engineering test flight in a series of Surveyor missions designed to achieve a soft-landing on the Moon.

The first spacecraft -- Surveyor A -- is scheduled for launch by the National Aeronautics and Space Administration from Cape Kennedy no earlier than May 30.

The launch vehicle will be the Atlas-Centaur (AC-10) which will be making its first operational flight.

From launch to touchdown on the lunar surface, the flight is expected to take 61 to 65 hours.

Later spacecraft in the Surveyor series will have the mission objectives of gathering lunar surface information needed for the Apollo manned lunar landing program.

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Primary objectives of Surveyor A:

- demonstrate the capability of the Atlas-Centaur 10 launch vehicle to inject the Surveyor spacecraft sucessfully on a lunar-intercept trajectory,
- demonstrate the capability of the Surveyor spacecraft to perform successful midcourse and terminal maneuvers, and a soft landing on the Moon, and
- demonstrate the capability of the Surveyor communications system and the Deep Space Network to maintain communications with the spacecraft during its flight and after the soft landing.

Surveyor will carry a single scanning television camera which is designed to photograph the Moon's surface and the crushable pads on two of the landing legs to determine how deeply the pads have penetrated the lunar surface.

A successful mission will prove the concept of a spacecraft capable of automatically decelerating from 6,000 miles per hour to a touchdown speed of about three and one-half miles per hour and functioning in the intense heat of the lunar day.

To accomplish the critical terminal descent and soft landing, Surveyor is equipped with a solid propellant retrorocket and three throttleable liquid fuel vernier engines, a flight programmer and analog computer, and radars to determine altitude and rate of descent.

The main braking force is provided by the main retro. After it is jettisoned, data from the radars are processed by the computer to throttle the verniers automatically so that Surveyor achieves a soft landing.

At launch Surveyor will weigh 2,194 pounds. The retro motor, which will be jettisoned after burnout, weighs 1,377 pounds. After expenditure of liquid propellants and use of attitude control gas, the landed weight of Surveyor on the Moon will be about 620 pounds.

More than 250 ground commands will be required to control Surveyor during flight and after a successful landing on the Moon. About 300 persons will be involved in flight control at peak times in the mission.

The Surveyor program is directed by NASA's Office of Space Science and Applications. Project management is assigned to NASA's Jet Propulsion Laboratory operated by the California Institute of Technology, Pasadena. Hughes Aircraft Co., under contract to JPL, designed and built the Surveyor spacecraft. 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, San Diego, Calif.

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Tracking and communication with the Surveyor is the responsibility of the NASA/JPL Deep Space Network (DSN). The stations assigned to the Surveyor program are Pioneer, at Goldstone in California's Mojave Desert; Johannesburg, South Africa; and Tidbinbilla, Australia. Data from the stations will be transmitted to JPL's Space Flight Operations Facility in Pasadena, the command center for the mission.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

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SURVEYOR A SPACECRAFT

Frame, Mechanisms and Thermal Control

The triangular aluminum frame of the Surveyor provides mounting surfaces and attachments for the landing gear, main retrorocket, vernier engines and associated tanks, thermal compartments, antennas and other electronic and mechanical assemblies.

It is constructed of thin-wall aluminum tubing, with the members interconnected to form the triangle. A mast, which supports the planar array antenna (high-gain) and single solar panel, is attached to the top of the frame. The basic frame weighs less than 60 pounds and installation hardware weighs 23 pounds.

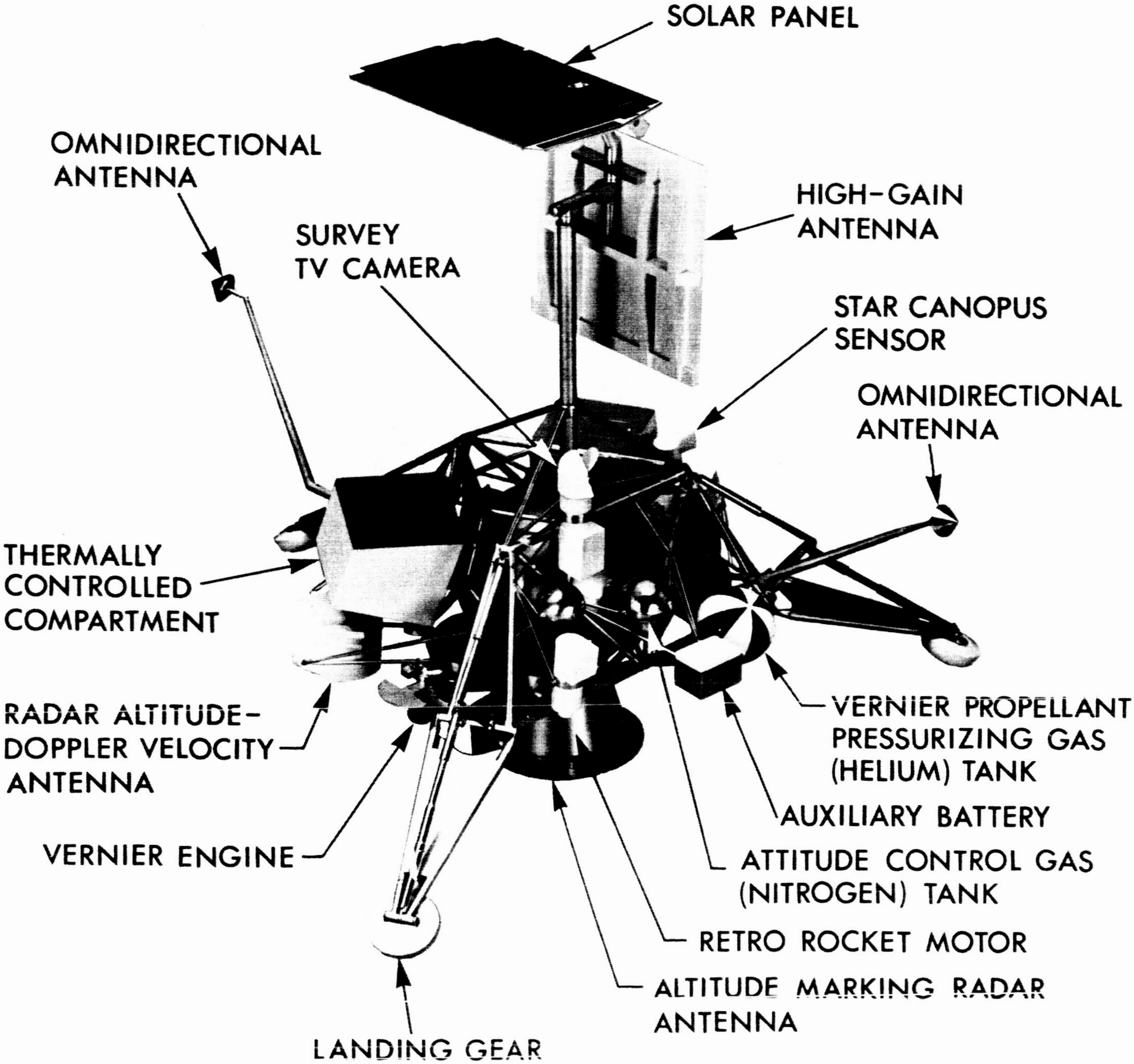
The Surveyor stands about 10 feet high and, with its tripod landing gear extended, can be placed within a 14-foot circle. A landing leg is hinged to each of the three lower corners of the frame and an aluminum honeycomb footpad is attached to the outer end of each leg. An airplane-type shock absorber and telescoping strut are connected to the frame so that the legs can be folded into the nose shroud during launch. Touchdown shock also is absorbed by the footpads and by the hydraulic shock absorbers which compress with the landing load. Blocks of crushable aluminum honeycomb are attached to the bottom of the spaceframe at each of its three corners to absorb part of the landing shock.

Two omnidirectional, conical antennas are mounted on the ends of folding booms which are hinged to the frame. The booms remain folded against the frame during launch until released by squib-actuated pin pullers and deployed by torsion springs. The antenna booms are released only after the landing legs are extended and locked in position.

An antenna/solar panel positioner atop the mast supports and rotates the planar array antenna and solar panel in either direction along four axes. This freedom of movement allows orienting the antenna toward Earth and the solar panel toward the Sun.

Two thermal compartments house sensitive electronic apparatus for which active thermal control is needed throughout the mission.

SURVEYOR


SOLAR PANEL
OMNIDIRECTIONAL ANTENNA
HIGH-GAIN ANTENNA
SURVEY TV CAMERA
STAR CANOPUS SENSOR
OMNIDIRECTIONAL ANTENNA
THERMALLY CONTROLLED COMPARTMENT
RADAR ALTITUDE-DOPPLER VELOCITY ANTENNA
VERNIER PROPELLANT PRESSURIZING GAS (HELIUM) TANK
AUXILIARY BATTERY
VERNIER ENGINE
ATTITUDE CONTROL GAS (NITROGEN) TANK
RETRO ROCKET MOTOR
ALTITUDE MARKING RADAR ANTENNA
LANDING GEAR

The equipment in each compartment is mounted on a thermal tray that distributes heat throughout the compartment. An insulating blanket, consisting of 75 sheets of aluminized Mylar, is sandwiched between each compartment's inner shell and the outer protective cover.

Compartment A, which maintains an internal temperature between 40 degrees and 125 degrees F., contains two radio receivers, two transmitters, the main battery, battery charge regulator, main power switch and some auxiliary equipment.

Compartment B, kept between zero and 125 degrees F., houses the central command decoder, boost regulator, central signal processor, signal processing auxiliary, engineering signal processor, and low data rate auxiliary.

Both compartments contain sensors for reporting temperature measurements by telemetry to Earth, and heater assemblies to maintain the thermal trays above their allowable minimums. The compartments are kept below the 125-degree maximum with thermal switches which provide a conductive path to the radiating surfaces for automatic dissipation of electrically generated heat. Compartment A contains nine thermal switches and compartment B, six. The thermal shell weight of compartment A is 25 pounds, and compartment B, 18 pounds.

Passive temperature control is provided all equipment not protected by the compartments through the use of paint patterns and polished surfaces.

Twenty-nine pyrotechnic devices mechanically release or lock the mechanisms, switches and valves associated with the antennas, landing leg locks, roll actuator, retro-rocket separation attachments, helium and nitrogen tanks, shock absorbers and the retro engine detonator. Some are actuated by command from the Centaur stage programmer prior to spacecraft separation from the Centaur, others are actuated by ground command.

A spherical solid propellant, retrorocket fits within the center cavity of the frame and supplies the main thrust for slowing the spacecraft on approach to the Moon. The unit is attached at three points on the frame near the landing leg hinges with explosive nut separation points for ejection after burnout. The motor case, made of high-strength steel and insulated with asbestos and rubber, is 36 inches in diameter. Including the molybdenum nozzle, the unfueled engine weighs 142 pounds. With propellant, the weight is about 1,377 pounds or more than 60 per cent of the total spacecraft weight.

Electrical harnesses and cables interconnect the spacecraft subsystems to provide correct signal and power flow. The harness connecting the two thermal compartments is routed through a thermal tunnel to minimize heat loss from the compartments. Coaxial cable assemblies, attached to the frame by brackets and clips, are used for high frequency transmission.

Electrical connection with the Centaur stage is established through a 51-pin connector mounted on the bottom of the frame between two of the landing legs. The connector mates with the Centaur connector when the Surveyor is mounted on the launch vehicle. It carries pre-separation commands from the Centaur programmer and can handle emergency commands from the blockhouse console. Ground power and pre-launch monitor circuits also pass through the connector.

Power Subsystem

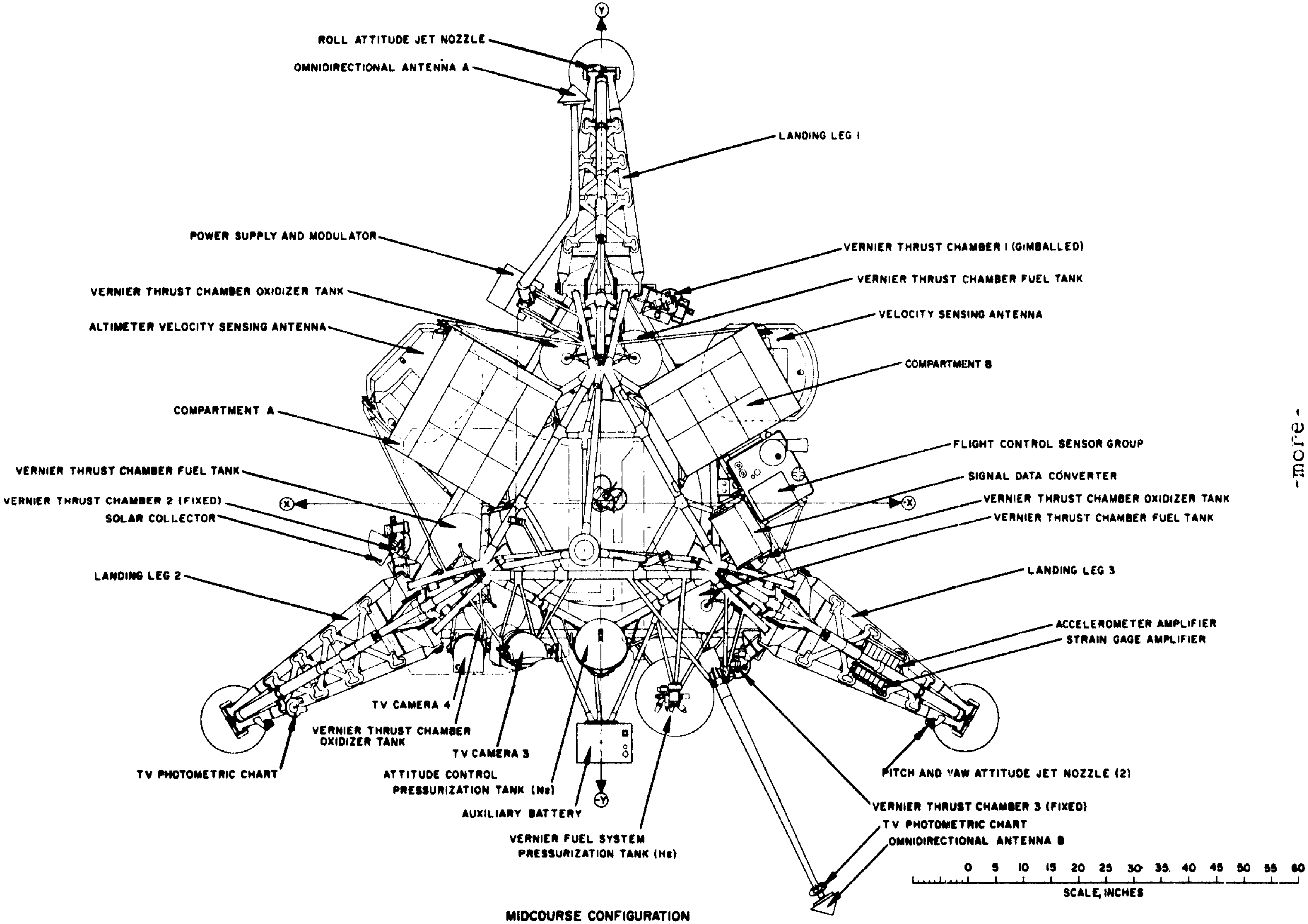
The power subsystem collects and stores solar energy, converts it to usable electric voltage, and distributes it to the other spacecraft subsystems. This equipment includes the solar panel, a main battery and an auxiliary battery, an auxiliary battery control, a battery charge regulator, main power switch, boost regulator, and an engineering mechanisms auxiliary.

The solar panel is the spacecraft's primary power source during flight and during operations in the lunar day. It consists of 3,960 solar cells arranged on a thin, flat surface of approximately nine square feet. The solar cells are grouped in 792 separate modules and connected in series-parallel to guard against complete failure in the event of a single cell malfunction.

The solar panel is mounted at the top of the Surveyor spacecraft's mast. Winglike, it is folded away during launch and deployed after the spacecraft has been ejected into the lunar transit trajectory.

When properly oriented during flight, the solar panel can supply about 89 watts which is most of the power required for the average operating load of all on-board equipment.

During operation on the lunar surface, the solar panel can be adjusted by Earth command to track the Sun within a few degrees, so that the solar cells remain always perpendicular to the solar radiation.



MIDCOURSE CONFIGURATION

ANTENNA AND SOLAR PANNEL POSITIONER
OMITTED FROM VIEW FOR CLARITY

On the Moon, the solar panel is designed to supply a minimum of 77 watts power at a temperature of 140 degrees F., and a minimum of 57 watts at a temperature of 239 degrees F.

A 14-cell rechargeable, silver-zinc main battery is the spacecraft's power reservoir. It is the sole source of power during launch; it stores electrical energy from the solar panel during transit and lunar-day operations; and it provides a back-up source to meet peak power requirements during both of those periods. Fully charged, the battery provides 3,800 watt-hours at a discharge rate of 1.0 amperes. Battery output is approximately 22 volts direct current for all operating and environmental conditions in temperatures from 40 degrees to 125 degrees F.

The auxiliary battery is a non-rechargeable, silver-zinc battery contained in a sealed magnesium cannister. It provides a power backup for both the main battery and the solar panel under peak power loading or emergency conditions. This battery has a capacity of from 800 to 1,000 watt-hours, depending upon power load and operating temperature.

The battery charge regulator and the booster regulator are the two power conditioning elements of the spacecraft's electrical power subsystem. The battery charge regulator couples the solar panel to the main battery for maximum conversion and transmission of the solar energy necessary to keep the main battery at full charge.

It receives power at the solar panel's varying output and delivers this power to the main battery at a constant battery terminal voltage. The battery charge regulator includes sensing and logic circuitry for automatic battery charging whenever battery voltage drops below 27 volts.

The booster regulator unit receives unregulated power from 17 to 27.5 volts direct current from the solar panel, the main battery, or both, and delivers a regulated 29 volts direct current to the spacecraft's three main power transmission lines. These three lines supply all the spacecraft's power needs, except for a 22-volt unregulated line which serves heaters, switches, actuators, solenoids and electronic circuits which do not require regulated power or provide their own regulation.

Telecommunications

Communications equipment aboard Surveyor serves three functions: providing transmission and reception of radio signals; decoding commands sent to the spacecraft; and selecting and converting engineering and television data into a form suitable for transmission.

The first group include the three antennas: one high-gain, directional antenna, and two low-gain, omnidirection antennas; two transmitters and two receivers with transponder interconnections. Dual transmitters and receivers are used for reliability.

The high-gain antenna transmits 600-line television data. The low-gain antennas receive ground commands and transmit other data including 200-line television data from the spacecraft. Either low-gain antenna can be connected to either receiver. The transmitters can be switched to either low-gain antenna or to the high-gain antenna and can operate at low or high power levels. Thermal control of the three antennas is passive, dependent on surface coatings to keep temperatures within acceptable limits.

The command decoding group can handle up to 256 commands both direct (which control on-off operations) and quantitative commands (which control time interval operations). Each incoming command is checked in a central command decoder which will reject a command, and signal the rejection to Earth if the structure of the command is incorrect. Acceptance of a command is also radioed to Earth. The command is then sent to subsystem decoders that translate the binary information into an actuating signal for the function command such as squib firing and change data modes.

Processing of most engineering data, (temperatures, voltages, currents, pressures, switch positions, etc.) is handled by the engineering signal processor or the auxiliary processor. There are over 200 engineering measurements of the spacecraft. None are continuously reported. There are four commutators in the engineering signal processor to permit sequential sampling of selected signals. The use of a commutator is dependent on the type and amount of information required during various flight sequences. Each commutator can be commanded into operation at any time and at any of the five bit rates: 17.2, 137.5, 550, 1,100 and 4,400 bits-per-second.

Commutated signals from the engineering processors are converted to 10-bit data words by an analog-to-digital converter in the central signal processor and relayed to the transmitter. The low-bit rates are normally used with transmissions over the low-gain antennas and the low-power levels of the transmitters.

Video data from the TV cameras is fed directly to the transmitters only during high-power operation and requires the use of high-gain antenna when in the 600-line mode.

Propulsion

The propulsion system consists of three liquid fuel vernier rocket engines and a solid fuel retrorocket. The verniers are used for the midcourse maneuver as well as in the terminal lunar landing sequence.

The vernier engines are supplied fuel by three fuel tanks and three oxidizer tanks. There is one pair of tanks, fuel and oxidizer, for each engine. The fuel and oxidizer in each tank is contained in a bladder. Helium stored under pressure is used to deflate the bladders and force the fuel and oxidizer into the feed lines.

The oxidizer is nitrogen tetroxide with 10 per cent nitric oxide. The fuel is monomethylhydrazine monohydrate. An ignition system is not required for the verniers as the fuel and oxidizer are hypergolic, burning upon contact. The throttle range is 30 to 104 pounds of thrust.

The main retro is used at the beginning of the terminal descent to the lunar surface and slows the spacecraft from an approach velocity of about 6,000 mph to approximately 240 mph. It burns an aluminum, ammonium-perchorate and polyhydro carbon, case-bonded composite-type propellant.

The nozzle has a graphite throat and a laminated plastic exit cone. The case is of high-strength steel insulated with asbestos and silicon dioxide-filled buna-N rubber to maintain the case at a low temperature level during firing.

Engine thrust varies from 8,000 to 10,000 pounds over a temperature range of 50 to 70 degrees F. Passive thermal control, insulating blankets and surface coatings, will maintain the grain above 50 degrees F. It is fired by a pyrogen igniter. The main retro weighs approximately 1,377 pounds and is spherical shaped, 36 inches in diameter.

Flight Control Subsystem

Flight control of Surveyor, control of its attitude and velocity from Centaur separation to touchdown on the Moon, is provided by: primary Sun sensor, automatic Sun acquisition sensor, Canopus sensor, inertial reference unit, altitude marking radar, inertia burnout switch, radar altimeter and Doppler velocity sensors, flight control electronic, and three pairs of cold gas jets. Flight control electronics includes a digital programmer, gating and switching, logic and a signal data converter for the radar altimeter and Doppler velocity sensors.

The information provided by the sensors is processed through logic circuitry in the flight control electronics to yield actuating signals to the gas jets and to the three liquid fuel vernier engines and the solid fuel main retromotor.

The Sun sensors provide information to the flight control electronics indicating whether or not they are illuminated by the Sun. This information is used to order the gas jets to fire and maneuver the spacecraft until the Sun sensors are on a direct line with the Sun. The primary Sun sensor consists of five cadmium sulphide photo-conductive cells. During flight, Surveyor may deviate slightly off of pointing directly at the Sun. Such deviations are continuously corrected by signals from the primary sensor to the flight electronics ordering the pitch and yaw gas jets to fire to again center the Sun sensors on the Sun.

Sun acquisition is required before locking on to the star Canopus. Gas jets are used to center the star sensor on Canopus, so as to maintain roll axis attitude during cruise modes. If star or Sun lock is lost, control is automatically switched from optical sensors to gyros which sense changes in spacecraft attitude inertially.

The inertial reference unit is also used during events when the optical sensors cannot be used -- midcourse maneuver and descent to the lunar surface. This device senses changes in attitude of the spacecraft and in velocity with three gyros and an accelerometer. Information from the gyros is processed by the control electronics to fire gas jets to change or maintain the desired attitude. During lunar descent thrust phases, the inertial reference unit controls vernier engine thrust levels by differential throttling for pitch and yaw control and swiveling one engine for roll control. The accelerometer controls the total thrust level.

The altitude marking radar will provide the signal for firing of the main retro. It is located in the nozzle of the retro motor and is ejected when the motor ignites. The radar will generate a signal at about 60 miles above the lunar surface. The signal starts the programmer automatic sequence after a pre-determined period (directed by ground command); the programmer then commands vernier and retro ignition and turns on the radar altimeter and Doppler velocity sensors.

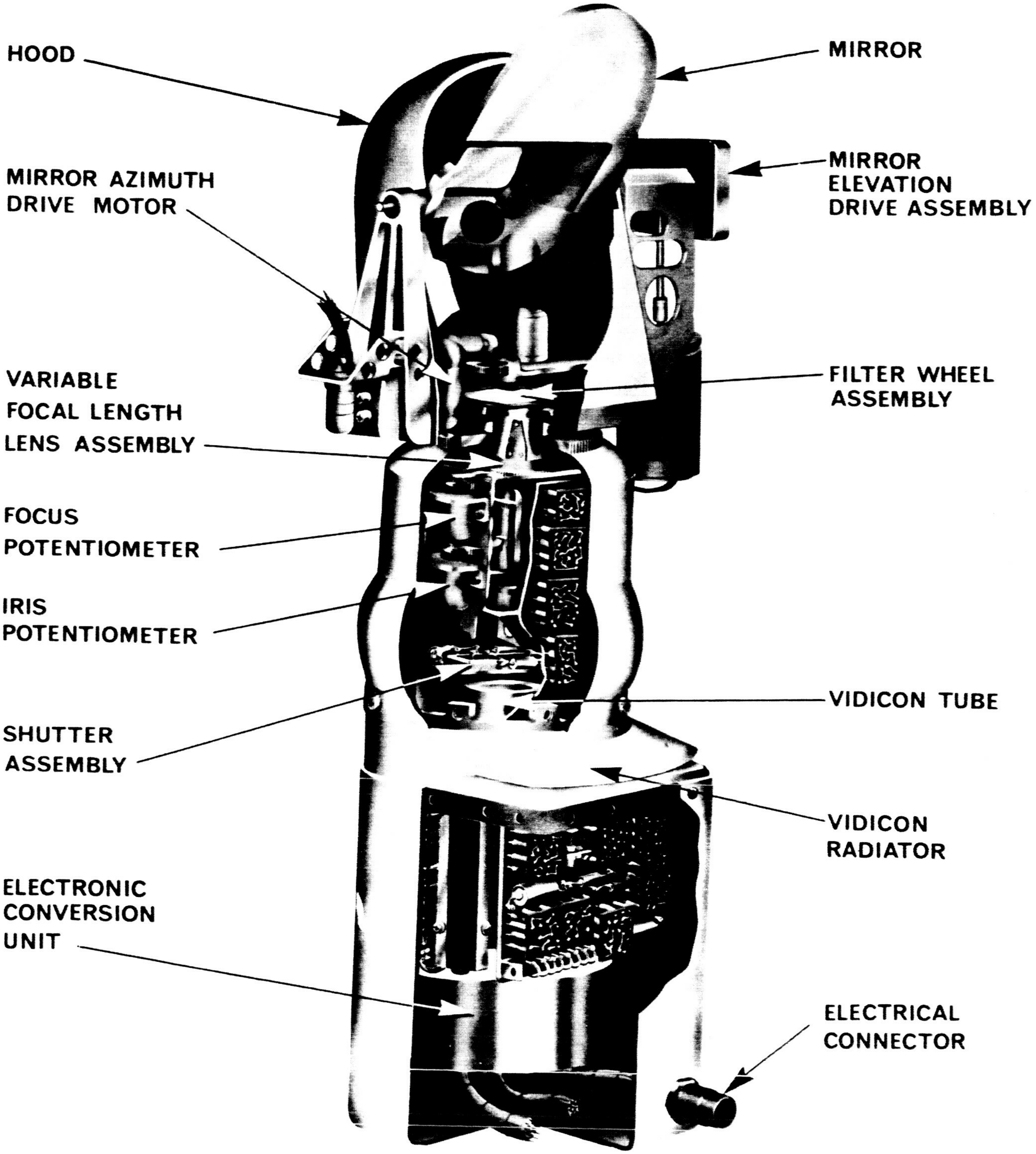
The inertia burnout switch will close when the thrust level of the main retro engine drops below 3.5 g, generating a signal which is used by the programmer to command jettisoning of the retro motor and switching to control by the radar altimeter and Doppler velocity sensors.

Control of the spacecraft after main retro burnout is vested in the radar altimeter and Doppler velocity sensors. Two radar dishes are involved. An altimeter/velocity sensing antenna radiates two beams and a velocity sensing antenna two beams. Beams 1, 2, and 3 can yield vertical or transverse velocity. Beam 4 provides altitude or slant range information. Beams 1, 2, and 3 provide velocity data by adding the Doppler shift (frequency shift due to velocity) of each beam in the signal data converter. The converted range and velocity data is fed to the gyros and gating logic which in turn control the thrust signals to the vernier engines.

The flight control electronics provides for processing sensor information into telemetry and to actuate spacecraft mechanisms. It consists of control circuits, a command decoder and an AC/DC electronic conversion unit. The programmer controls timing of main retro phase and generates precision time delays for attitude maneuvers and midcourse velocity correction.

The attitude jets provide attitude control to the spacecraft from Centaur separation to main retro burn. The gas jet system is fed from a spherical tank holding 4.5 pounds of nitrogen gas under high pressure, regulating and dumping valves and three pairs of opposed gas jets with solenoid operated valves for each jet. One pair of jets is located at the end of each of the three landing legs. The pair on one leg control motion in a horizontal plane, imparting roll motion to the spacecraft. The other two pairs control pitch and yaw.

SURVEYOR SURVEY TV CAMERA



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Television

The Surveyor A spacecraft will carry 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 from a position where it reflects a portion of a landing leg to 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 either narrow angle, 6.4 x 6.4 field of view, or 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 either 200 or 600-line pictures. The latter requires that the high-gain directional antenna and the high power level of the transmitter are both working. 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.

Surveyor A also will carry a downward-looking television camera mounted on the lower frame of the spacecraft. However, this camera is not planned to be turned on during this mission.

Engineering Instrumentation

Engineering evaluation of the Surveyor test flights will be made by an engineering payload including an auxiliary battery, 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 measuring structural vibration during main retro burn.

The auxiliary battery will provide a backup for both emergency power and peak power demands to the main battery and the solar panel. It is not rechargeable. The auxiliary engineering signal processor provides two additional telemetry commutators for determining the performance of the spacecraft. It processes the information in the same manner as the engineering signal processor, providing additional signal capacity and redundancy.

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ATLAS-CENTAUR (AC-10) LAUNCH VEHICLE

Atlas-Centaur's primary objective is to inject the Surveyor A spacecraft on a lunar-transfer trajectory with sufficient accuracy so that the midcourse maneuver correction required some 20 hours after liftoff does not exceed some 165-feet-per-second or 111.85 miles-per-hour.

The Centaur stage is then required to perform a retromaneuver after spacecraft separation. This alters Centaur's trajectory sufficiently to avoid impacting the Moon and also prevents Surveyor's star seeker from mistaking Centaur for Canopus on which Surveyor will focus for spacecraft orientation.

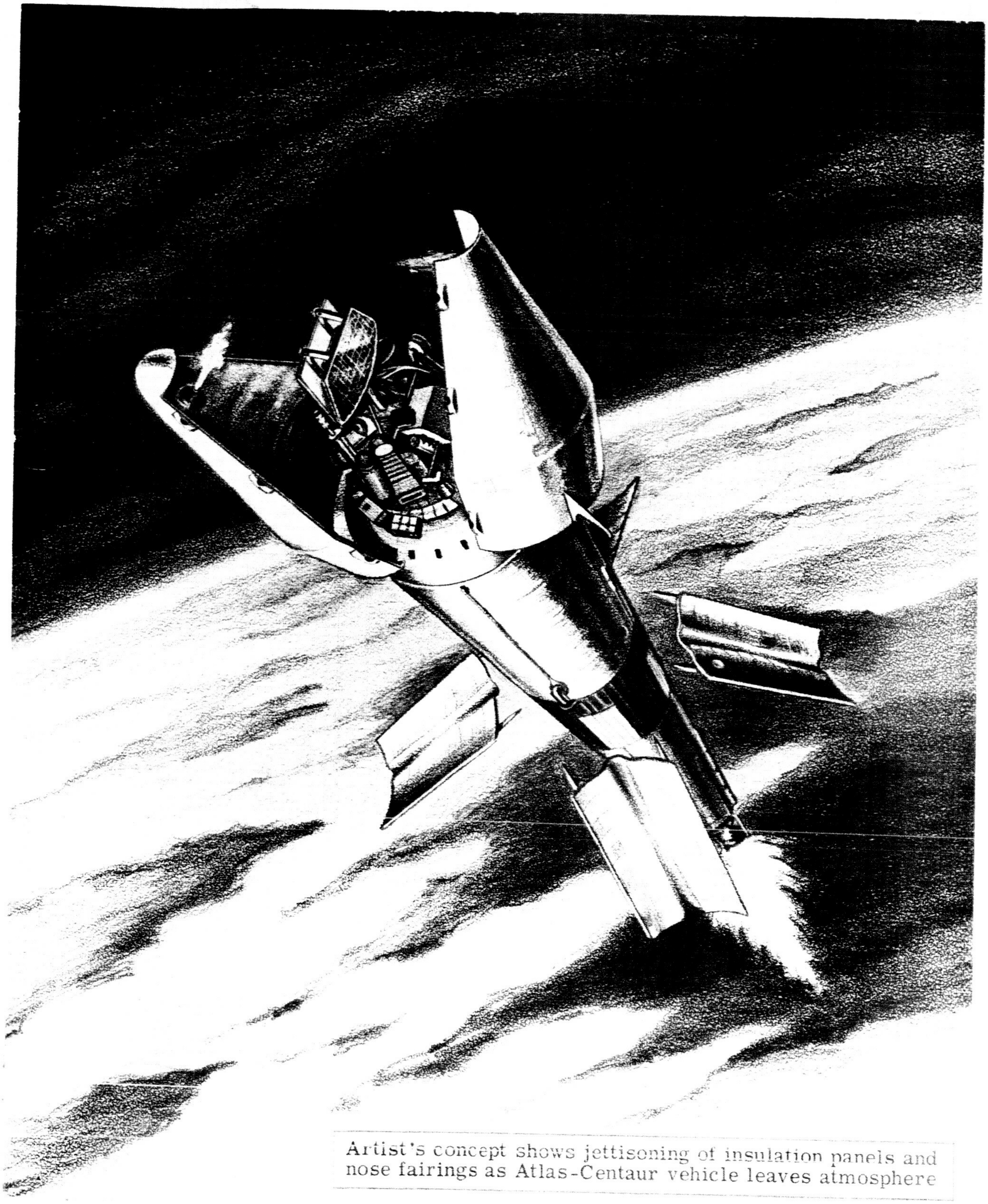
Configuration of the AC-10 vehicle is similar to that of AC-6, which on Aug. 11, 1965, demonstrated Centaur's capability to inject a Surveyor spacecraft on a direct-ascent, lunar-transfer trajectory. For the AC-10 vehicle, Centaur's inertial guidance system has been updated, four 50-pound thrust hydrogen-peroxide engines have been added for the retromaneuver, the attitude control engines have been uprated, and some minor telemetry systems have been modified.

The Centaur launch vehicle includes an LV-3C Atlas booster combined with a Centaur second stage. Both stages are 10 feet in diameter and are connected by an interstage adapter.

The Atlas first stage is 75 feet high, including the interstage adapter, and uses a standard MA-5 propulsion system. It consists of two booster engines and a sustainer engine, developing a total of 388,000 pounds of thrust. Two vernier engines of 670 pounds thrust each provide roll control.

The Centaur upper stage, including the nose fairing which surrounds Surveyor, is 48 feet long. Centaur is powered by two high-energy RL-10 hydrogen-oxygen engines, each with 15,000 pounds thrust. The RL-10 was the first high-energy engine developed for the space program and the first to be flown successfully in space.

Centaur's tank is constructed of stainless steel, 0.014 inches thick. Atlas is also fabricated of stainless steel.



Artist's concept shows jettisoning of insulation panels and nose fairings as Atlas-Centaur vehicle leaves atmosphere

The Centaur stage is surrounded by thermal insulation panels to minimize the boiloff of liquid hydrogen which is maintained at -423 degrees F. The four panels are jettisoned after the vehicle leaves the atmosphere.

The nose fairing, constructed of honeycombed fiberglass, surrounds the payload and guidance and electronic equipment packages mounted on Centaur and provides thermal and aerodynamic protection during flight through the atmosphere. The clamshell fairings are jettisoned shortly after the insulation panels.

Atlas and Centaur are separated in flight by a linear-shaped charge which severs the interstage adapter. Eight retrorockets mounted on the aft end of Atlas are fired to increase the rate of separation.

In addition to its primary propulsion system, the Centaur stage uses hydrogen-peroxide attitude control rockets of 3.5 and 6 pounds thrust and four 50-pound thrust hydrogen-peroxide thrusters which are used during the retromaneuver.

Pre-flight Checkout

Atlas-Centaur vehicles are subjected to rigorous preflight checkout procedures prior to shipment to Cape Kennedy for erection and subsequent launch.

The Atlas-Centaur vehicle and its Surveyor payload rehearse the lunar mission in a unique facility designed to ground-test all stages--including the payload--of a space vehicle.

This flight simulation is done in a Combined Systems Test Stand (CSTS) by Convair and Hughes personnel in San Diego. CSTS, operated for NASA by Convair, is designed to reduce vehicle preparation time at Cape Kennedy. During Atlas-Centaur-Surveyor testing, personnel are present from NASA, Convair, JPL and Hughes.

In combined systems testing, the Atlas-Centaur-Surveyor combination simulates electronically all aspects of a lunar mission. Recording equipment in the CSTS operations room is similar to that at Cape Kennedy and countdown procedures used are the same as for an actual launch. Tests are run to coincide with launch-on-time conditions.

Centaur's RL-10 engines undergo at least three test firings prior to each mission. During its development and operational program, the RL-10 has accumulated about 8000 firings--including test firings and Centaur and Saturn I missions. Total firing time for the RL-10 has passed 1,000,000 seconds.

Centaur's inertial guidance system, which issues all flight control commands following Atlas booster engine cut-off, is checked out at the contractor's facility prior to acceptance for a Centaur flight vehicle. This system is built by Honeywell, Inc., at its St. Petersburg, Fla., facility.

Once the vehicles, spacecraft, their systems and subsystems have satisfactorily passed combined systems testing, they are shipped to Cape Kennedy for erection on the Centaur launch complex.

The Atlas booster for AC-10 was erected at Pad 36-A on March 21, followed by the Centaur stage on March 31, and the Surveyor spacecraft on April 17.

The vehicle successfully completed a tanking test, actual tanking of both Atlas and Centaur propellants, on April 20. This was followed by a Joint Flight Acceptance Test (J-FACT) on April 26. A final Combined Readiness Test (CRT) is scheduled for May 26. The latter test confirms that the vehicle-spacecraft combination is in a launch-ready condition.

The main test program was conducted at the Convair Kearney Mesa plant, the Sycamore Canyon test facility and at Pt. Loma in San Diego. Additional testing includes a two-year series of dynamic tests at the NASA Lewis Research Center's Plum Brook Station with a complete Atlas-Centaur/Surveyor, simulated high-altitude testing in Lewis' Space Power Chamber and separation and nose fairing jettison tests in a vacuum chamber at Lewis, located in Cleveland.

Centaur Flight History

The Centaur vehicle has completed its single-burn, direct-ascent development program and was declared operational for lunar and planetary missions, following the successful AC-6 mission last August. During the AC-6 mission, a dynamic model of Surveyor was injected toward a target in space, called an imaginary Moon, with sufficient accuracy that, had a Surveyor spacecraft been directed to a landing on the Moon, a midcourse velocity correction of only 9.5 miles per hour would have been required.

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Yet to be demonstrated in the Centaur development program is a restart capability which will provide greater flexibility in vehicle launch operations by widening launch windows--periods during which lunar or planetary payloads must be launched to intercept the target--from minutes to hours. Earth parking orbits also would permit Surveyor launches to be attempted during winter months when lunar lighting conditions are unfavorable for direct-ascent trajectories.

The Centaur project was initiated by the Advanced Research Projects Agency in 1958 as the nation's first high-energy rocket vehicle. Using liquid hydrogen with a liquid oxygen oxidizer, Centaur provides about a 40 per cent increase in performance over vehicles using conventional kerosene-type fuels.

The project was transferred to NASA's Marshall Space Flight Center in 1960 and later to the agency's Lewis Research Center in late 1962.

The exact cause of the depletion of hydrogen-peroxide fuel on the AC-8 mission has not been determined. A similar vehicle development flight--last in the series of Centaur vehicle tests--is scheduled later this year.

Other Atlas-Centaur vehicles are scheduled to carry Surveyor spacecraft to the Moon and Mariner spacecraft to Mars during the 1969 launch opportunity.

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ATLAS-CENTAUR FACT SHEET

(All figures approximate)

Liftoff Weight: 303,000 lbs.

Liftoff Height: 113 feet

Launch Complex: 36-A

	Atlas Booster	Centaur Stage
Weight	263,000 lbs.	37,500 lbs. (less payload)
Height	75 feet (including interstage adapter	48 feet (with fairing)
Thrust	388,000 lbs. (sea level)	30,000 lbs. (at altitude)
Propellants	RP-1 (fuel) and liquid oxygen (oxidizer)	Liquid hydrogen (fuel) and liquid oxygen (oxidizer)
Propulsion	MA-5 system (2-165,000 lb. thrust booster engines, 1-57,000 lb. sustainer engine, and 2-670 lb. vernier engines)	Two RL-10 engines
Velocity	5560 mph at BECO 7700 mph at SECO	23,500 mph at injection
Guidance	Preprogrammed autopilot through BECO	Inertial

ATLAS-CENTAUR FLIGHT SEQUENCE

EVENT	NOMINAL TIME, SEC.	ALTITUDE, STATUTE MI.	SURFACE RANGE STATUTE MI.	VEL/MPH
1. Liftoff	0	0	0	0
2. Booster Engine Cutoff	142	36	49	5560
3. Booster Engine Jettison	145	39	54	5630
4. Jettison Insulation Panels	176	58	100	6150
5. Jettison Nose Fairing	203	74	144	6700
6. Sustainer Engine Cutoff	240	97	212	7600
7. Atlas-Centaur Separation	242	98	215	7600
8. Centaur Engine Start	251	104	234	7600
9. Centaur Engine Cutoff	685	144	1740	23,500
10. Spacecraft Separation	757	111	2200	23,500
11. Centaur Reorientation	762	109	2200	23,500
12. Centaur Retrothrust	997	207	3700	23,500

(Launch vehicle mission completed at T plus 21 minutes)

Figures used are approximate but typical of potential trajectories for AC-10, depending on day of launch.

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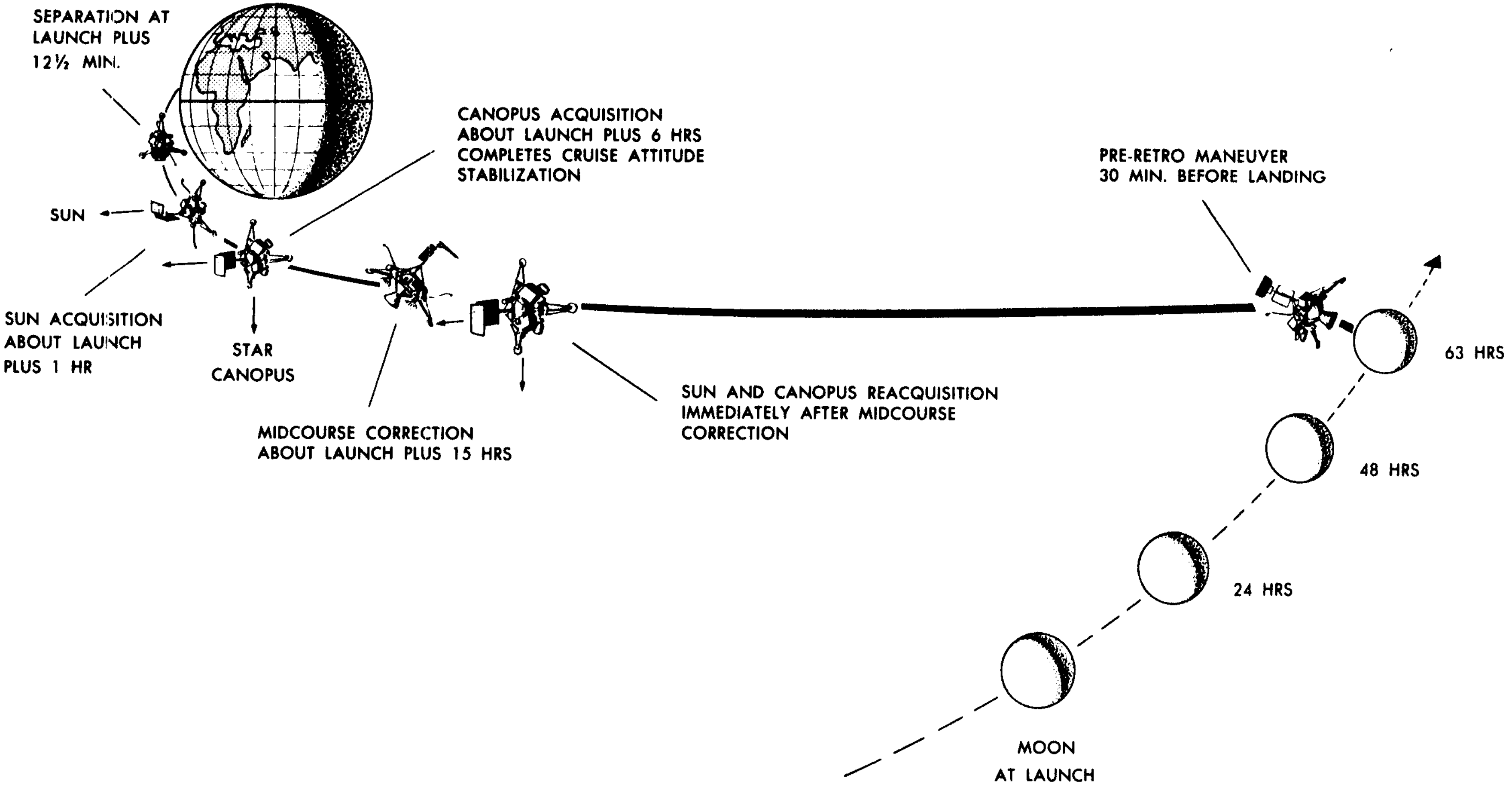
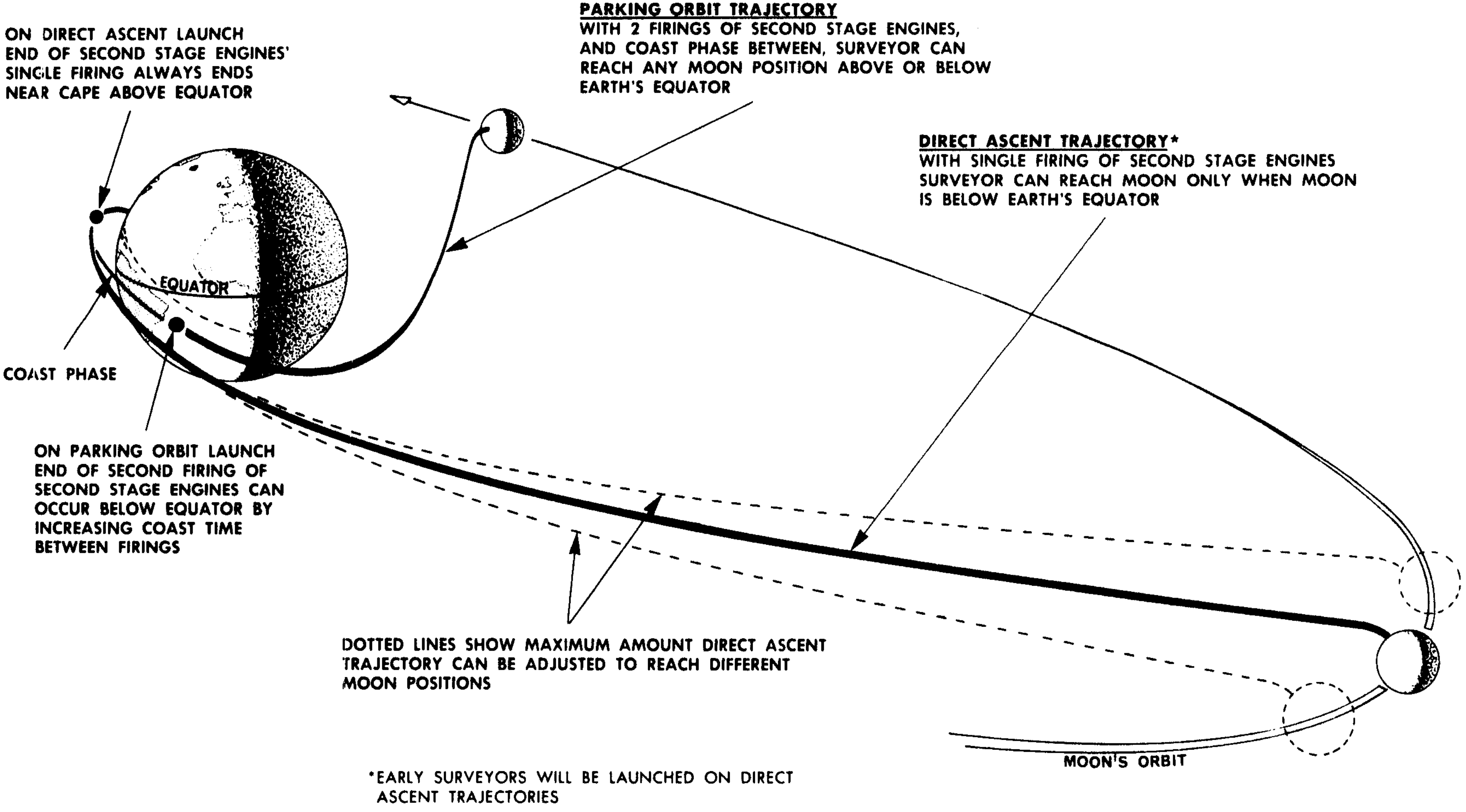
SURVEYOR FLIGHT PROFILE



SURVEYOR TRAJECTORIES TO THE MOON



TRACKING AND COMMUNICATION

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

The Deep Space Network consists of six permanent space communications stations in Australia, Spain, South Africa, and the California Mojave Desert; a spacecraft monitoring station at Cape Kennedy; and a spacecraft guidance and command station at Ascension Island in the South Atlantic.

The DSN facilities assigned to the Surveyor project are Pioneer at Goldstone, Calif.; and those at Johannesburg, South Africa, and Tidbinbilla in the Canberra Complex, Australia.

The Goldstone facility is operated by JPL with the assistance of the Bendix Field Engineering Corp. The Tidbinbilla facility is operated by the Australian Department of Supply. The Johannesburg facility is operated by the South African government through the Counsel of Scientific and Industrial Research and the National Institute for Telecommunications Research.

The DSN 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 the Goddard Space Flight Center, Greenbelt, Md.

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

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 command 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 DSN 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 a Surveyor spacecraft 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 persistance 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 spacecraft operations.

TRAJECTORY

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

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A primary consideration is the direct ascent launch as opposed to the parking orbit technique. A parking orbit is more complex in that it requires the Centaur second stage to fire its engines to achieve the initial circular orbit, coast in orbit about the Earth and then to fire its engines the second time to accelerate the spacecraft to the required lunar transit velocity.

In its first operational missions the Centaur will not be required to perform the complex double burn. After separation from the Atlas booster, the Centaur will ignite its engines which will continue to burn until the lunar transit velocity has been reached. This velocity varies slightly with launch day and time but is approximately 24,500 mph.

Use of the direct ascent trajectory limits each monthly launch period to those days when the Moon is at negative declinations -- that is, in positions, relative to Earth, below the Earth's equator.

The days of the month available for launching are determined by the attainable range in the flight path angle of the Centaur at injection -- that point in time when the Centaur engines cease firing and the required velocity for a lunar flight has been reached. The flight path angle is the angle at which Centaur is moving relative to a horizontal plane of the Earth below. Changes in this angle compensate for the daily change in the position of the Moon.

The attainable range in the angle is determined by the fuel available in the Atlas-Centaur combination, as both vehicles are involved in the angle of Centaur at injection. Any deviation from a horizontal flight path at injection requires more fuel to inject a given spacecraft weight at the required velocity.

The time span during each day that Surveyor can be launched -- the launch window -- 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. However, by altering the plane as a result of changing the launch azimuth, or direction of launch from the launch site, between an allowable 80 to 115 degrees, East of North, the launch window can be extended up to as much as two hours.

The launch azimuth constraint of 80 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 to 65 hours, is determined by the fact that Surveyor must reach the Moon during the viewing period of the prime Deep Space Net station at Goldstone.

The trajectory is also influenced by the landing site selection. This selection is based on several considerations, one that a limitation is imposed on the first Surveyor flights the spacecraft's angle of approach to the Moon must not exceed 20 degrees off vertical. There is essentially only one point on the Moon for each launch day that a spacecraft can land vertically.

The 20-degree consideration then, in effect, draws a constraining circle around this point. Surveyor must land within that circle.

The landing sites are further limited by the curvature of the Moon. The trajectory engineer cannot pick a site, even if it falls within his 20-degree circle, 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 the landing area selected for the Apollo manned lunar mission.

Lighting conditions on the Moon on arrival of the spacecraft at a given landing site are determined by the launch day which, in turn, is controlled by the use of direct ascent trajectories which limits the launch days available. In later missions using a parking orbit, the launch day can be picked to provide optimum light conditions.

Thus the trajectory engineer must tie together the direct ascent 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 allow Surveyor to remain too long in the Earth's shadow. Too long a period could result in malfunction of components or subsystems. In addition, the Surveyor must not remain in the shadow of the Moon beyond given limits.

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 nearly 6000 miles per hour 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 launch can be performed with sufficient accuracy to impact the Moon in exactly the desired area without a midcourse maneuver. The uncertainties involved in a launch usually yield a trajectory or an injection velocity that vary slightly from the desired values. These 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 in a specific direction to change its velocity. The trajectory of a body at a point in space is basically determined by its velocity.

For example, a simple midcourse maneuver 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. Generally, however, the midcourse is far more complex and will involve changes both in velocity and its 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.

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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.

SURVEYOR A FLIGHT MISSION

Surveyor will be launched by an Atlas first stage and Centaur second stage into a direct ascent lunar trajectory. A parking orbit will not be used in order to simplify the demands on the Centaur in its first operational mission.

Atlas Phase

All five of the Atlas engines -- three main engines and two vernier control engines -- are ignited just before liftoff. For the first two seconds, the Atlas-Centaur rises vertically and then for 13 seconds rolls to the desired flight plane azimuth of from 85 to 115 degrees depending upon launch time.

After 15 seconds of flight, the vehicle begins pitching over the desired flight trajectory which continues throughout the Atlas-powered phase of the flight.

At 142 seconds after liftoff, booster engine cutoff (BECO) occurs when an acceleration level of 5.7 Gs is sensed. Three seconds later the boosters are jettisoned and the sustainer engine continues to propel the vehicle and Centaur guidance starts steering the Atlas.

After 176 seconds of flight, the four insulation panels around the Centaur stage are jettisoned and 27 seconds later the nose fairing is jettisoned. Atlas sustainer engine cutoff (SECO) occurs at fuel depletion after 240 seconds of flight at an altitude of about 97 miles. Two seconds later, Atlas and Centaur separate.

Centaur Phase

Prior to ignition of the Centaur stage, the RL-10 engines are prechilled with propellants to avoid vaporization of the -423 degree F. liquid hydrogen as it enters the turbopumps. Initial prechilling was performed on the ground prior to liftoff using liquid helium at -452 degrees F., in order to minimize in-flight propellant use.

At 251 seconds after liftoff at an altitude of about 104 miles, Centaur's two engines are ignited for a planned burn of 434 seconds. Shutdown occurs at about 685 seconds when the guidance system senses that the vehicle has attained proper velocity.

Shortly after cutoff, the programmer **commands** extension of Surveyor's legs and two omnidirectional antennas and orders the spacecraft's transmitter to high power. The programmer then commands separation of Surveyor from Centaur after some 757 seconds of flight at an altitude of 111 miles. Three spring-loaded cylinders force Centaur and Surveyor apart.

Five seconds later, Centaur is rotated 180 degrees by its attitude control system in order to perform a retro-maneuver to insure that sunlight reflected from Centaur will not confuse Surveyor's optical sensors and to prevent Centaur from impacting the Moon.

Residual propellants are blown through Centaur's engines for about four minutes resulting in Centaur and Surveyor being separated by at least 200 miles some five hours after launch.

At liftoff plus 21 minutes, Atlas-Centaur has completed its part of the mission. The Centaur stage continues in a highly elliptical Earth orbit, extending more than 250,000 miles into space and circling theEarth once each 11 days with an orbital inclination of about 33.6 degrees.

Initial Surveyor Phase

After separation from Centaur, Surveyor gives an automatic command to fire explosive blots to unlock the solar panel. A stepping motor moves the panel to a prescribed position. Solar panel deployment can also be commanded from the ground if the automatic sequence fails.

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

The Sun acquisition sequence begins immediately after separation from Centaur simultaneously with the solar panel deployment. The nitrogen gas jet system, which is activated at separation, will first eliminate 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 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 pulse 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 station at Johannesburg, South Africa, the first DSN station 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 axis.

Canopus Acquisition

Canopus acquisition is commanded from the ground about six hours after launch. The gas jets 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 orders the roll to stop and locks on to the star. The brightness of the light source it is seeing is 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. 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 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 pulsing intermittently to keep the craft aligned on the Sun and Canopus.

The engineering and tracking information is being received from Surveyor at one of the stations of the Deep Space Net. The data is communicated to the Space Flight Operations Facility at JPL where the flight path of the spacecraft is being carefully calculated and the condition of the spacecraft continuously monitored.

Midcourse Maneuver

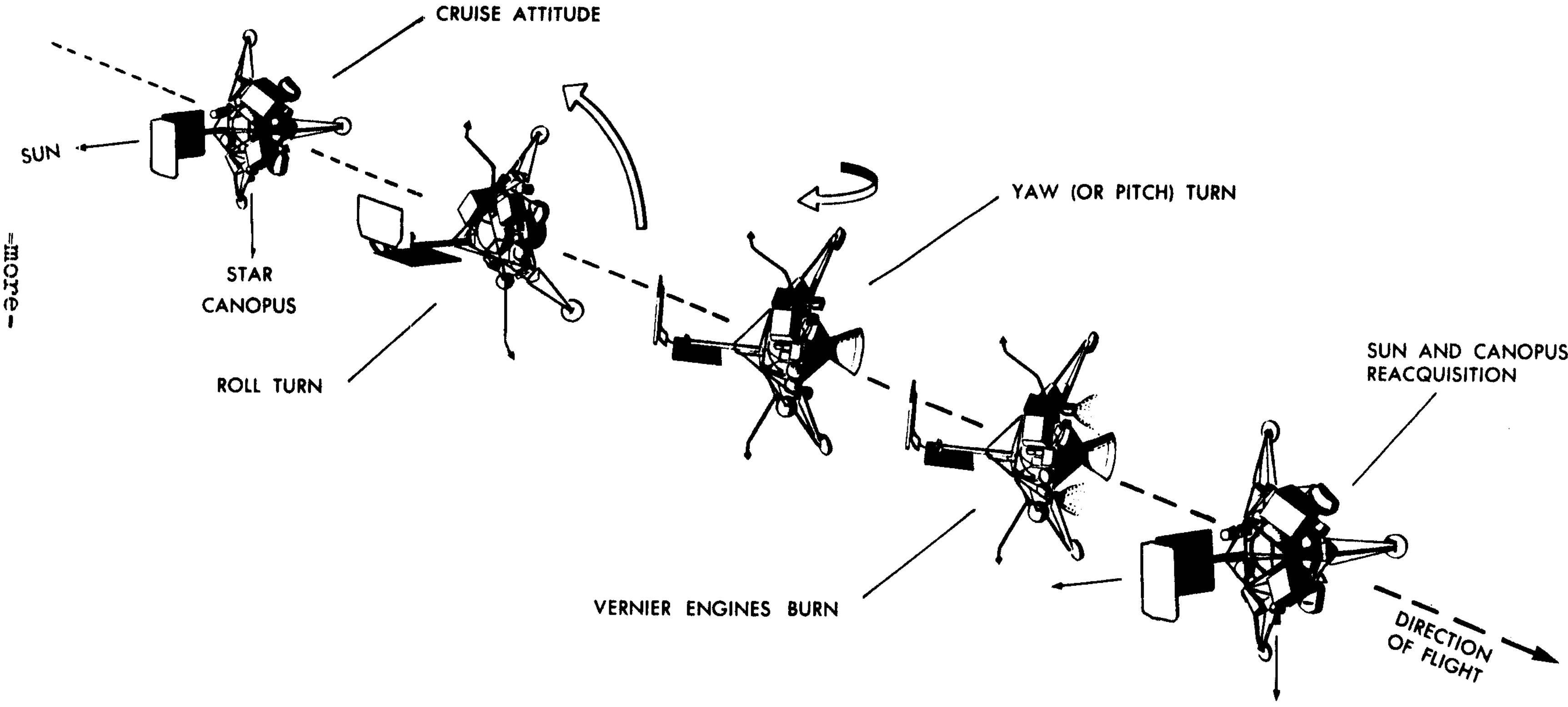
Tracking data is used to determine how large a trajectory correction must be made to land Surveyor in a given target area. This trajectory correction, called the midcourse maneuver, is required because of uncertainties in the launch operation that prevent absolute accuracy in placing a spacecraft on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

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

The thrust for the midcourse is provided by the spacecraft's three liquid fuel vernier engines. This will be the first midcourse maneuver to be performed with this type of propulsion system. Total thrust level is controlled by an accelerometer at a constant acceleration equal to 0.1 Earth g. 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, Surveyor is commanded to roll, then pitch or yaw to achieve this alignment. Normally, two maneuvers are required, a roll-pitch or a roll-yaw.

SURVEYOR MIDCOURSE CORRECTION



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, ground controllers command it to perform the first maneuver. The second maneuver is handled in the same fashion. When the motors are properly aligned, 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.

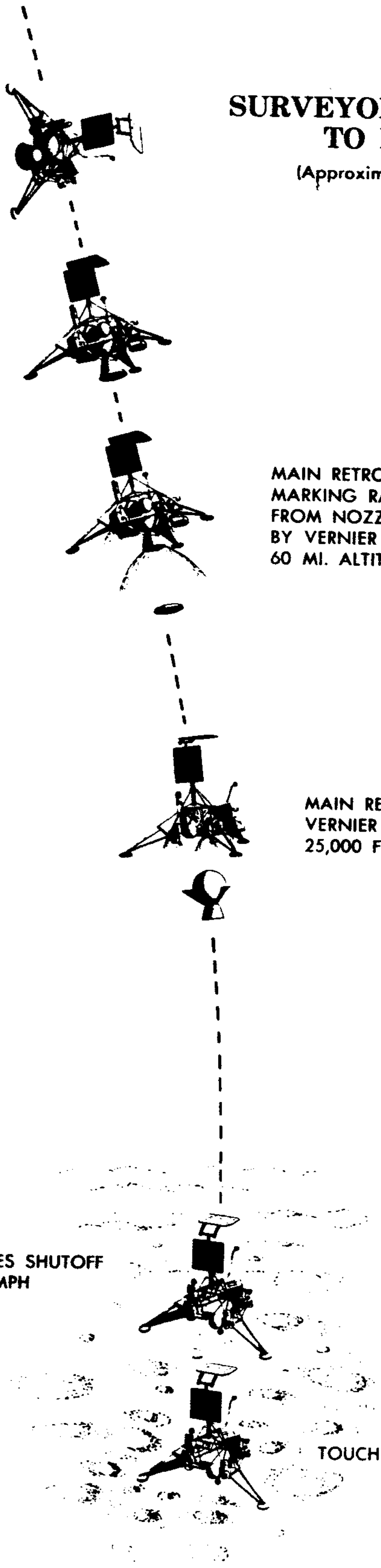
Terminal Sequence

The first step starts about 1000 miles above the Moon's surface. The exact descent maneuvers depend on the flight path and orientation of the Surveyor with respect to the Moon and the target area. Normally there 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 maneuvers is to align the main retro rocket with the approach velocity vector. To perform the maneuvers, the spacecraft breaks its lock on the Sun and Canopus. Attitude control is maintained by inertial sensors. Gyros sense changes in the attitude and order the gas jets to fire to maintain the correct attitude until the retrorocket is ignited.

With the main retro aligned, the altitude marking radar is activated by ground command at approximately 200 miles above the Moon's surface. All subsequent terminal events are automatically controlled by radar and the Flight Control Programmer. The auxiliary battery is connected to help the main battery supply the heavy loads required during descent.

SURVEYOR TERMINAL DESCENT TO LUNAR SURFACE

(Approximate Altitudes and Velocities Given)



CRUISE ATTITUDE

PRE-RETRO MANEUVER 30 MIN.
BEFORE TOUCHDOWN ALIGNS
MAIN RETRO WITH FLIGHT PATH

MAIN RETRO START BY ALTITUDE
MARKING RADAR WHICH EJECTS
FROM NOZZLE, CRAFT STABILIZED
BY VERNIER ENGINES AT
60 MI. ALTITUDE, 6,100 MPH

MAIN RETRO BURNOUT AND EJECTION,
VERNIER RETRO SYSTEM TAKEOVER AT
25,000 FT, 240 MPH

VERNIER ENGINES SHUTOFF
AT 13 FT, 3½ MPH

TOUCHDOWN AT 10 MPH

At approximately 60 miles slant range from the Moon's surface, the marking radar starts the Flight Control Programmer which then counts down a previously stored delay time and commands ignition of the three liquid fueled, throttleable vernier engines and then the solid propellant main retro. The vernier engines maintain a constant spacecraft attitude during the main retro thrusting period, in a manner similar to that employed during midcourse thrusting. The spacecraft is traveling at approximately 6,000 miles per hour. The main retro burns out in 40 seconds at about 25 miles 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 controls 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 is then controlled by the RADVS and the vernier engines. Signals from RADVS are processed by the flight control electronics to throttle the three vernier engines reducing velocity as the altitude decreases. At 14 feet above the surface, Surveyor is slowed to five feet per second. At this point the engines are shut off and the spacecraft free falls to the surface.

The landing impact is cushioned by crushable foot pads and shock absorbers on each of the three legs and by crushable honeycomb aluminum blocks under the frame in case of an exceptionally hard landing.

Post-landing Events

Of prime interest to the engineers who designed Surveyor is the engineering telemetry received during the descent and touchdown. Touchdown is followed by periods of engineering telemetry to determine the condition of the spacecraft.

If the spacecraft is in operational condition on the surface, flight control power is turned off to conserve battery power and a series of wide angle 200-line TV pictures are taken.

The solar panel and high gain planar array antenna are aligned with the Sun and Earth. 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: the power remaining in the batteries in the event that the Sun is not acquired by the solar panel, spacecraft reaction to the intense heat of the lunar day, etc. The first Surveyors are not expected to last through a lunar night.

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ATLAS-CENTAUR AND SURVEYOR TEAMS

NASA HEADQUARTERS, WASHINGTON, D.C.

Dr. Homer E. Newell	Associate Administrator for Space Science and Applications
Robert F. Garbarini	Deputy Associate Administrator for Space Science and Applications (Engineering)
Oran W. Nicks	Director, Lunar and Planetary Programs
Benjamin Milwitzky	Surveyor Program Manager
V. L. Johnson	Director, Launch Vehicle and Propulsion Programs
R. Duff Ginter	Centaur Program Manager

JET PROPULSION LABORATORY, PASADENA, CALIF.

Dr. William H. Pickering	Director
Gen. A. R. Luedecke	Deputy Director
Robert J. Parks	Surveyor Project Manager
Howard H. Haglund	Deputy Project Manager for Hughes Aircraft Co. Operations
Walker E. Giberson	Deputy Project Manager for Mission Requirements, Plans and Operations
Dr. Leonard Jaffe	Project Scientist
Dr. Eberhardt Rechtin	Assistant Laboratory Director for Tracking and Data Acquisition
Dr. Nicholas A. Renzetti	Surveyor Tracking and Data Systems Manager
W. E. Larkin	JPL Engineer in Charge, Goldstone
J. Buckley	Pioneer Station Manager, Goldstone

R. J. Fahnestock	JPL DSN Resident in Australia
R. A. Leslie	Tidbinbilla Station Manager
R. C. Terbeck	JPL DSN Resident in South Africa
D. Hogg	Johannesburg Station Manager

LEWIS RESEARCH CENTER, CLEVELAND, O.

Dr. Abe Silverstein	Director
Bruce T. Lundin	Associate Director for Development
Edmund R. Jonash	Centaur Project Manager

KENNEDY SPACE CENTER, FLA.

Dr. Kurt R. Debus	Director
Robert H. Gray	Director of Unmanned Launch Operations

HUGHES AIRCRAFT COMPANY, CULVER CITY, CALIF.

Dr. Fred P. Adler	Vice President and Manager of Space Systems Division

GENERAL DYNAMICS/CONVAIR, SANDIEGO, 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.

R. B. Foster	Centaur Guidance Program Manager

MAJOR SUBCONTRACTORS

SURVEYOR

AiResearch Division Garrett Corporation Torrance, Calif.	Ground support equipment
Airite El Segundo, Calif.	Nitrogen tanks
Airtek Division Fansteel Metallurgical Corp. Compton, Calif.	Propellant tanks
Ampex Redwood City, Calif.	Tape recorder
Astrodata Santa Ana, Calif.	Time clocks
Bell & Howell Company 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 Company Joplin, Mo.	Auxiliary batteries
Electric Storage Battery Raleign, N.C.	Main batteries
Electro-Development Corp. Seattle, Wash.	Strain gage electronics
Electro-Mechanical Research Sarasota, Fla.	Decommutators
Endevco Corporation Pasadena, Calif.	Accelerometers

General Electro Dynamics Garland, Tex.	Vidicon tubes
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
Kearfott Division General Precision Company Little Falls, N.J.	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

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Sanborn Waltham, Mass.	L. F. oscillograph
Scientific-Atlanta Atlanta, Ga.	System test stand
Singer-Metrics Bridgeport, Mass.	F. M. calibrator
Thiokol Chemical Corp. Elkton Division Elkton, Md.	Main retro engine
Thiokol Chemical Corp. Reaction Motors Division Denville, N. J.	Vernier propulsion system
Telemetrics Santa Ana, Calif.	Simulator
United Aircraft Corp. Norden Division Southampton, Penn.	Subcarrier oscillator
Vector Southhampton, Penn.	Subcarrier oscillator

ATLAS

Rocketdyne Div. of North American Aviation Inc. (associate prime) Canoga Park, Calif.	MA-5 propulsion system
Thiokol Chemical Corp. Reaction Motors Div.	LOX and fuel staging valves
Hadley Co. Inc.	Valves, regulators and disconnect coupling
Fluidgenics Inc.	Regulators
General Precision Inc. Kearfott Div. San Marcos, Calif.	Displacement gyros
Honeywell Inc. Aeronautical Div.	Rate gyros

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Fifth Dimension Inc.	Commutators
Bendix Corp. Bendix Pacific Div.	Telepaks and oscillators
Fairchild-Hiller Stratos Western Div.	LOX fuel and drain valves
Bourns Inc.	Transucers and potentiometers
Washington Steel Co. Washington, Pa.	Stainless steel

CENTAUR

General Dynamics/Ft. Worth Div., Ft. Worth, Tex.	Insulation panels and nose fairing
Pesco Products Div. of Borg-Warner Corp. Bedford, Ohio	Boost pumps for RL-10 engines
Bell Aerosystems Co. of Bell Aerospace Corp. Buffalo, N.Y.	Attitude control system
Liquidometer Aerospace Div. Simmonds Precision Products, Inc. Long Island, N.Y.	Propellant utilization system
General Precision Inc. Aerospace Gp., Kearfott Div., San Marcos, Calif.	Computer for inertial guidance system
Goodyear Aerospace Div. of Goodyear Tire and Rubber Co. Akron, Ohio	Handling trailer
Systems and Instruments Div. of Bulova Watch Co. Flushing, N.Y.	Destructors
Consolidated Controls Corp. El Segundo, Calif.	Safe and arm initiator

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Borg-Warner Controls Div. of Borg-Warner Corp. Santa Ana, Calif.	Inverter
Sippican Corp. Marion, Mass.	Modules for propellant utilization system
General Electric Co. Lynn, Mass.	Turbine
Vickers Div. of Sperry Rand Corp. Troy, Mich.	Hydraulic pumps
Edcliff Instruments, Inc. Monrovia, Calif.	Transducers and switches
Rosemount Engineering Co. Minneapolis, Minn.	Transducers
Scientific Data Systems Santa Monica, Calif.	Computers
W. O. Leonard,Inc. Pasadena, Calif.	Hydrogen and oxygen vent valves

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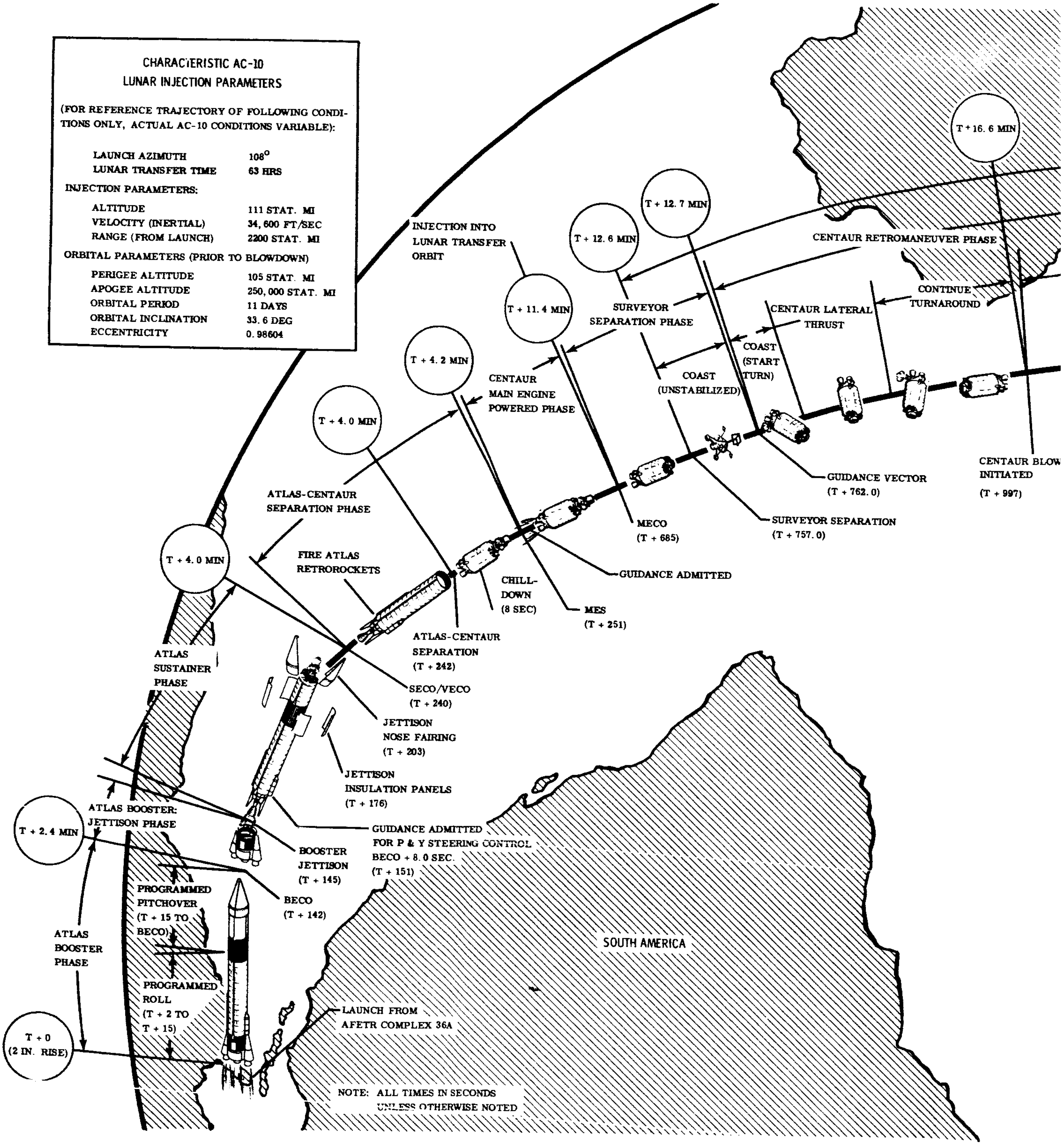
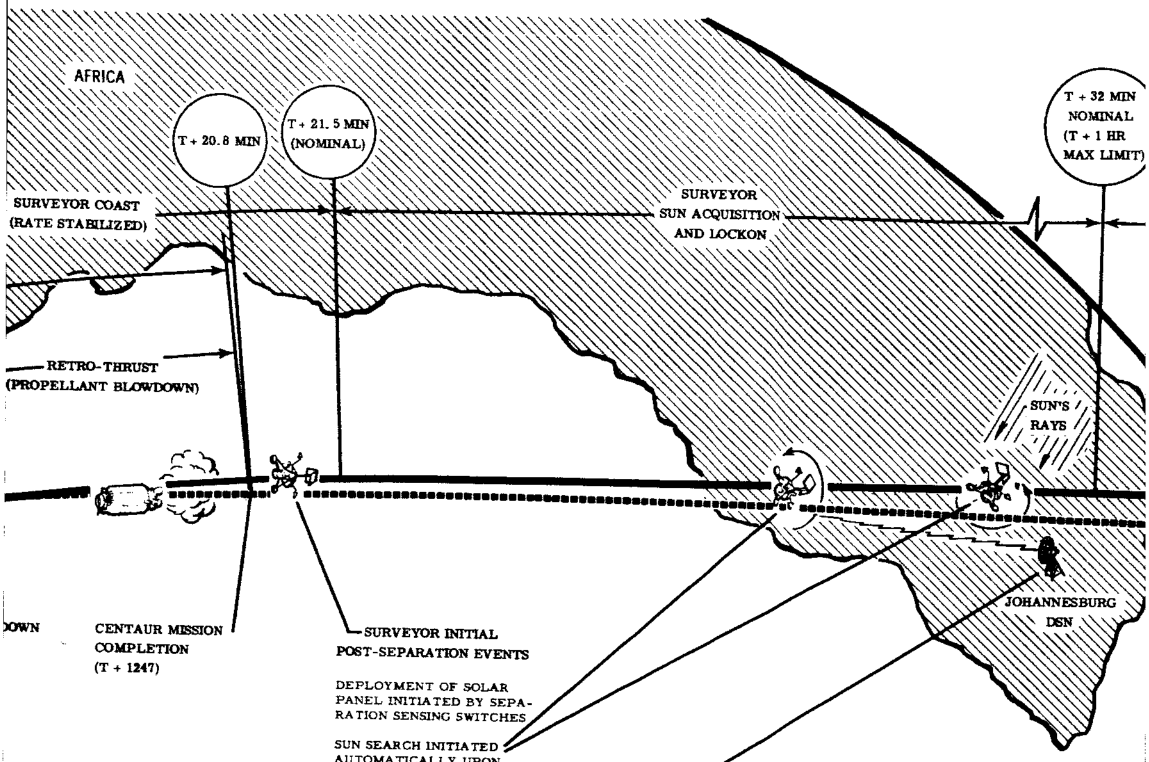
CHARACTERISTIC AC-10 LUNAR INJECTION PARAMETERS

(FOR REFERENCE TRAJECTORY OF FOLLOWING CONDITIONS ONLY, ACTUAL AC-10 CONDITIONS VARIABLE):

LAUNCH AZIMUTH	108°
LUNAR TRANSFER TIME	63 HRS
INJECTION PARAMETERS:	
ALTITUDE	111 STAT. MI
VELOCITY (INERTIAL)	34,600 FT/SEC
RANGE (FROM LAUNCH)	2200 STAT. MI
ORBITAL PARAMETERS (PRIOR TO BLOWDOWN)	
PERIGEE ALTITUDE	105 STAT. MI
APOGEE ALTITUDE	250,000 STAT. MI
ORBITAL PERIOD	11 DAYS
ORBITAL INCLINATION	33.6 DEG
ECCENTRICITY	0.98604





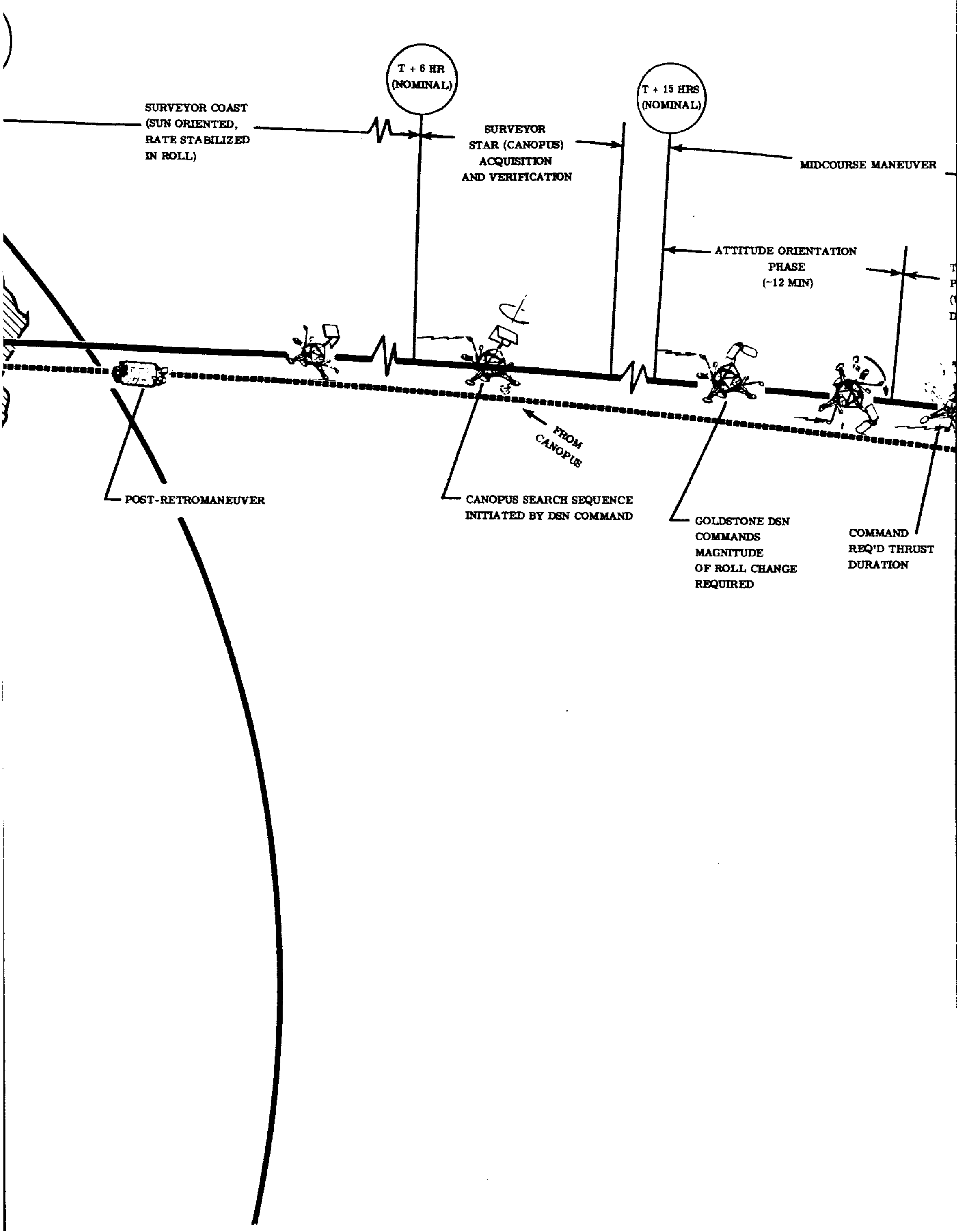
SURVEYOR INITIAL POST-SEPARATION EVENTS

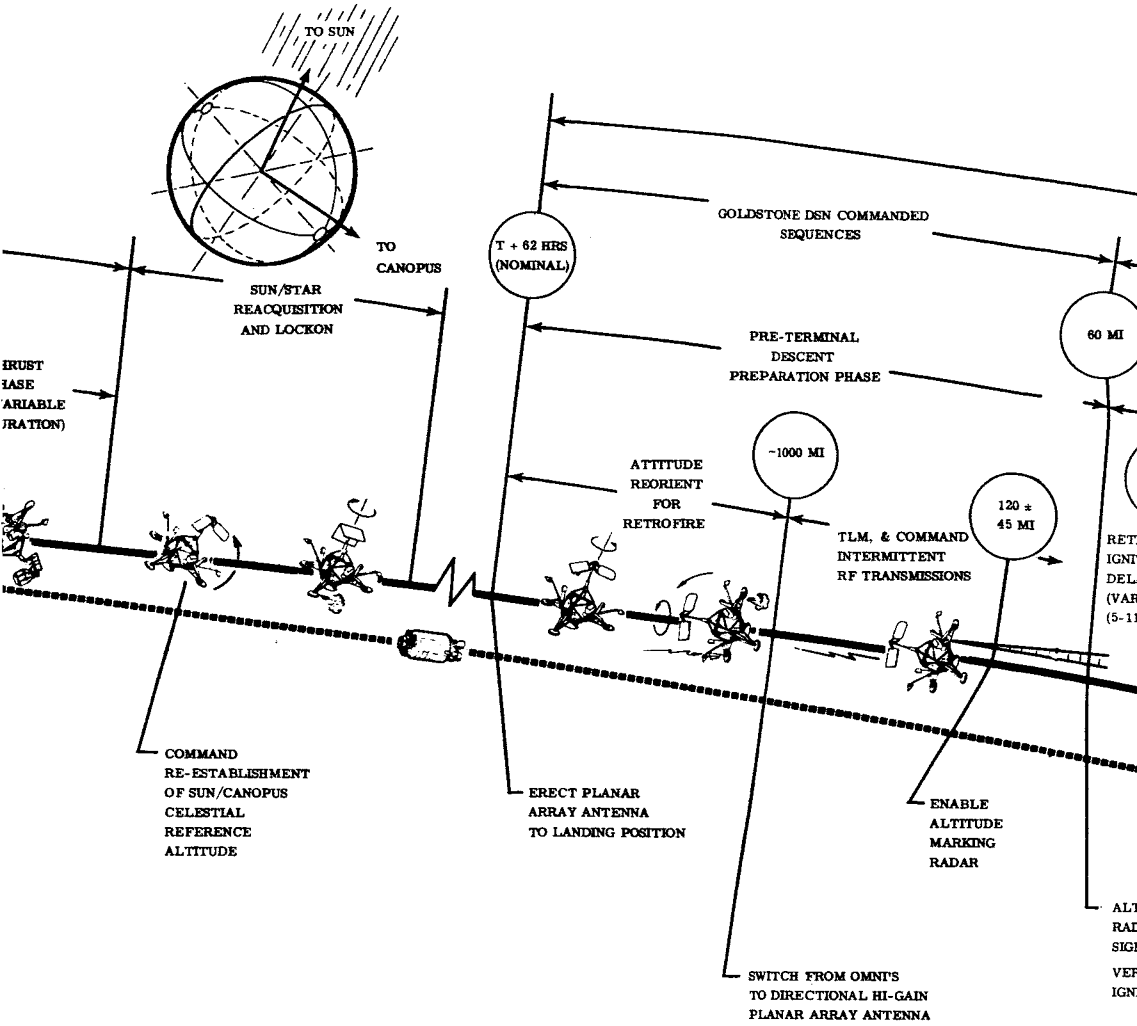
DEPLOYMENT OF SOLAR PANEL INITIATED BY SEPARATION SENSING SWITCHES

SUN SEARCH INITIATED AUTOMATICALLY UPON COMPLETION OF SOLAR PANEL DEPLOYMENT USING SUN SENSORS & GN_2 JETS UNTIL SPACECRAFT LONGITUDINAL AXIS POINTED TOWARD SUN

ACQUISITION BY JOHANNESBURG DSN GROUND STATION (WHEN IN VIEW) WITH ENSUING TRAJECTORY AND SPACECRAFT PERFORMANCE EVALUATIONS

SWITCH SURVEYOR TRANSMITTER BACK TO LOW-POWER


T + 6 HR (NOMINAL)
T + 15 HRS (NOMINAL)
SURVEYOR COAST (SUN ORIENTED, RATE STABILIZED IN ROLL)
SURVEYOR STAR (CANOPUS) ACQUISITION AND VERIFICATION
MIDCOURSE MANEUVER
ATTITUDE ORIENTATION PHASE (~12 MIN)
FROM CANOPUS
POST-RETROMANEUVER
CANOPUS SEARCH SEQUENCE INITIATED BY DSN COMMAND
GOLDSTONE DSN COMMANDS MAGNITUDE OF ROLL CHANGE REQUIRED
COMMAND REQ'D THRUST DURATION


TO SUN
TO CANOPUS
SUN/STAR REACQUISITION AND LOCKON
IRUST
IASE
'ARIABLE
JRATION)
T + 62 HRS (NOMINAL)
GOLDSTONE DSN COMMANDED SEQUENCES
60 MI
PRE-TERMINAL DESCENT PREPARATION PHASE
~1000 MI
ATTITUDE REORIENT FOR RETROFIRE
120 ± 45 MI
TLM, & COMMAND INTERMITTENT RF TRANSMISSIONS
RET
IGNI
DEL
(VAR
(5-11
COMMAND RE-ESTABLISHMENT OF SUN/CANOPUS CELESTIAL REFERENCE ALTITUDE
ERECT PLANAR ARRAY ANTENNA TO LANDING POSITION
ENABLE ALTITUDE MARKING RADAR
ALT
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SIGI
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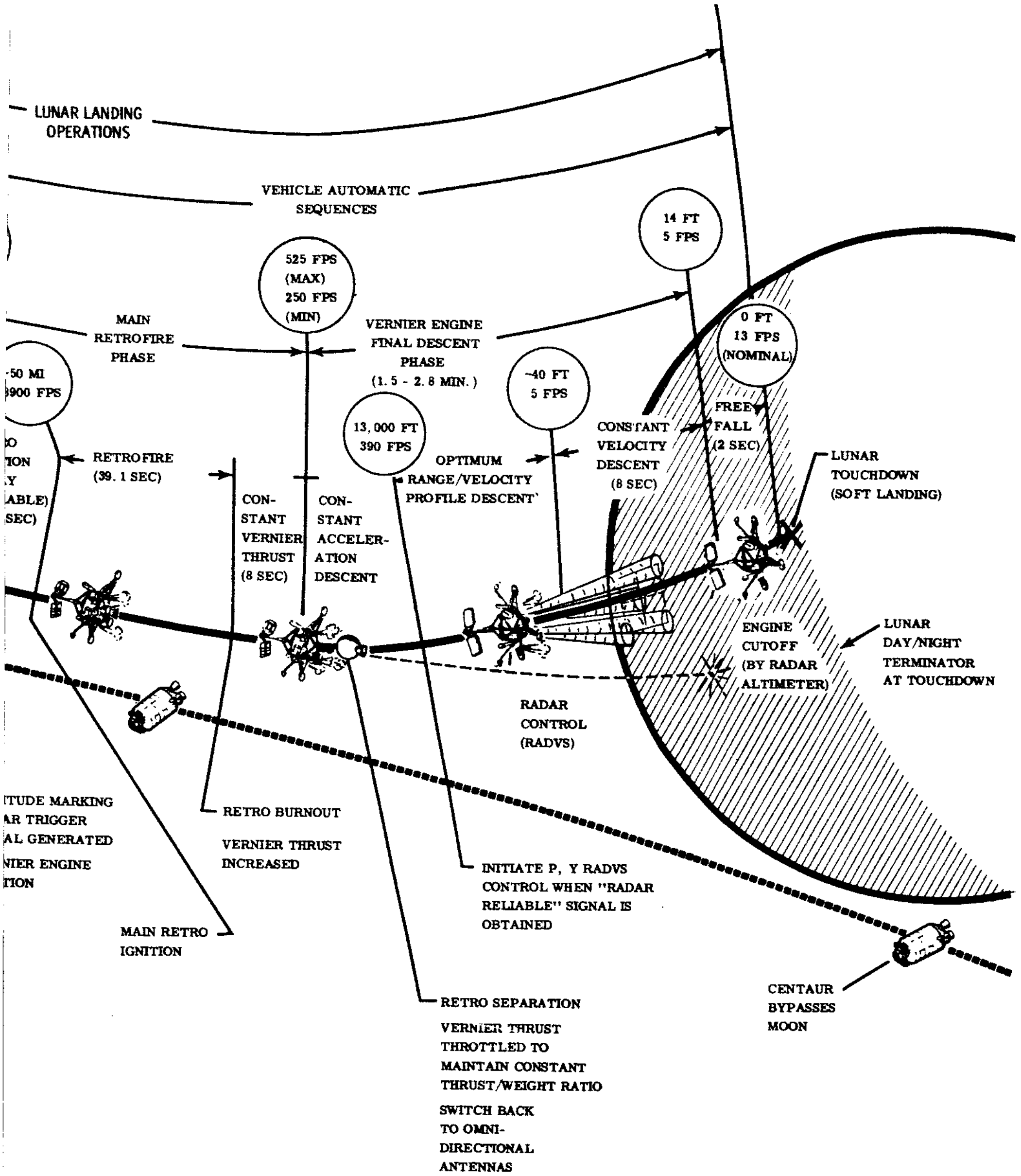
SWITCH FROM OMNI'S TO DIRECTIONAL HI-GAIN PLANAR ARRAY ANTENNA



LUNAR LANDING OPERATIONS
VEHICLE AUTOMATIC SEQUENCES
525 FPS (MAX) 250 FPS (MIN)
14 FT 5 FPS
0 FT 13 FPS (NOMINAL)
MAIN RETROFIRE PHASE
VERNIER ENGINE FINAL DESCENT PHASE (1.5 - 2.8 MIN.)
-50 MI
3900 FPS
~40 FT 5 FPS
13,000 FT 390 FPS
O
ION
Y
ABLE)
SEC)
RETROFIRE (39.1 SEC)
CON-STANT VERNIER THRUST (8 SEC)
CON-STANT ACCELER-ATION DESCENT
OPTIMUM RANGE/VELOCITY PROFILE DESCENT
CONSTANT VELOCITY DESCENT (8 SEC)
FREE FALL (2 SEC)
LUNAR TOUCHDOWN (SOFT LANDING)
ENGINE CUTOFF (BY RADAR ALTIMETER)
LUNAR DAY/NIGHT TERMINATOR AT TOUCHDOWN
RADAR CONTROL (RADVS)
ITUDE MARKING
AR TRIGGER
AL GENERATED
NIER ENGINE
TION
RETRO BURNOUT
VERNIER THRUST INCREASED
INITIATE P, Y RADVS CONTROL WHEN "RADAR RELIABLE" SIGNAL IS OBTAINED
MAIN RETRO IGNITION
CENTAUR BYPASSES MOON
RETRO SEPARATION
VERNIER THRUST THROTTLED TO MAINTAIN CONSTANT THRUST/WEIGHT RATIO
SWITCH BACK TO OMNI-DIRECTIONAL ANTENNAS