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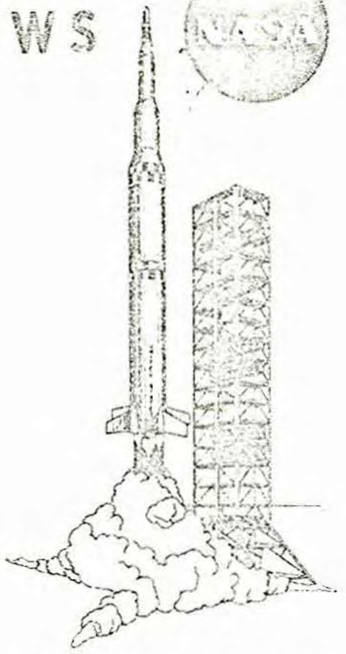
NEWS



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546
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FOR RELEASE: THURSDAY A.M.
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PRESS KIT

PROJECT: APOLLO 6
(To be launched on
or after Apr. 3)

contents

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3/21/68

NEWS

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WASHINGTON, D.C. 20546

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FOR RELEASE: THURSDAY A.M.
March 28, 1968

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APOLLO 6 SCHEDULED

The second flight of the Apollo/Saturn V space vehicle is scheduled for launch from the John F. Kennedy Space Center, Fla., on or after April 3. The mission is designated Apollo 6.

Primary purpose of this second flight of the Saturn V is to qualify the launch vehicle for future manned flights.

The successful first flight of Saturn V in Apollo 4, last Nov. 9, verified spacecraft systems and tested the command module under heat conditions expected on a lunar return. Therefore, spacecraft objectives, including recovery, are secondary in the Apollo 6 flight.

The majority of primary objectives will be met in the boost phase of flight. Events leading through the parking orbit stage and reignition of the launch vehicle's third stage S-IVB engine will satisfactorily complete primary mission objectives.

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These include:

. Demonstration of structural, thermal, porpulsion and separation characteristics of the first, second and third stages of the Saturn V in powered flight.

. Qualification of the third-stage continuous vent system, its auxiliary propulsion system and the J-2 engine restart capability while in orbit.

For this mission, the emergency detection system will be flown closed-loop (designed to operate without ground command) for the first time. It was not operational during the Apollo 4 flight.

A new crew hatch will be flown aboard the spacecraft for the first time.

In Apollo 6, a different method will be used in shutting down the engines of the first stage from that used in Apollo 4.

The Apollo spacecraft and Saturn third stage will be placed in a 100 nautical (115 statute) mile orbit.

-more-

Reignition of the third stage will occur about three hours, 10 minutes into the flight over the Eastern Test Range. The burn will last some five minutes 10 seconds and will place the vehicle on a simulated translunar coast ellipse with a 279,000 nauticle (320,000 statute) mile apogee. The actual apogee is dependent upon the day of launch.

Following third-stage shutdown, the Apollo 6 third stage-spacecraft combination will be maneuvered 180 degrees by the stage's auxiliary propulsion system in preparation for separation of the third stage from the command and service module.

Three minutes after third-stage engine cutoff, the command and service module will separate from the third stage which will continue on its path to lunar distance moving at more than 20,750 nautical (23,850 statute) mph.

Meanwhile the first spacecraft service-propulsion-system engine burn will slow Apollo 6 to about 16,700 nautical (19,200 statute) mph and lower its apogee to 12,000 nautical (13,820 statute) miles which will be achieved at six hours 22 minutes after liftoff.

The second firing of the SPS engine -- 3 minutes 8 seconds duration -- will occur 9 hours 22 minutes into the flight. This burn is intended to increase entry velocity to 21,600 nautical (24,900 statute) mph.

Entry will be less steep than on Apollo 4, giving a greater heat load to the command module heat shield. The command module will travel 2,500 nautical (2,880 statute) miles after reentering the atmosphere.

Following separation from the service module and deployment of the Earth-landing system, the Apollo 6 command module is scheduled to land 340 nautical (391 statute) miles north-northwest of Kauai, Hawaii, 9 hours 49 minutes after liftoff.

The Saturn V launch vehicle consists of three propulsive stages and an instrument unit (IU).

The first stage (S-IC) is 138 feet tall, 33 feet in diameter and weighs 306,140 pounds dry. Its fuel and oxidizer tanks hold 4,400,000 pounds (214,200 gallons of RP-1 kerosene, and 346,400 gallons of liquid oxygen). Its five F-1 engines develop a combined 7.5 million pounds thrust at liftoff and burn almost 15 tons of propellant per second.

The second stage (S-II), 81.5 feet tall and 33 feet in diameter, weighs 88,200 pounds dry. Fully loaded it weighs 1.033 million pounds including 267,700 gallons of liquid hydrogen fuel and 87,400 gallons of liquid oxygen. Its five J-2 engines provide 1 million pounds of thrust.

The third stage (S-IVB) is 58.4 feet tall, 21 feet 8 inches in diameter and weighs 26,454 pounds dry. It carries 230,000 pounds of propellant -- 66,900 gallons of liquid hydrogen and 20,400 gallons of liquid oxygen. Its single J-2 engine develops 200,000 pounds of thrust in space.

The instrument unit, 3 feet high and 21 feet 8 inches in diameter, weighs 4,763 pounds and contains six major systems -- structural, thermal control, guidance and control, measuring and telemetry, radio frequency and electrical.

The Apollo 6 spacecraft includes the conical command module, 12 feet high and 12 feet 10 inches in diameter at the base. It weighs 12,500 pounds.

The service module is a cylinder 22 feet high, 12 feet 10 inches in diameter and weighs 55,000 pounds including propellant at launch. It contains the service propulsion system engine which develops 21,500 pounds of thrust.

The lunar module test article, weighing 26,000 pounds, is contained within the spacecraft lunar module adapter (SLA) which weighs 3,900 pounds, measures 28 feet high, and tapers from 22 feet in diameter at the base to 12 feet 10 inches at the top.

-more-

The spacecraft launch escape system, atop the command module, is 33 feet tall with a base diameter of 4 feet. It weighs 8,200 pounds including a cover over the apex of the command module to protect against aerodynamic heating during launch and against the rocket exhaust of the launch escape system motors. The system provides the capability to lift the command module from the remainder of the space vehicle in event of an emergency on the pad or shortly after launch. The launch escape system is jettisoned soon after the second stage ignites.

-end-

DIFFERENCES IN APOLLO 4 AND APOLLO 6 FLIGHTS

Total heat shield cold soak will be obtained in Apollo 6 by pointing the service propulsion system toward the Sun and shielding the entire heat shield. Apollo 4 was oriented so that half of the heat shield was cold soaked.

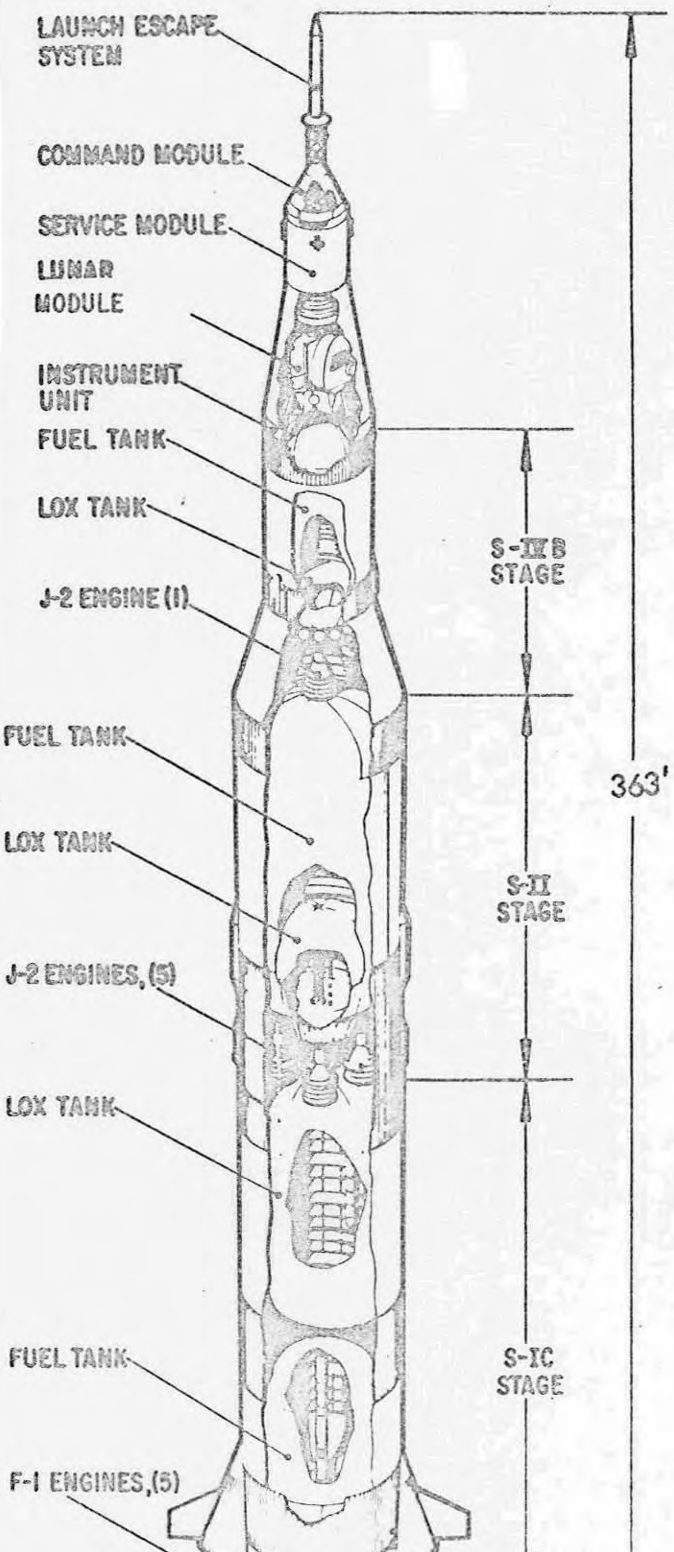
The second burn of the Apollo 6 third stage will be almost 30 seconds longer to simulate injection into a lunar trajectory. It will be posigrade -- a combination posigrade-retrograde burn was used in Apollo 4. To further simulate a lunar mission, the spacecraft will separate from the third stage nearly eight minutes earlier.

The first burn of the service propulsion system (SPS) in Apollo 6 will be retrograde and about four minutes longer than Apollo 4 posigrade burn. Apollo 6 retro movement will take the spacecraft out of the lunar trajectory and restrict its apogee to 12,000 nautical (13,820 statute) miles. Apollo 4 apogee was 9,769 nautical (11,170 statute) miles.

The second SPS burn in Apollo 6 will be more than a minute shorter because the higher apogee requires less change in velocity to reach the desired spacecraft reentry speed.

Apollo 6 will reenter 1 hour 10 minutes later from higher apogee. Planned reentry velocity for Apollo 6 is about 170 feet per second greater, compared to Apollo 4, and entry angle to the atmosphere will be shallower.

This will make the maximum heat rate almost 200 British Thermal Units (BTU) lower than Apollo 4, but the maximum heat load will be nearly 1,900 BTU's greater. It will make the C-band communications blackout almost a minute longer than in Apollo 4.


LAUNCH ESCAPE SYSTEM
COMMAND MODULE
SERVICE MODULE
LUNAR MODULE
INSTRUMENT UNIT
FUEL TANK
LOX TANK
J-2 ENGINE (1)
FUEL TANK
LOX TANK
J-2 ENGINES, (5)
LOX TANK
FUEL TANK
F-1 ENGINES, (5)
S-IVB STAGE
S-II STAGE
S-IC STAGE
363'

SATURN V

SATURN V LAUNCH VEHICLE

The Saturn V launch vehicle is 281 feet tall. Total height of the Apollo 6 on the launch pad, with the Apollo spacecraft and launch escape system in place, is 363 feet. It weighs 6,208,949 pounds fully loaded.

The three-stage launch vehicle is capable of placing 285,000 pounds into low Earth orbit or sending about 100,000 pounds to the Moon. The Saturn V is painted white with sections marked in black for better optical tracking. Other painted markings include identification in red letters and the United States flag on the first stage.

First Stage

The first stage (S-IC) of the Saturn V is 138 feet tall and 33 feet in diameter, not including the fins and engine shrouds on the thrust structure. It was developed jointly by the National Aeronautics and Space Administration's Marshall Space Flight Center, Huntsville, Ala., and the Boeing Co.

Marshall assembled four S-IC stages: a structural test model, a static test version and the two flight stages; the second of these is the first stage in Apollo 6. The first flight stage launched Apollo 4 on the first Saturn V flight Nov. 9, 1967.

Boeing, as prime contractor, built two ground test units. Boeing is responsible for assembly of the other 13 flight stages at Marshall's Michoud Assembly Facility in New Orleans.

The static test model and the first three flight versions were fired at the Marshall Space Flight Center Test Laboratory. All other S-IC stages are being test fired at Marshall's Mississippi Test Facility in Hancock County, Miss.

Dry weight of the first stage is 306,140 pounds. Its two propellant tanks have a total capacity of 4.4 million pounds of fuel and oxidizer -- some 214,200 gallons of RP-1 (kerosene) and 346,400 gallons of liquid oxygen. Stage weight at separation, including residual propellants, will be 367,325 pounds. The normal propellant flow rate to the five F-1 engines is 28,000 pounds per second. The five engines produce a combined thrust roughly equivalent to 180 million horsepower at maximum speed.

-more-

During the planned 148 seconds of burn time, the engines will propel the Apollo/Saturn V to an altitude of 32 nautical (37 statute) miles and carry it downrange 46 nautical (53 statute) miles, making good a speed of 5,278 nautical (6,194 statute) miles-per-hour at first stage engine cutoff.

Four of the engines are mounted on a ring, each 90 degrees from its neighbor. These four can be gimballed to control the rocket's direction of flight.

The fifth engine is mounted rigidly in the center.

Second Stage

The second stage (S-II) is 81.5 feet tall and 33 feet in diameter. It weighs 88,200 pounds dry, 1,033,497 pounds loaded with propellant. Weight at separation will be 108,098 pounds.

The 19,898-pounds difference between dry weight and weight at separation includes the 10,650-pound S-IC/S-II interstage section, 2,720 pounds of ullage rocket propellants and other items on board.

The stage's two propellant tanks carry about 267,700 gallons of liquid hydrogen and 87,400 gallons of liquid oxygen. Its five J-2 engines develop a combined thrust of 1 million pounds.

The second stage carries the rocket to an altitude of 100 nautical (115 statute) miles and a distance of some 818 nautical (942 statute) miles downrange. Before burnout it will be moving 13,381 nautical (15,409 statute) mph. The J-2 engines will run about six minutes.

The Space Division of North American Rockwell Corp., builds the second stage at Seal Beach, Calif. The cylindrical vehicle is made up of the forward skirt (to which the third stage connects), the liquid hydrogen tank, the liquid oxygen tank, the thrust structure (on which the engines are mounted) and an interstage section (to which the first stage connects). The tanks are separated by an insulated common bulkhead.

North American Rockwell conducted research and development static testing at the Santa Susana, Calif., test facility and at the NASA Mississippi Test Facility. The flight stage for the Apollo 6 was shipped via the Panama Canal for captive firings at Mississippi Test Facility.

Third Stage

The third stage (S-IVB) was developed by the McDonnell Douglas Corp. at Huntington Beach, Calif. It is the larger and more powerful successor to the S-IV that served as the second stage of the Saturn I.

The third stage is flown from its manufacturing site to McDonnell Douglas' Test Center, Sacramento, Calif., for static test firings. The stage is then flown to the NASA Kennedy Space Center.

Measuring 58 feet 5 inches long by 21 feet 8 inches in diameter, the stage weighs 26,454 pounds dry. At separation in flight its weight will be 29,170 pounds exclusive of the liquid hydrogen and liquid oxygen in the main tanks. This extra weight consists mainly of solid and liquid propellants used in retro and ullage rockets and in the auxiliary propulsion system (APS).

An interstage section connects the second and third stages. This 7,660-pound section stays with the second stage at separation, exposing the single J-2 engine mounted on the thrust structure. The after skirt, connected to the interstage at the separation plane, encloses the liquid oxygen tank which holds some 20,400 gallons of the oxidizer. Above this is the large fuel tank holding about 66,900 gallons of liquid hydrogen. Weight of the S-IVB and payload at insertion into parking orbit will be 284,078 pounds. Weight at injection into translunar trajectory will be 132,778 pounds.

Total usable propellants carried in the two tanks is 230,000 pounds, with fuel and oxidizer separated by an insulated common bulkhead. Insulation is necessary in both upper stages because liquid oxygen, at about 293 degrees below zero F, is too warm for liquid hydrogen, at minus 423 degrees.

The aft skirt also serves as a mount for two auxiliary propulsion system modules spaced 180 degrees apart. Each module contains three liquid-fueled 147-pound thrust engines, one each for roll, pitch and yaw, and a 72-pound-thrust, liquid-fueled ullage engine.

Four solid-propellant retro-rockets of 37,500 pounds thrust each are mounted on the interstage to back the second stage away from the third stage at separation. The third stage also carries two solid-propellant ullage motors of 3,400 pounds thrust each. These motors help to move the third stage forward and away from the second stage upon separation and serve the additional purpose of settling the liquid propellants in the bottoms of the tanks in preparation for J-2 ignition. The first J-2 burn is 129 seconds, the second, 5 minutes 10 seconds.

Propulsion

The 41 rocket engines of the Saturn V have thrust ratings ranging from 72 pounds to more than 1.5 million pounds. Some engines burn liquid propellants, others use solids.

The five F-1 engines in the first stage burn RP-1 (kerosene) and liquid oxygen. Each engine in the first stage develops 1.415 million pounds of thrust at lift-off, building up to 1.7 million pounds thrust before cutoff. The cluster of five F-1s gives the first stage a thrust range from 7.57 million pounds at liftoff to 8.5 million pounds just before cutoff.

The F-1 engine weighs almost 10 tons, is more than 18 feet high and has a nozzle-exit diameter of nearly 14 feet. The F-1 undergoes static testing for an average 650 seconds in qualifying for the 150-second run during the Saturn V first stage booster phase. This run period, 800 seconds, is still far less than the 2,200 seconds of the engine guarantee period. The engine consumes almost three tons of propellants per second.

The first stage of the Saturn V for this mission has four other rocket motors. These are the solid-fuel retro-rockets which will slow and separate the stage from the second stage. Each rocket produces a thrust of 87,900 pounds for 0.6 seconds.

The main propulsion for the second stage is a cluster of five J-2 engines burning liquid hydrogen and liquid oxygen. Each engine develops a mean thrust of 200,000 pounds (variable from 175,000 to 225,000 in phases of flight), giving the stage a total thrust of 1 million pounds.

Designed to operate in the hard vacuum of space, the 3,500-pound J-2 is more efficient than the F-1 because it burns the high-energy fuel hydrogen.

The second stage also has four 21,000-pound-thrust solid-fuel rockets engines. These are the ullage rockets mounted on the interstage section. These rockets fire to settle liquid propellant in the bottom of the main tanks and help attain a "clean" separation from the first stage, then they drop away with the interstage at second plane separation.

Fifteen rocket engines perform various functions on the third stage. A single J-2 provides the main propulsive force; there are two main ullage rockets, four retro-rockets and eight smaller engines in the auxiliary propulsion system.

Instrument Unit

The Instrument Unit (IU) is a cylinder three feet high and 21 feet 8 inches in diameter. It weighs 4,763 pounds.

Components making up the "brain" of the Saturn V are mounted on cooling panels fastened to the inside surface of the instrument unit skin. The refrigerated "cold plates" are part of a system that removes heat by circulating fluid coolant through a heat exchanger that evaporates water from a separate supply into the vacuum of space.

The six major systems of the instrument unit are structural, thermal control, guidance and control, measuring and telemetry, radio frequency and electrical.

The instrument unit maintains navigation, guidance and control of the vehicle; measurement of vehicle performance and environment; data transmission with ground stations; radio tracking of the vehicle; checkout and monitoring of vehicle functions; detection of emergency situations; generation and network distribution of electric power for system operation; and preflight checkout and launch and flight operations.

A path-adaptive guidance scheme is used in the Saturn V instrument unit. A programmed trajectory is used in the initial launch phase with guidance beginning only after the vehicle has left the atmosphere. This is to prevent movements that might cause the vehicle to break apart while attempting to compensate for winds, jet streams and gusts encountered in the atmosphere.

If such air currents displace the vehicle from the optimum trajectory in climb, the vehicle derives a new trajectory from its instantaneous state of position, velocity and direction. This calculation is made about once each second throughout the flight. The launch vehicle digital computer and launch vehicle data adapter perform the navigation and guidance computations.

The ST-124M inertial platform -- the heart of the navigation, guidance and control system -- provides space-fixed reference coordinates and measures acceleration along the three mutually perpendicular axes of the coordinate system.

International Business Machines Corp. is prime contractor for the instrument unit and is the supplier of the guidance signal processor and guidance computer. Major suppliers of instrument unit components are: Electronic Communications, Inc., control computer; Bendix Corp., ST-124M inertial platform; and IBM Federal Systems Division, launch vehicle digital computer and launch vehicle digital computer and launch vehicle data adapter.

LAUNCH VEHICLE INSTRUMENTATION AND COMMUNICATIONS

Some 2,800 measurements will be taken in flight on the Saturn V launch vehicle. This includes 891 in the first stage, 960 in the second stage, 612 in the third stage and 338 in the instrument unit.

The Saturn V will carry 23 telemetry systems, four tracking systems, one command system, six motion picture cameras in recoverable capsules and two television cameras.

The 2,800 measurements are a sharp increase over the average 1,365 measurements taken on Saturn IB, 925 on Saturn I, 150 on Jupiter and 75 on Redstone.

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APOLLO 6 SPACECRAFT

There are no primary spacecraft objectives in the Apollo 6 mission -- structures and systems in the command and service modules were verified in the Apollo 4 mission.

Command Module (CM)

The command module is a cone 12 feet high with base diameter of 12 feet 10 inches, a habitable volume of 210 cubic feet and an approximate launch weight of 12,500 pounds.

Outer structure is stainless steel honeycomb bonded between steel alloy sheets with surface application of phenolic epoxy resin ablative material varying from 0.5 to 2.5 inches thick for protection from reentry temperatures to 5,000 degrees F.

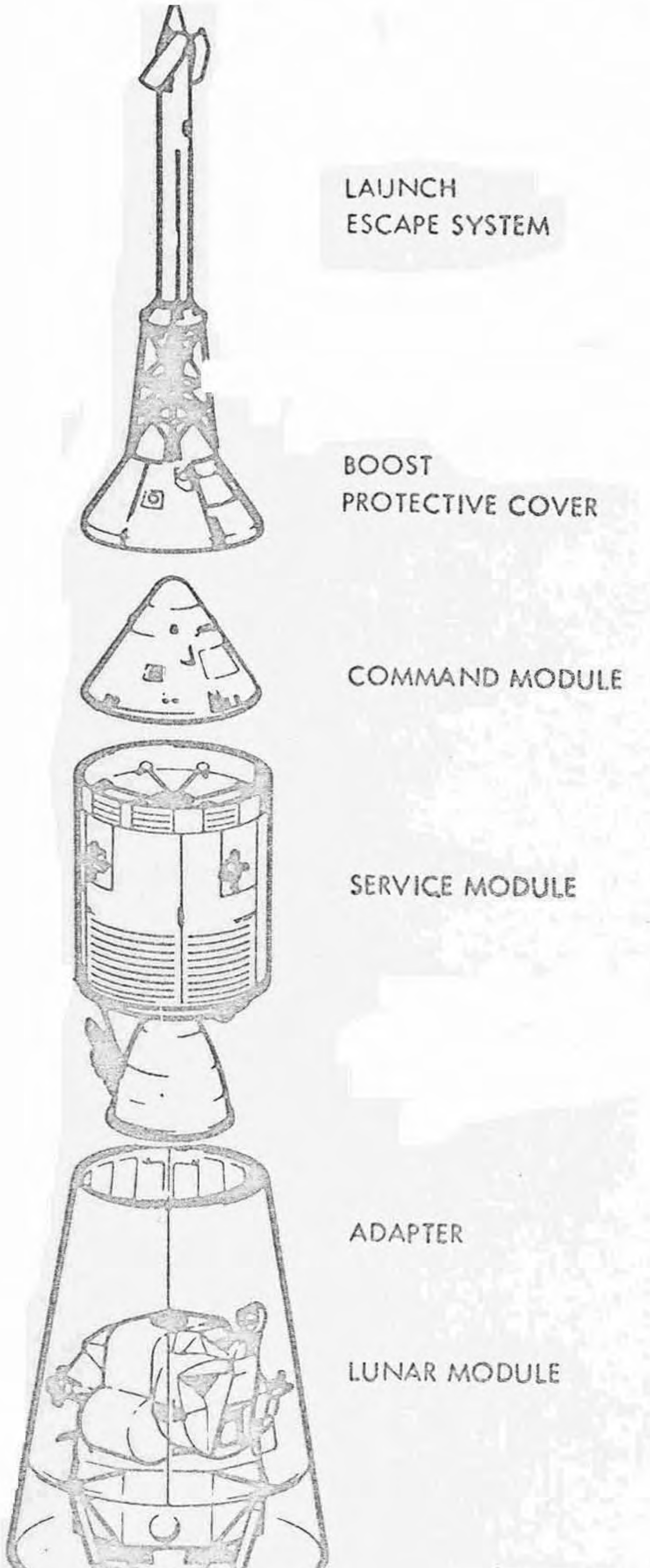
Inner structure is aluminum honeycomb between aluminum alloy with sandwich thickness from 0.25 inch at forward access tunnel to 1.5 inches at base; fibrous insulation separates outer and inner structures.

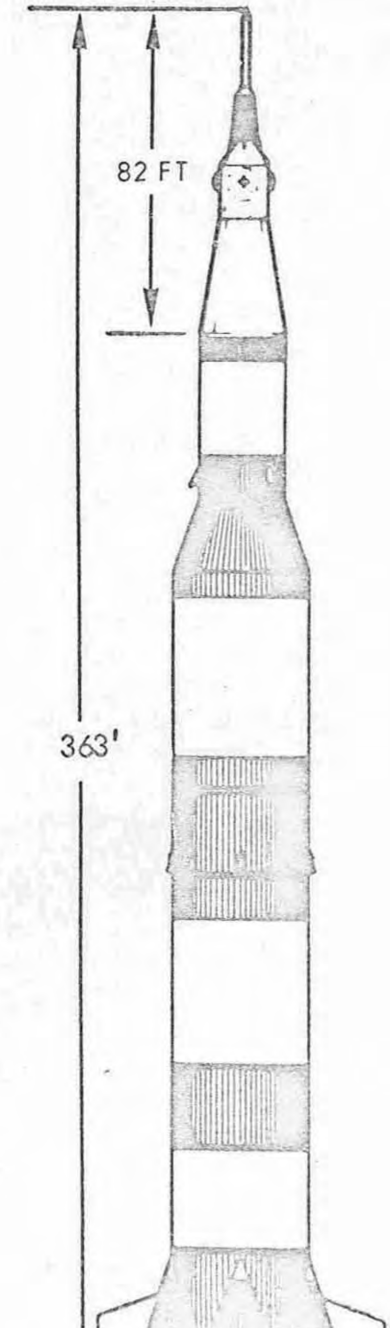
The command module has an inner pressure structure and an outer structure (heat shield) separated by stringers for support and a microquartz fiber for thermal insulation. The outer housing holds pressure structure heating below 600 degrees F. The combined structures keep temperatures inside the spacecraft at comfortable levels during orbital flight and below 200 degrees F. during reentry.

The three-piece heat shield is constructed of brazed honeycomb stainless steel to which is bonded a phenolic epoxy resin ablative (heat dissipating) material, which burns away during reentry. Thickness of the ablative material varies from 0.7 to 2.7 inches based on the anticipated aerodynamic heat distribution over the command module. The three sections of the shield protect the forward section, crew compartment and the aft section.

This flight will carry an Apollo mission programmer with special equipment necessary to operate the spacecraft subsystem in the absence of crew. The VHF and S-band omnidirectional antennas will be modified accordingly.

The quick-operating, outward-opening unified hatch will be flown for the first time as a complete unit on Apollo 6. The hatch concept, together with thermal seals, was proved on Apollo 4; the hatch is qualified for manned flights, pending completion of ground tests.


LAUNCH ESCAPE SYSTEM
BOOST PROTECTIVE COVER
COMMAND MODULE
SERVICE MODULE
ADAPTER
LUNAR MODULE


82 FT
363'

Width of the hatch tapers from 36.85 inches at the bottom to 25.73 inches at the top. It is 27.03 inches high. The hatch is made of aluminum covered with fiberglass and ablative material.

The hatch can be unlatched in about five seconds or sealed from within the cabin by operating a permanently-mounted lever. It can be opened or sealed from outside with the aid of a hand tool. A device powered by nitrogen gas under pressure counters the force of gravity and seal friction to provide positive hatch opening.

A vent valve in the hatch permits quick depressurization of the cabin from inside or outside. The hatch has a window. It is one of several major safety developments since the Apollo fire of Jan 27, 1967.

Service Module (SM)

The service module is a 22-foot high cylinder, including an extension to service propulsion system (SPS) engine, with a diameter of 12 feet 10 inches. Approximate launch weight is 42,600 pounds with an engine thrust of 21,500 pounds in vacuum.

Structure is aluminum honeycomb outer skin one-inch thick formed by six panels bolted to solid aluminum structural uprights. The interior is divided into six wedge-shaped compartments of three different sizes around a center cylindrical section:

50-degree segments, housing auxiliary equipment, designated sectors 1 and 4;
60-degree segments, housing fuel tanks for SPS, designated sectors 3 and 6; and
70-degree segments, housing oxidizer tanks for SPS, designated sectors 2 and 5.

A cylindrical center section houses two helium tanks to pressurize service propulsion system tanks, and the SPS engine.

Space radiators to dissipate heat from the electrical power system (EPS) and the environmental control system (ECS) are located externally on four of the six panels making up the service module skin; electrical power system radiators on 2 and 5. However, these radiators are not connected for the Apollo 6 mission.

Four reaction control system (RCS) packages, each made up of four engines and one fuel tank, oxidizer tank, and pressurant tank with associated plumbing and electrical connections, are located equi-distant around the circumference of the service module.

Spacecraft Lunar Module Adapter (SLA)

The Spacecraft Lunar Module Adapter is a tapered cylinder 28 feet high and 22 feet in diameter at base, 12 feet 10 inches at top, of 1.75 inch thick aluminum honeycomb, weighing 3,800 pounds. It houses the lunar module test article (LTA-2R).

Lunar Module Test Article (LTA-2R)

This device is instrumented to measure vibration, acoustics and structural integrity at 36 points. Data will be telemetered to the ground stations during the first 12 minutes of flight.

The article, weighing 26,000 pounds, will remain with the last stage of the launch vehicle. Lunar Module Test Article-2R uses a flight-type descent stage without landing gear. Its propellant tanks will be filled with water glycol and freon to simulate fuel and oxidizer. The ascent stage is a ballasted aluminum structure containing no flight systems.

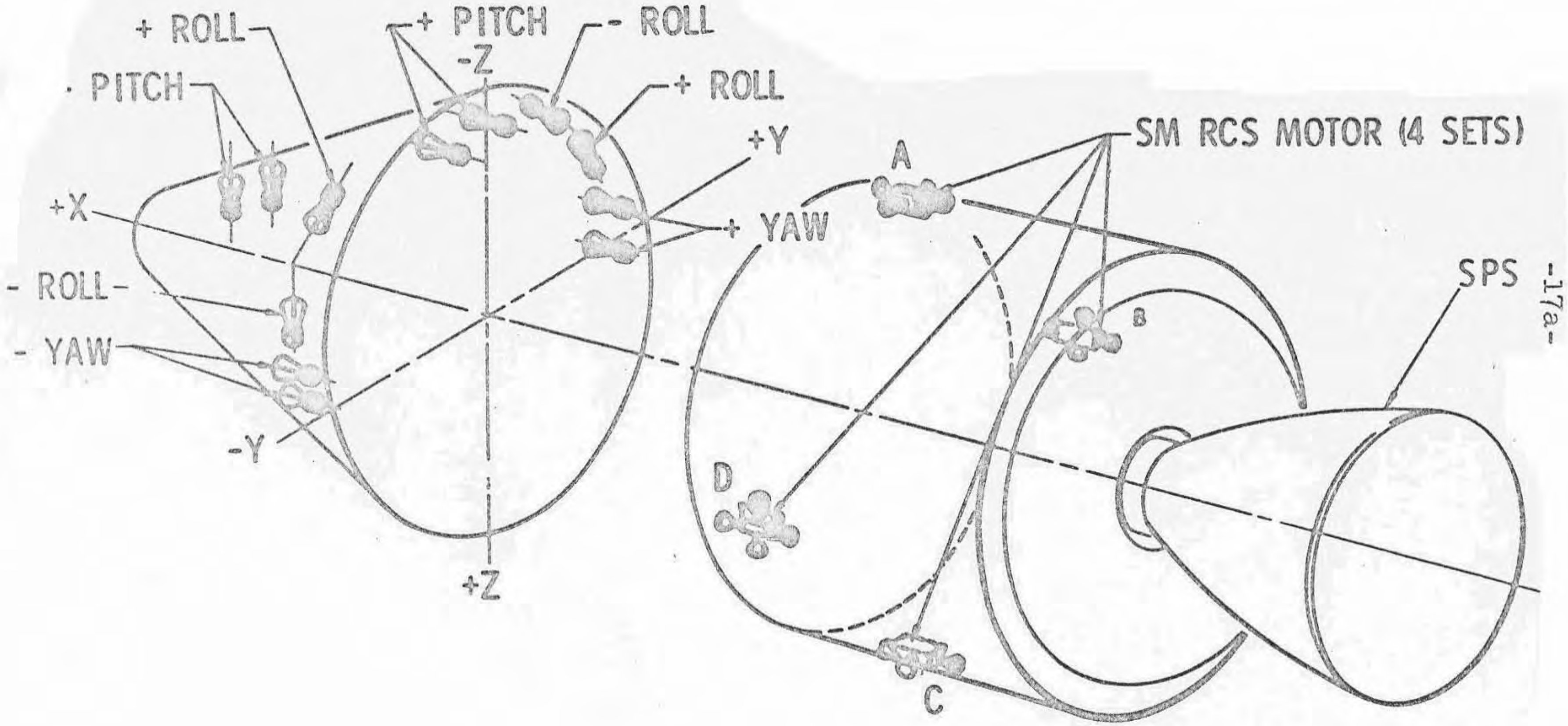
Spacecraft Systems

Reaction Control System (RCS)

The reaction control system provides thrust for attitude movements of the spacecraft in response to automatic control signals from the stabilization and control system (SCS) in conjunction with the guidance and navigation system (G&N) or to maunal control signals from crew through hand controllers.

Service module reaction control system consists of four independent subsystems of four 100-pound-thrust engines each (16 engines total) packaged as modules and located in quadrants near the top of the service module. Propellants are hypergolic (ignites spontaneously when mixed together). It is made up of Aerozine 50 (half- and-half blend of hydrazine and unsymmetrical dimethylhydrazine) fuel and nitrogen tetroxide oxidizer. In each quad, two of the four engines control roll, the other two, either yaw or pitch, depending on the location of the quad.

ENGINE LOCATION



Command Module

Reaction control system includes two independent subsystems of six 93-pound thrust engines each (12 engines total) operating in tandem. A single subsystem can control attitude if one subsystem fails. Propellant is hypergolic with monomethyl-hydrazine fuel and nitrogen tetroxide oxidizer. The command module reaction control system is not activiated until the command module and the service module have separated before reentry.

Service Propulsion System (SPS)

The service propulsion system must provide thrust for major velocity changes and in Earth orbital missions for the de-orbit burn to achieve reentry. The engine is 3 feet 5 inches high with 9-foot, 4-inch exhaust expansion skirt of columbium-titanium. It weighs 810 pounds, produces 21,500 pounds of thrust in a vacuum, and is rated at 36 restarts with 8 minutes 20 seconds of total burn time. Propellant is hypergolic Aerozine 50 fuel and nitrogen tetroxide oxidizer, and is pressure-fed from the service module storage tanks by helium gas. The service propulsion system engine is gimbal-mounted to keep the direction of thrust aligned through the spacecraft center of gravity.

Launch Escape System (LES)

The launch escape system includes three solid propellant motors for escape and pitch control. They serve to pull spacecraft up and away from the launch vehicle in the event of mission abort on the pad or during launch to an altitude above 270,000 feet. The launch escape system is 33 feet tall with a 4-foot base diameter. It weighs 8,900 pounds including a boost protective cover which fits over the apex of the command module for protection against boost heating and the rocket exhaust of the launch escape motors. The three motors all using polysulfide propellant, are:

(1) Launch escape motor with 147,000 pounds-thrust over 3 seconds duration;
(2) Pitch control motor with 2,850 pounds-thrust for 0.5 seconds and,
(3) Tower jettison motor, 32,000-pounds-thrust for 1 second.

Stabilization and Control System (SCS)

The stabilization and control system maintains spacecraft attitude, thrust vector of the service propulsion system engine, and may serve as backup inertial reference system. It operates automatically or manually. Components of the stabilization and control system appropriate to the Apollo 6 mission are:

(1) Body-mounted attitude gyros (BMAG): Three identical units mounted along spacecraft body axes. Attitude displacement creates signal to the reaction control system to restore desired attitude.

(2) Rate gyro assembly (RGA): Three gyros to show rate of change of spacecraft attitude.

(3) Attitude gyro accelerometer assembly (AGAA): The three BMAG units plus a pendulous accelerometer to display acceleration data for automatic termination of service propulsion system engine thrusting.

(4) Attitude set and gimbal position indicators which set desired angle changes and displays service propulsion system engine gimball pitch and yaw position angle.

(5) Velocity change indicator displays remaining velocity change (Delta V).

(6) Electronic control assemblies to process and condition signals from SCS components.

Mission Control Programmer (MCP)

The Mission Control Programmer receives information from the updata link ground command, the Saturn instrument unit, ground support equipment, the guidance and navigation, Earth landing and environmental control systems.

Guidance and Navigation (G&N)

The semi-automatic Guidance and Navigation System is interrelated with stabilization and control system, service propulsion system, reaction control system, electric power system, environmental control system, telecommunications, and instrumentation systems. It performs basic functions of inertial guidance, attitude reference and optical navigation. The system has two Apollo 6 related subsystems:

(1) Inertial guidance to measure changes in spacecraft attitude, help generate steering command, and measure changes in velocity. It is operated automatically by the guidance computer:

(2) Guidance computer and two display and keyboard panels (DSKY) to calculate steering signals and engine on-off signals, to position inertial measurement unit stable member, to position optical unit, to conduct limited G&N malfunction isolation, and to provide display panel information. The computer is digital with both an erasable and a fixed memory.

-more-

Earth orbital operations of the guidance and navigation system are in prelaunch, guidance monitor, orbital navigation, inflight inertial measuring unit alignment, attitude control and reentry phases.

Electrical Power System (EPS)

The electric power system is made up of six main areas:

(1) Fuel cells to produce electricity through chemical reaction of hydrogen and oxygen pressure-fed into cells by nitrogen gas.

Each of the three power plants consists of 31 series-connected cells and each cell contains a hydrogen compartment, an oxygen compartment, a hydrogen electrode and an oxygen electrode. Each power plant is 44 inches high, 22 inches in

(2) Four zinc-silver oxide batteries located in the command module lower equipment bay to provide spacecraft power during reentry and after landing and to supplement fuel cell power during peak load periods, plus two independent and isolated zinc-silver oxide batteries to ignite explosive devices, plus two similar batteries in the service module to power service module jettison controllers after command module and service module separation.

(3) Cryogenic storage tanks and plumbing to hold and route hydrogen and oxygen for fuel cells and oxygen for environmental control system.

(4) Three solid-state inverters in the command module lower equipment bay convert fuel cell and battery direct current power to alternating current.

(5) The associated power distribution equipment.

(6) Three batteries for the Mission Control Programmer.

Environmental Control System (ECS)

The Environmental Control System consists of:

(1) The water system which holds about 17 quarts of potable water, some of it a by-product of the fuel cells, and about 28 quarts of waste water used in the evaporator which helps cool the glycol system.

(2) The glycol system to absorb and transport heat from the cabin, electronic equipment and a portion of the potable water to the space radiators.

Telecommunications System

The Telecommunications System provides telemetry and tracking and ranging communications between the spacecraft and ground stations, and capability to synchronize timing references for other spacecraft systems and to correlate telemetry data. The Apollo 6 system falls into two main categories:

(1) Data, with transmission and tape recording capability for structure and system inflight instrumentation and timing data, and

(2) Tracking and ranging, using C-band and S-band tracking by ground stations to help determine accurately the angular position and range of the spacecraft from the station.

System equipment divides into three groups:

(1) Data, including signal-conditioning, data storage, and central timing equipment, up data digital decoder, pulse-code modulation telemeter, premodulation processor:

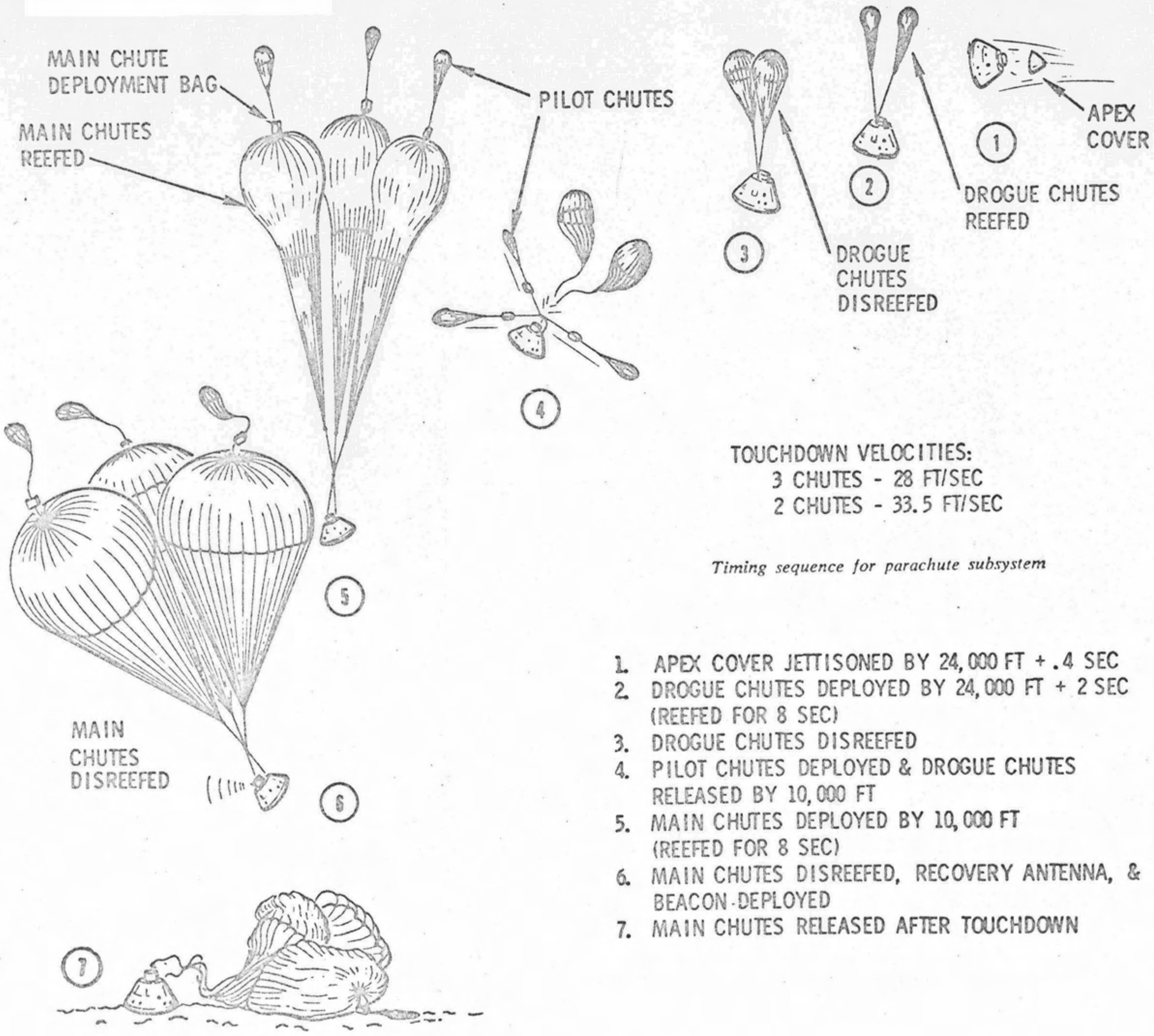
(2) RF electronics, including VHF/FM transmitter and VHF/AM transceiver, C-band transponder, unified S-band equipment, UHF recovery beacon, and HF transceiver;

(3) Antennas, which are VHF omnidirectional, S-band, VHF recovery, HF recovery, C-band.

Operational instruments associated with the data equipment and data transmission include some 24 classes of transducers to measure system pressure, temperature, flow, attitude, angular position, rates, events quantity and frequency.

Earth Landing System (ELS)

The Earth Landing System which safely lands the command module through automatic sequencing of drogue and main parachute deployment system, includes recovery equipment for deployment and activation after landing.



TOUCHDOWN VELOCITIES:
3 CHUTES - 28 FT/SEC
2 CHUTES - 33.5 FT/SEC

Timing sequence for parachute subsystem

1. APEX COVER JETTISONED BY 24,000 FT + .4 SEC
2. DROGUE CHUTES DEPLOYED BY 24,000 FT + 2 SEC (REEFED FOR 8 SEC)
3. DROGUE CHUTES DISREEFED
4. PILOT CHUTES DEPLOYED & DROGUE CHUTES RELEASED BY 10,000 FT
5. MAIN CHUTES DEPLOYED BY 10,000 FT (REEFED FOR 8 SEC)
6. MAIN CHUTES DISREEFED, RECOVERY ANTENNA, & BEACON-DEPLOYED
7. MAIN CHUTES RELEASED AFTER TOUCHDOWN

Parachute Subsystem:

(1) Two drogue chutes, concial ribbon nylon with canopy diameter of 13.7 feet;

(2) Three pilot chutes, ring-slot nylon 7.2 feet diameter;

(3) Three main chutes, ringsail nylon 83.5 feet diameter weighing 127 pounds each including canopy, risers and deployment bag.

Recovery Equipment:

(1) Uprighting system consisting of three compressor-inflated bags, used to upright the spacecraft if it lands apex down (Stable II) in the water;

(2) Fluorescent sea dye marker with 12-hour capacity;

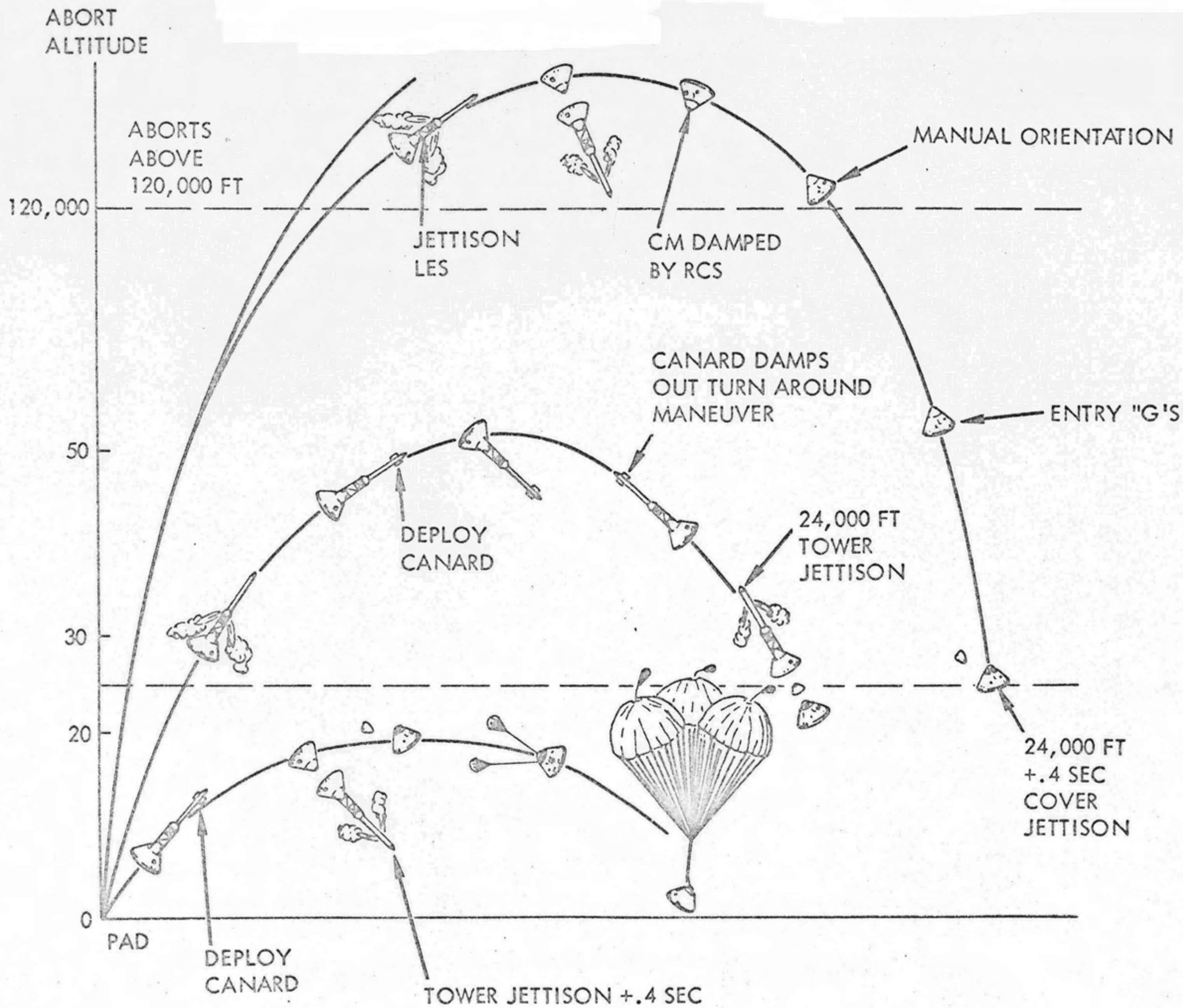
(3) Flashing beacon on command module apex;

(4) VHF recovery beacon transmitter, located in command module lower equipment bay and activated during descent to provide continuous line-of-sight signals; in addition, it has an HF recovery beacon;

(5) Swimmers' umbilical, part of the tether holding the sea dye marker cannister.

Launch Abort Capabilities

The Launch Escape System (LES) provides safe abort capabilities prior to liftoff through first 173 seconds of flight through automatic initiation by the emergency detection system (EDS), which senses booster malfunction. The three launch escape system abort phases -- pad, low altitude and high altitude -- are indicated in the accompanying chart. In the normal mission, the launch escape system is jettisoned shortly after ignition of the launch vehicle second stage; an abort after that time is accomplished by the service propulsion system engine. Operation of the Earth landing system under abort conditions is essentially the same as in a normal reentry descent.



Sequence of pad, low-altitude, and high-altitude aborts

ABLATOR TEST PANELS

Three ablator test panels will be flown on the Apollo 6 command module. Two will be in the simulated windward umbilical cavity and the third will replace the meteoroid window cover of the left crew window.

The two patches in the umbilical area are 4 by 9-inch rectangles 1.49 inches thick with an additional .07-inch thick fiber glass backing. One of these patches is the current Apollo Avco honeycomb heat shield material with one-third of the ablator material removed to represent a possible weight saving technique. The second patch is a low density, modified polyurethane foam developed by NASA's Ames Research Center. It is being studied as a possible heat shield material for future spacecraft.

The polyurethane foam material has a density of 2.2 pounds per cubic foot, compared to 33 pounds per cubic foot for the present honeycomb heat shield material.

The test panel over the window is a trapezoid 12.32 inches high, 13.1 inches wide at the base and 10.6 inches wide at the top. It is divided into three vertical sections. The left section contains the honeycomb material with one-third of the ablator removed. The middle section is end grain balsa wood. The right section is the modified polyurethane foam. All three sections are 0.7 inches thick.

Balsa is the natural material of lowest density with reasonable ablation properties. It is being compared with other materials in a flight test.

LAUNCH VEHICLE CAMERA SYSTEMS

More cameras will be carried aboard the Saturn V launch vehicle on the Apollo 6 mission than on any previous Saturn. The first stage will carry four motion picture cameras and two television cameras, and the second stage, two motion picture cameras. The film cameras will be ejected for recovery.

First Stage -- Film Cameras

Four film cameras will be mounted on the inside of the forward skirt of the first stage. Two cameras (1 and 3) will be mounted lens forward and canted inward five degrees to view the separation of the first and second stages. These two cameras will start 144 seconds after liftoff and run about 40 seconds. Two cameras (2 and 4) will be mounted lens-aft, with lenses connected by fiber optic bundles to manhole covers in the top of the liquid oxygen tank. These covers provide viewing windows and mounts for strobe lights. The tank will be lighted inside by pulsed strobe to enable the cameras to record the behavior of the liquid oxygen in flight. These two cameras will be turned on 30 seconds before liftoff; the strobe lights will be turned off shortly before first stage cutoff.

All first stage film cameras are carried in recoverable capsules inserted in ejection tubes. They will be ejected 174 seconds after vehicle liftoff, or 25 seconds after stage separation, 44 nautical (50.2 statute) miles at a point 76 nautical (88 statute) miles downrange. Camera impact is expected some 400 miles downrange about 10 minutes after liftoff.

First Stage -- Television

Both television cameras will be mounted inside the thrust structure of the first stage. A fiber optic bundle from each camera will split into two separate bundles going to lenses mounted outside the heat shield in the engine area. This will provide two images for each camera, or four for the system. The images will be tilted 90 degrees from vertical to give a wider view as two images appear on each cathode ray tube. Each lens will view the center engine and one outer engine, thus providing a view of each outer engine working in conjunction with the fixed center engine.

A removable aperture disk can be changed from f/2 to f/22 to vary the image intensity. (Fiber optics reduce image intensity about 70 per cent.) A quartz window, rotated by a DC motor with a friction drive, protects the objective lens on the end of the fiber optic bundle. Fixed metallic mesh scrapers will remove soot from the rotating windows. Images from the two objective lenses are combined into the dual image in the larger fiber optics bundle by a "T" fitting. A 14-element coupling lens adapts the large dual image bundle to the camera.

Images from both cameras are multiplexed together for transmission on a single telemetry link. The images are unscrambled at the receiving station.

The video system cameras contain 28-volt vidicon tubes, pre-amplifiers and vertical sweep circuits for 30 frames per second scanning.

The TV cameras operate continuously from 16 hours 25 minutes before liftoff until destroyed on first stage reentry.

Second Stage -- Film

The two film cameras carried on the second stage are mounted on the thrust structure near the outer periphery at vehicle Positions I and III. Both face aft to view the separation of the first and second stages and the later jettisoning of the after interstage. Camera I is between engines 1 and 4 and camera 2 is between engines 2 and 3. The cameras are turned on by the switch selector about 148.5 seconds after liftoff and shortly before first plane separation. Operation time is about 40 seconds. The film will be marked at 0.1 second before first plane separation, one-tenth of a second after S-II engine start and 0.1 second after second plane separation. The capsules will be ejected about 8 seconds after second plane separation, or about 187.5 seconds after liftoff, at an altitude of 49 nautical (56 statute) miles some 45 nautical (52 statute) miles downrange. The S-II cameras will impact 670 seconds after liftoff, 410 nautical (470 statute) miles downrange.

Ejection and Recovery

When the camera capsules are ejected, stabilization flaps open for the initial part of the descent. When the capsules descend to about 15,000 feet above ground a para-balloon will inflate automatically, causing flaps to fall away. A recovery radio transmitter and flashing light beacon are turned on about 6 seconds after para-balloon inflation. After touchdown, the capsule effuses a dye marker to aid sighting, and it releases a shark repellent to protect the capsules, para-balloon (which keeps the capsule afloat) and the recovery team.

The Navy's LPD-4 (Landing Platform Dock) USS Austin will be cruising about midway between the splashdown areas for the first and second stage camera capsules with helicopters and frogmen covering both points. Capsules will be picked up and flown by helicopter to KSC. The capsules will then be transferred to a data plane at Patrick Air Force Base, Fla., for immediate transfer to the Marshall Center at Huntsville where the film will be processed.

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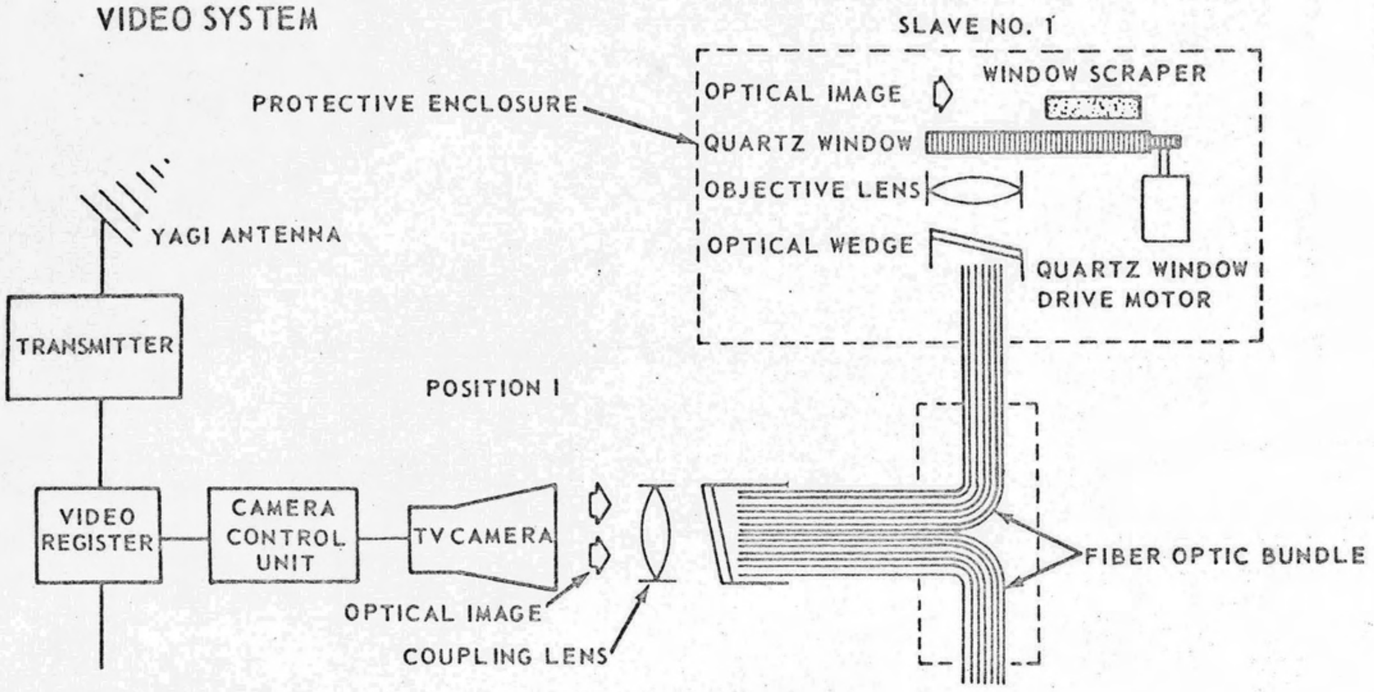
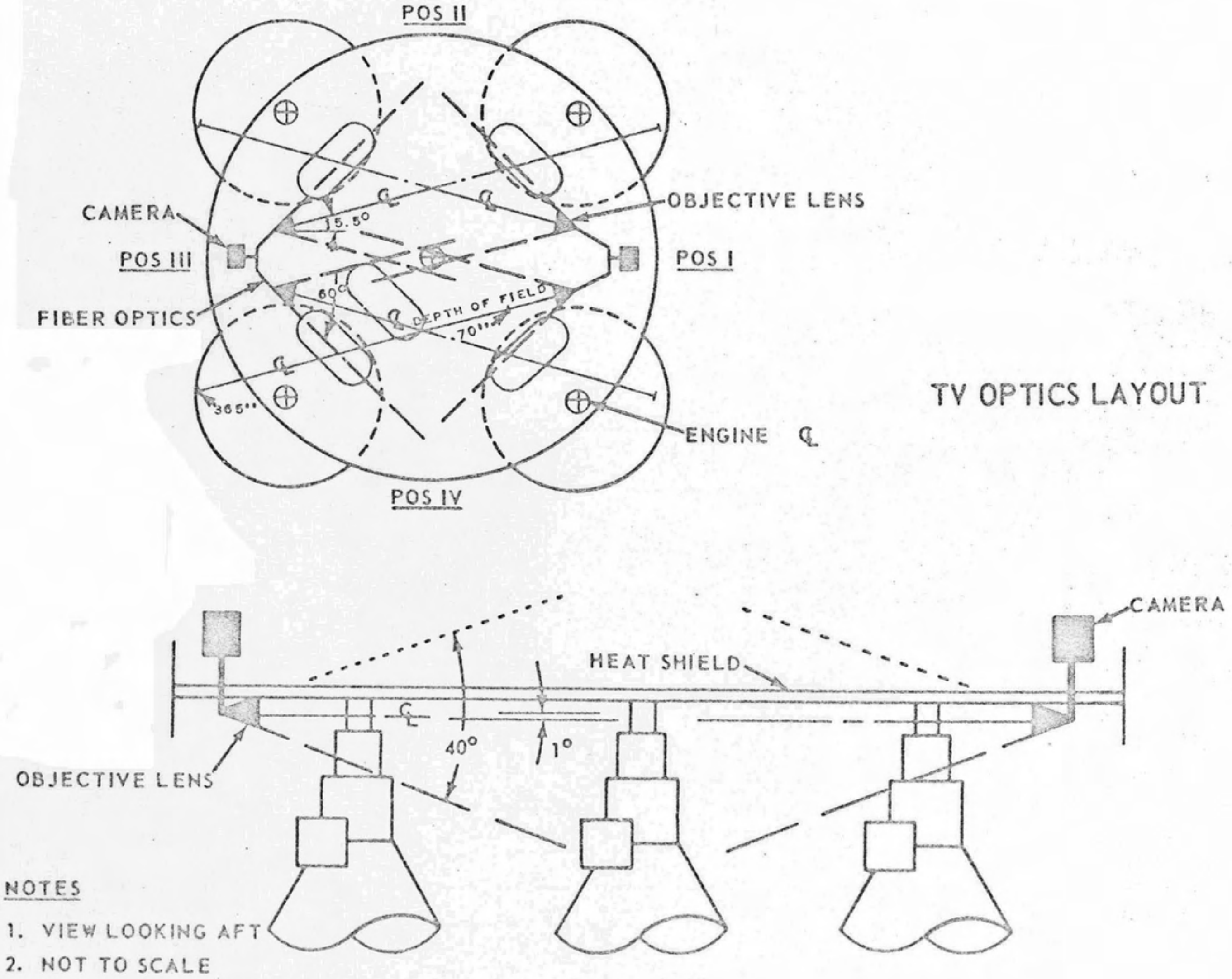
VIDEO SYSTEM



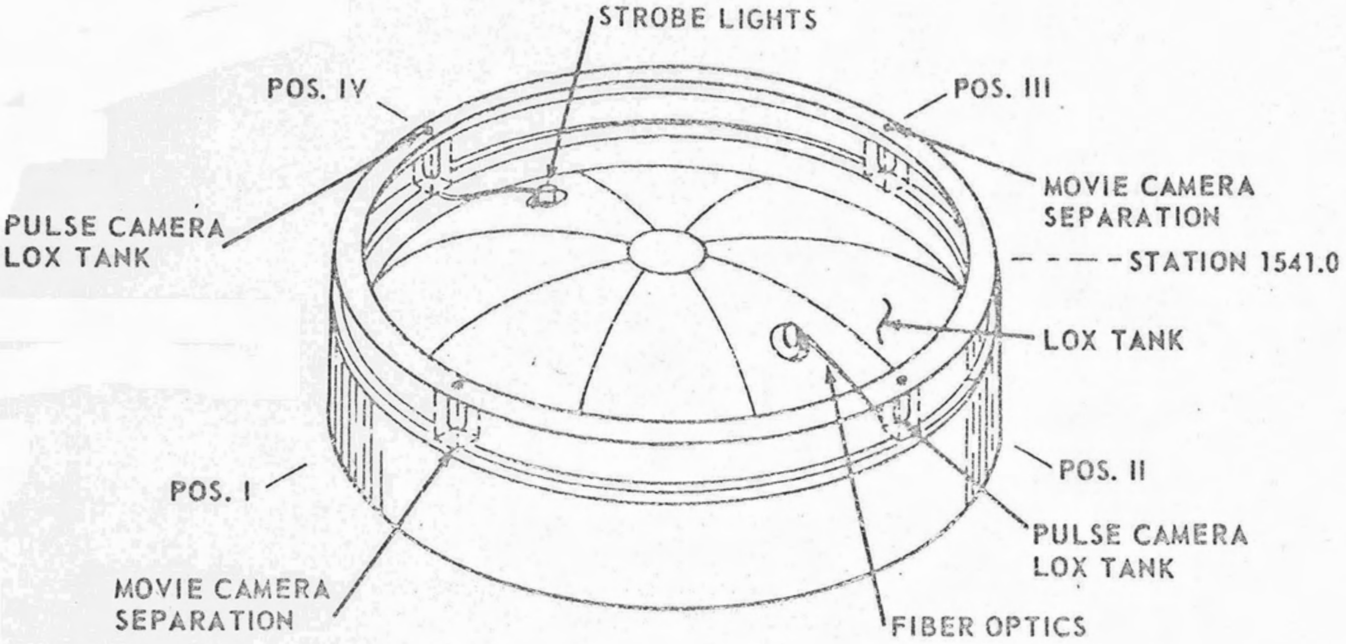
TV OPTICS LAYOUT



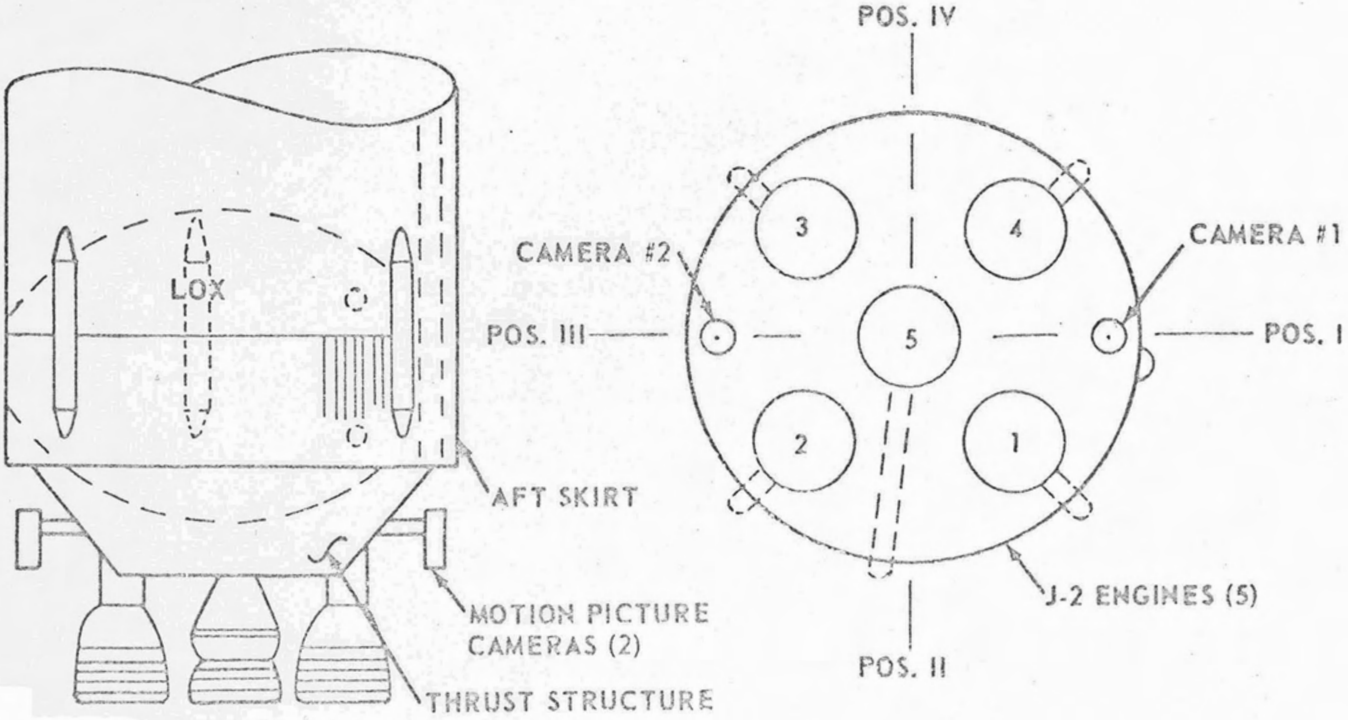
NOTES

1. VIEW LOOKING AFT
2. NOT TO SCALE

S-IC FORWARD SKIRT



S-II STAGE



SPACECRAFT CAMERAS

Two cameras will be mounted within the command module crew compartment. A 16mm Millikan motion picture camera will be pointed out the left rendezvous window. A 70mm Maurer still camera will photograph through the hatch window.

The Millikan, operating at 10 frames-per-second, will be turned on 2 minutes after liftoff and turned off 13 minutes after liftoff. It will be turned on again 9 hours 12 minutes after liftoff and operate through the landing phase until 9 hours 50 minutes after liftoff.

Objectives are to photograph reentry horizon reference, window degradation, reentry plasma flow and brilliance, boost protective cover jettison and orbital insertion.

The Maurer will operate for two hours starting 1 hour 29 minutes after liftoff, with 8.6 seconds between exposures. The objective is Earth photography to be used for the preparation of guidance and navigation landmark identification, for navigation performance analysis, and as image materials in the engineering and training simulators. The spacecraft will be off the coast of Baja California when the camera is turned on.

Coverage will be approximately 78 nautical (90 statute) miles wide centered on the ground track, and the interval between frames provides overlap of about 55 per cent.

A sequence controller operates each camera. Objectives are desirable, but not mandatory.

APOLLO 6 LAUNCH OPERATIONS

Preflight test, checkout and launch of the Apollo 6 are under the direction of NASA's John F. Kennedy Space Center.

KSC responsibilities include initial verification of the launch vehicle stages, spacecraft and ground support facilities for flight. These steps are followed by mating and integration of the space vehicle, countdown and launch. The final countdown will be run by a government-industry team of more than 450 persons.

Launch operations for Apollo 6 will be conducted for the first time from Firing Room 2 of the Launch Control Center. That firing room connects to High Bay No. 2 of the Vehicle Assembly Building (VAB) where the space vehicles undergo prelaunch testing. A new mobile launcher also is being used for this mission.

This technique follows the concept at Launch Complex 39 that specific firing rooms be assigned to counterpart high bays in order to maintain integrity in the checkout procedures from the arrival of the flight hardware until launch. Preparation and launch of the first Saturn V vehicle were thus controlled from Firing Room and High Bay No. 1.

Pad A, site of the first launch, Nov. 9, 1967, will be used again for Apollo 6. Damage caused by the initial launch was minimal and the facility was refurbished by late January.

Following electrical mating, checks of the space vehicle emergency detection system and a series of simulated countdown and flight operations were made first with the umbilical connections intact (plugs in), then with the umbilicals releasing at simulated liftoff (plugs out).

The Apollo 6 space vehicle was transported to Pad A Feb. 6, making the 3.5-mile trip with no major problem, in less than eight hours. Space vehicle cutoff and malfunction test and the Flight Readiness Test (FRT) were completed in late February and early March.

The Countdown Demonstration Test (CDDT), last milestone before picking up the final countdown, is a complete "dress rehearsal" of the launch count, including propellant loading. The CDDT is completed, a three-day recycle time allowed, then the final countdown is begun.

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APOLLO 6 COUNTDOWN

The Apollo 6 final countdown will last some 30 hours, with a clock start at T-minus-24 hours. A six-hour built-in hold is planned at T-minus-8 hours, before launch vehicle propellant loading.

Certain spacecraft functions such as fuel cell activation are accomplished in the countdown demonstration test. Following are highlights of the count:

T-minus-24 hours	Install launch vehicle flight batteries
19:30	Launch vehicle call to stations
18:45	Verify launch vehicle power on
16:00	Range safety command checks
15:30	Launch vehicle power transfer tests
12:00	Move mobile service structure to parked position
11:15	Spacecraft closeout - three hour operation. Verify spacecraft switch list, final cabin inspection, check environmental control system, install hatch, pressurize cabin and check cabin leak.
11:00	Install launch vehicle destruct packages
8:15	Retract Apollo spacecraft access arm (No. 9)
8:00	Start 6-hour built-in hold. Resume count. Prepare to load launch vehicle propellant.
6:28	Start third stage (S-IVB) liquid oxygen loading
6:00	Start loading second stage (S-II) liquid oxygen
5:45	Mission Control Center, Houston -- launch vehicle preflight command checks

4:22	Start first stage (S-IC) liquid oxygen loading
3:00	Space vehicle emergency detection system test.
2:57	Start second stage (S-II) liquid hydrogen loading.
2:05	Start loading third stage (S-IVB) liquid hydrogen
2:00	Launch vehicle attitude command checks
60 minutes	Start final launch vehicle radio frequency and telemetry checks
55	Retract launch vehicle primary damper arm
45	Begin terminal countdown
37	Range safety command checks
27	Power transfer checks
20	Spacecraft and lunar test article command checks
15	Spacecraft and lunar test article on internal power
10	Arm launch escape system
6	Space vehicle status check
5 min. 30 seconds	Arm destruct system
3:10	Initiate firing command (automatic sequencer)
1:37	Start launch vehicle pressurization
50 seconds	Launch vehicle power transfer to internal
8.9	Ignition sequence starts
02	All engines running
00	Launch commit and liftoff

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INTEGRATION, CHECKOUT AND LAUNCH

Saturn V stages are shipped to the Kennedy Space Center by ocean-going vessels and by specially-designed aircraft. Apollo spacecraft modules are transported by air. The command module, service module and lunar module test article are first taken to the Manned Spacecraft Operations Building for servicing and checkout. The Saturn V stages are taken immediately to the Vehicle Assembly Building (VAB).

Checkout and Mating

Receiving inspection is performed on the stages, then they are erected beginning with the S-IC. Separately packaged items such as fins and interstage skirts are installed and mandatory modifications made. Tests which cannot be performed after stage mating are performed on the S-II and S-IVB stages in the VAB's low bay area prior to stage mating.

S-IC Stage. After being transported to the high bay area of the VAB, the S-IC stage is lifted to a vertical position. The stage is positioned above the launch platform of the Mobile Launcher and lowered into place. After positioning, it is secured to the four hold-down support arms.

Engine shrouds are installed on the stage. The fins are installed on the planes of the four outboard engines. Each fin has a span of 11.5 feet and a surface area of 75 square feet. The stage is vertically aligned and mated to the ground support equipment.

Launcher electrical ground support equipment is connected to the Launch Control Center via the high-speed digital data link, and the S-IC stage test program is begun, using launch control equipment. The test program follows the building block pattern with some initial checks at the component level and progressive expansion into subsystem-systems and composite system tests. These checks are conducted with the Vehicle Assembly Building work platforms in place, and with umbilical arms connected.

S-II Stage, S-IVB Stage, and Instrument Unit. Along with S-IC stage checkout and alignment, all low-bay testing of the upper stages will have been completed and the upper stages prepared for mating.

The upper stages are moved to the High Bay and mated atop the S-IC stage. Umbilical connection begins immediately and continues during the mating operation on a non-interference basis. After the S-IVB has been mated to S-II, the instrument unit is assembled to S-IVB. The vehicle is aligned vertically after each stage has been mated.

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Saturn V Launch Vehicle. After the stages and instrument unit are mechanically mated and aligned, the S-II and S-IVB are electrically mated to the launcher ground support equipment. The stages are then electrically mated and launch vehicle systems tested.

After completing the flight sequence test, the launch vehicle is ready for the Apollo spacecraft electrical mating. Erection and mechanical mating of the spacecraft onto the launch vehicle can be accomplished shortly after S-IVB stage and instrument unit erection.

Apollo Spacecraft. Along with stage mating operations in the Vehicle Assembly Building, component and systems tests of the Apollo spacecraft are run in the Manned Spacecraft Operations Building.

Integrated tests are conducted after the command and service modules are mated. After completion of these tests, the command-service module is mated with spacecraft lunar module adapter (SLA) and the lunar module test article. Ordnance is installed and preparations are made to transport the spacecraft to the VAB. Following spacecraft erection and mechanical mating to the launch vehicle, the spacecraft is connected to its ground support equipment and acceptance checkout equipment, and integrated spacecraft testing is begun.

Space Vehicle Tests. The first space vehicle tests provide power and cooling capability to the vehicle, validate the connections and set up the instrumentation. When this has been completed, systems testing can begin. The systems tests are controlled and monitored by the Launch Control Center.

Transfer to Launch Site

The transporter is moved into position beneath the Mobile Launcher. Its hydraulic jacks engage the fittings on the launcher and raise it approximately 3 feet so that it will clear the Vehicle Assembly Building support pedestals. Then the transporter moves with its load out of the VAB. Arriving at the launch pad, the transporter moves the Mobile Launcher into position and lowers it onto the steel pedestals. The transporter also carries the Mobile Service Structure (MSS) into position alongside the space vehicle for access during launch pad operations.

Launch Preparations

Upon arrival at the launch pad, services such as digital data link, communication circuitry, pneumatic supply lines, propellant lines, environmental controls, and electrical power supply lines are connected to the Mobile Launcher and space vehicle. After all connections have been made, power is again applied to the vehicle and the control and monitor links verified. Radio frequency systems are checked out with their associated ground station and the digital data acquisition system is validated.

A spacecraft systems verification test is performed, followed by a space vehicle cut-off and malfunction test. Radio frequency compatibility is established and preparations are made for a final flight readiness test. The flight readiness test involves sequency tests paralleling the actual countdown and in-flight operations. Compatibility with the stations of the Eastern Test Range and the Mission Control Center in Houston, are verified at this time.

Following an evaluation of the flight readiness test, all systems are reconfigured for launch, and all plugs reverified. A countdown demonstration test (CDDT) is performed as the final test prior to launch. The CDDT consists of an actual launch countdown, complete with propellant loading, terminating just prior to ignition. This test exercises all systems along with the launch crew, and prepares the "team" for the actual operation to follow.

Launch Countdown

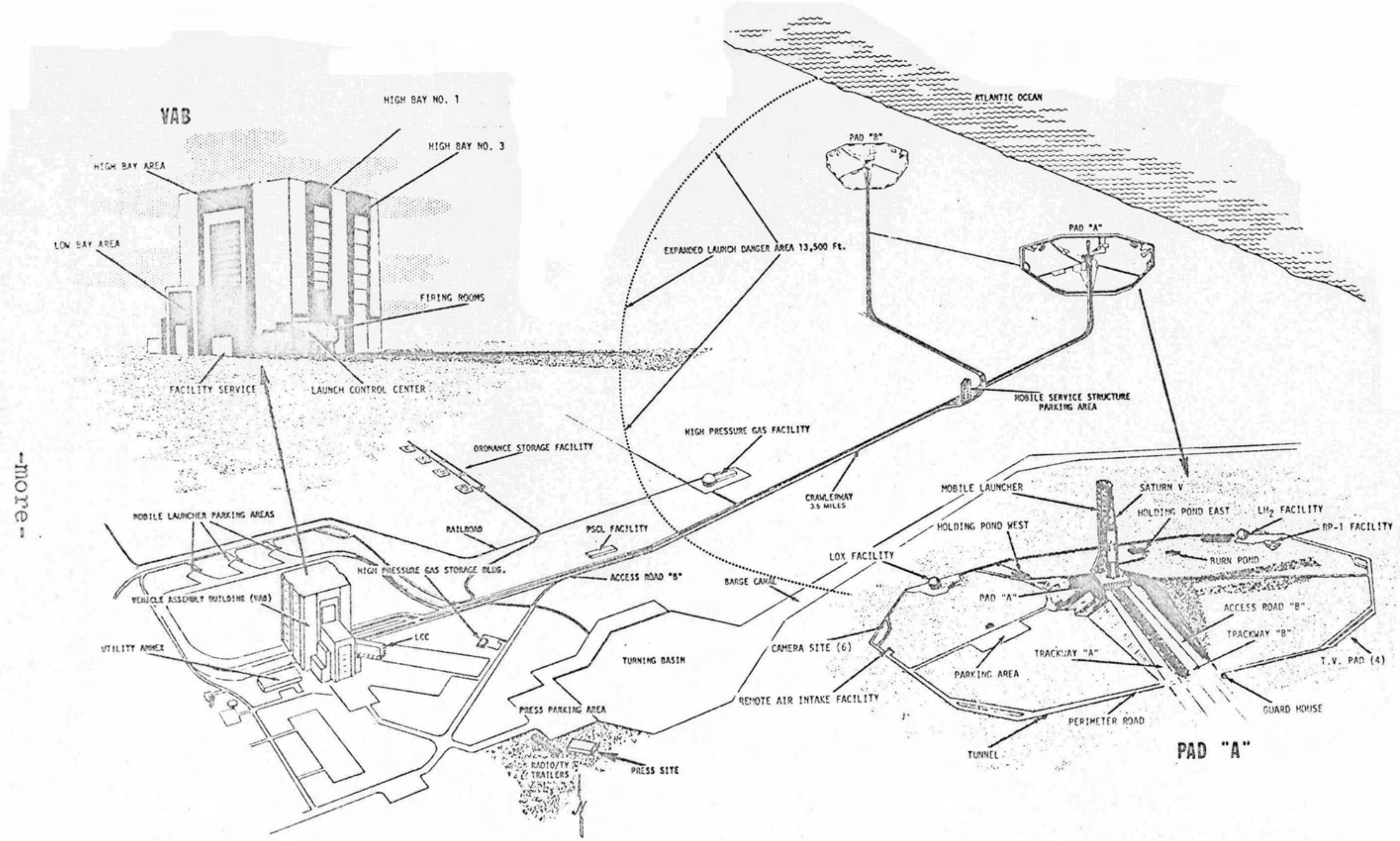
Upon completion of the countdown demonstration test, the space vehicle is recycled to pre-count status, and preparations are made for the final countdown phase of launch operations. While on the pad during the countdown, the command module will be filled with nitrogen.

Propellant Loading

Propellant loading of the Apollo spacecraft is performed prior to launch day. Aerozine 50 is the fuel and nitrogen tetroxide, the oxidizer. Also prior to launch day, hypergolics for the S-IVB stage reaction control system are loaded and ordnance connected. Kerosene is loaded. Loading of the cryogenic propellants for the launch vehicle begins on launch day about T-7 hours

Liquid oxygen loading is begun first. The tanks are pre-cooled before filling. Precool of one tank can be accomplished while another is filling. Loading is started with the S-II stage to 40 per cent, followed by the S-IVB stage to 100 per cent. The S-II is then brought to a full 100 per cent followed by the S-IC to 100 per cent. This procedure allows time to check liquid oxygen leaks before the S-II is fully loaded.

Liquid hydrogen loading begins next, starting with S-II to 100 per cent. Loading of S-IVB is last. Topping of cryogenic tanks of the launch vehicle continues until launch. Total cryogenic loading time from start to finish is 4 hours 30 minutes.



NASA COMPLEX 39
JOHN F. KENNEDY SPACE CENTER, FLORIDA

FACILITIES

The major components of Complex 39 include: (1) the Vehicle Assembly Building (VAB) where the Apollo space vehicle is assembled and prepared; (2) the Launch Control Center, electronic "brain" of the Complex; (3) the Mobile Launcher, upon which the Apollo is erected for checkout and from which it will be launched; (4) the Mobile Service Structure, which provides external access to the Apollo/Saturn V space vehicle at the launch site; (5) the Transporter which carries the space vehicle, its Mobile Launcher, and the Mobile Service Structure to the launch pad; (6) the Crawlerway; and (7) the launch pad itself.

The Vehicle Assembly Building

The heart of Launch Complex 39 is the Vehicle Assembly Building where the 363-foot-tall space vehicle is assembled and tested.

The VAB contains 129,482,000 cubic feet of space. It is 716 feet long, 518 feet wide and covers 343,500 square feet of floor space. The foundation of the building rests on 4,225 steel pilings, each 16 inches in diameter, driven from 150 to 170 feet to bedrock. The skeletal structure of the building contains 60,000 tons of structural steel and the exterior is covered by more than a million square feet of insulated aluminum siding.

The building has a high bay 525 feet high and a low bay 210 feet high. Both bays are serviced by a transfer aisle for movement of vehicle stages.

The low bay work area, approximately 442 feet wide and 274 feet long, contains eight stage preparation and checkout areas. These areas are equipped with systems to simulate stage interface and operation with other stages and the instrument unit of the Saturn V launch vehicle.

The high bay provides the facilities for assembly and checkout of both the launch vehicle and spacecraft. It contains four separate bays for vertical assembly and checkout. Two bays are now equipped, a third bay is being outfitted and a fourth is reserved for possible changes in vehicle configuration.

Work platforms -- some as high as three-story buildings -- in the high bays provide access by surrounding the launch vehicle at varying levels. Each high bay has five platforms. Each platform consists of two bi-parting sections that move in from opposite sides and mate, providing a 360-degree access to the section of the space vehicle being checked.

The Mobile Launchers, carried by Transporter vehicles, move in and out of the VAB through four doors in the high bay area, one in each of the bays. Each door is shaped like an inverted T. They are 152 feet wide and 114 feet high at the base, narrowing to 76 feet in width. The door is 456 feet high.

The lower section of each door is of the aircraft hangar type that slides horizontally on tracks. Above this are seven telescoping vertical lift panels stacked one above the other, each 50 feet high and driven by an individual motor.

These doors are designed to withstand hurricane-force winds. Operating time to open and close them is about 45 minutes.

Launch Control Center

The Launch Control (LCC) is adjacent to the VAB. This four-story structure is a radical departure from the dome-shaped blockhouses at other launch sites.

The electronic "brain" of Launch Complex 39, the LCC was used for checkout and test operations while Apollo 6 was being assembled inside the VAB. The LCC contains display, monitoring, and control equipment used for both checkout and launch operations.

The building has telemeter checkout stations on its second floor, and four firing rooms, one for each high bay of the VAB, on its third floor. Three firing rooms will contain identical sets of control and monitoring equipment, so that launch of a vehicle and checkout of others may take place simultaneously.

A high speed computer data link is provided between the LCC and the Mobile Launcher for checkout of the launch vehicle. This link can be connected to the Mobile Launcher at the VAB or at the pad.

Mobile Launcher

The Mobile Launcher is a transportable launch platform and umbilical tower for the space vehicle. NASA has three of these huge facilities.

The launch platform is a two-story steel structure, 25 feet high, 160 feet long, and 135 feet wide. It is positioned on six steel pedestals 22 feet high when in the VAB or at the launch pad. At the launch pad, in addition to the six steel pedestals, four extendable columns also are used to stiffen the Mobile Launcher against rebound loads, if the engine cuts off.

The umbilical tower, extending 398 feet above the launch platform, is mounted on one end of the launch platform. A hammerhead crane at the top has a hook height of 376 feet above the deck with a traverse radius of 85 feet from the center of the tower.

The 12-million-pound mobile launcher stands 445 feet high when resting on its pedestals. The base, covering about half an acre, is a compartmented structure built of 25-foot steel girders.

The launch vehicle sits over a 45-foot-square opening which allows an outlet for engine exhausts into a trench containing a flame deflector. This opening is lined with a replaceable steel blast shield, independent of the structure, and will be cooled by a water curtain initiated two seconds after liftoff.

There are nine hydraulically-operated service arms on the umbilical tower. These swing arms support lines for the vehicle umbilical systems and provide access for personnel to the stages.

On Apollo 6 two of the service arms (including the Apollo spacecraft access arm) are retracted early in the count. A third is released at T-30 seconds, and a fourth at T-16.7 seconds. The remaining five arms are set at T-0 to swing back at vehicle first motion.

The swing arms are equipped with a backup retraction system in case the primary mode fails.

The Apollo 6 vehicle is secured to the Mobile Launcher by four combination support and hold-down arms mounted on the launcher deck. The hold-down arms are cast in one piece, about 6 by 9 feet at the base and 10 feet tall, weighing more than 20 tons. Damper struts secure the vehicle near its top.

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After the engines ignite, the arms hold Apollo 6 for about six seconds until the engines build up to 95 per cent thrust and other monitored systems indicate they are functioning properly. The arms release on receipt of a launch commit signal at the zero mark in the count.

Transporter

The 6-million-pound Transporters, the largest tracked vehicles known, move Mobile Launchers into the VAB and Mobile Launchers along with assembled Apollo space vehicles to the launch pad. They also are used to transfer the Mobile Service Structure to and from the launch pads. NASA has two of these "crawlers".

The 114 by 131-foot Transporter moves on four double-tracked crawlers, each 10 feet high and 40 feet long. Each shoe on the crawler tracks weighs about a ton.

Sixteen traction motors powered by four 1,000-KW generators, which in turn are driven by two 2,750-horsepower diesel engines, provide the motive power for the Transporter. Two 750-KW generators, driven by two 1,065-horsepower diesel engines, power the jacking, steering, lighting, ventilating and electronic systems.

Maximum speed of the Transporter is about one-mile-per-hour loaded and about two-miles-per-hour unloaded. A trip from the pad with a Mobile Launcher, made at less than maximum speed, takes approximately seven hours.

The overall height of the Transporter is 20 feet from ground level to the top deck on which the Mobile Launcher stands for transportation. The flat deck is about the size of a baseball diamond (90 by 90 feet). The vehicle has two operator control cabs, one at each end of the chassis located diagonally opposite each other.

The Transporter moves on a roadway 131 feet wide, divided by a median strip. This is almost as broad as an eight-lane turnpike and is designed to accommodate a combined weight of about 18 million pounds.

The roadway is built in three layers with an average depth of seven feet. The roadway base layer is two-and-one-half feet of hydraulic fill compacted to 95 per cent density. The next layer consists of three feet of crushed rock packed to maximum density, followed by a layer of one foot of selected hydraulic fill. The bed is topped and sealed with an asphalt prime coat.

On top of the three layers is a cover of river rock, eight inches deep on the curves and six inches deep on the straightway. This layer reduces the friction during steering and helps distribute the load on the Transporter bearings.

Mobile Service Structure

A 402-foot-tall, 9.8-million-pound tower is used to service the Apollo launch vehicle and spacecraft at the pad. The 40-story steel-trussed tower, called a Mobile Service Structure, provides 360-degree platform access to the Saturn vehicle and the Apollo spacecraft.

The service structure has five platforms -- two self-propelled and three fixed, but movable. Two elevators carry personnel and equipment between work platforms. The platforms can open and close around the 363-foot space vehicle.

After depositing the Mobile Launcher with its space vehicle on the pad, the Transporter returns to a parking area about 7,000 feet from the pad. There it picks up the Mobile Service Structure and moves it to the launch pad. At the pad, the huge tower is lowered and secured to four mount mechanisms.

The top three work platforms are located in fixed positions which serve the lunar module, the service module, the command module and the launch escape system of the Apollo spacecraft. The two lower movable platforms serve the Saturn V.

The Mobile Service Structure remains in position until about T-11 hours when it is removed from its mounts and returned to the parking area.

Water Deluge System

A water deluge system provides a million gallons of industrial water for cooling and fire prevention during launch. Once the service arms are retracted at liftoff, a spray system cools these arms from the heat of the five Saturn F-1 engines during liftoff.

On the deck of the Mobile Launcher, 29 water nozzles start immediately after liftoff and deluges the face of the launcher for 30 seconds at the rate of 50,000 gallons-per-minute. After 30 seconds, the flow is reduced to 20,000 gpm.

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Positioned on both sides of the flame trench are a series of nozzles which will begin pouring water over the flame deflector at 8,000 gallons-per-minute, 10 seconds before liftoff.

Pad Areas

Both Pad A and Pad B of Launch Complex 39 are roughly octagonal in shape and cover about one-fourth of a square mile.

The center of the pad is a hardstand constructed of heavily reinforced concrete. In addition of the Mobile Launcher and the Saturn V, it must support--all at once--the 9.8-million-pound Mobile Service Structure and 5.5-million-pound Transporter.

Saturn V propellants, liquid oxygen, liquid hydrogen, and RP-1, are stored near the pad perimeter. Stainless steel, vacuum-jacketed pipes carry the liquid oxygen (LOX) and liquid hydrogen from the tanks to the pad, up the Mobile Launcher and into the rocket propellant tanks.

LOX is supplied from a 900,000-gallon storage tank. A centrifugal pump with a discharge pressure of 320 pounds-per-square-inch pumps LOX at flow rates as high as 10,000-gallons-per-minute.

Liquid hydrogen, used in the second and third stages, is stored in an 850,000-gallon tank, and is sent through 1,500 feet of 10-inch, vacuum-jacketed invar pipe. A vaporizing heat exchanger pressurizes the storage tank to 60 psi for a 10,000-gallons-per-minute flow rate.

The RP-1 fuel, a high grade of kerosene, is stored in three tanks, each with a capacity of 86,000 gallons. It is pumped at a rate of 2,000 gallons-per-minute at 175 psig.

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LAUNCH EVENTS

TIME		EVENT	ALTITUDE Feet	VELOCITY MPH
Min.	Sec.			
00	00	Liftoff		
00	11	Tilt Initiation	736	2
01	19	Maximum Dynamic Pressure	44,293	1,005
02	23	S-IC Center Engine Cutoff	179,639	4,892
02	28	S-IC Outboard Engines Cutoff	194,430	5,280
02	28	S-II Ullage Ignition	195,952	5,299
02	29	S-IC Retrorocket Ignition	196,560	5,300
02	29	S-IC/S-II Separation	196,772	5,300
02	30	S-II Ignition	201,982	5,293
02	59	Jettison S-II Aft Interstage	278,942	5,599
03	05	Jettison Launch Escape Tower	292,864	5,674
03	07	Jettison S-II Aft Cameras 1 & 2	299,277	5,710
03	10	Initiation of IGM	306,036	5,750
08	38	S-II Engines Cutoff Command	619,872	14,492
08	39	S-IVB Ullage Rocket Ignition	620,081	14,502
08	39	S-II Retrorocket Ignition	620,111	14,502
08	39	S-II/S-IVB Separation	620,133	14,502
08	43	S-IVB Engine Ignition	621,159	14,504
08	51	S-IVB Ullage Case Jettison	623,256	14,591
10	52	S-IVB First Guidance Cutoff	628,229	16,514
11	02	Insertion Into Parking Orbit	628,270	16,520

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Apollo 6 Normal Events Summary

Event	Time From Lift-Off (Hr:Min:Sec)	Weight (Lbs.)	Altitude (Ft.)	Geodetic Latitude (Deg.)	Longitude (Deg.)	Inertial Velocity (Ft/Sec)
Earth Parking Orbit						
Start Earth Parking Orbit	00:11:02	284,078	628,270	32.6N	55.1W	25,570
Start Second Revolution	01:38:33	282,394	654,009	32.2N	80.6W	25,557
Start 3rd Stage Attitude Orientation and Pre-ignition Sequence	03:04:34	281,514	672,362	31.0N	113.4W	25,545
Second 3rd Stage Burn						
Engine Ignition	03:10:09	281,264	670,356	32.5N	88.0W	25,555
Engine Cut-off	03:15:37	132,948	1,059,929	27.1N	60.2W	35,557
Coast to First SPS Burn						
Begin Reorientation to S-IVB/ CSM Separation Attitude	03:15:57	132,777	1,178,617	26.5N	58.4W	35,500
End of Reorientation to S-IVB/ CSM Separation Attitude	03:18:01	132,777	1,976,357	22.3N	47.7W	34,867
CSM/3rd Stage Separation	03:18:39	55,203	2,291,920	21.0N	44.8W	34,625
Begin Reorientation to First SPS Ignition Attitude	03:18:52	55,191	2,411,187	20.5N	43.8W	34,533
End of Reorientation to First SPS Ignition Attitude	03:18:53	55,191	2,419,284	20.5N	43.8W	34,527
First SPS Burn						
SPS Engine Ignition	03:20:17	55,191	3,260,446	17.5N	37.9W	33,913
SPS Engine Cut-off	03:24:31	37,743	6,222,662	9.3N	24.2W	28,151

Apollo 6 Normal Events Summary (Cont'd.)

Event	Time From Lift-Off (Hr:Min:Sec)	Weight (Lbs.)	Altitude (Ft.)	Geodetic Latitude (Deg.)	Longitude	Inertial Velocity (Ft/Sec)
Earth Intersecting Coast						
Begin Reorientation to Cold-Soak Attitude	03:24:37	37,707	6,289,037	9.1N	24.0W	28,099
End of Reorientation to Cold-Soak Attitude	03:25:38	37,698	7,009,327	7.4N	21.5W	27,619
Apogee	06:21:52	37,632	72,847,047	32.2S	44.7E	7,415
Begin Reorientation to Second SPS Ignition Attitude	09:07:46	37,570	14,849,495	2.0N	87.6E	23,273
End of Reorientation to Second SPS Ignition Attitude	09:08:45	37,561	14,091,275	3.0N	88.9E	23,640
RCS Thrusters On	09:21:44	37,561	4,544,443	20.6N	116.9E	29,337
Second SPS Burn						
Second SPS Engine Ignition	09:22:14	37,517	4,226,537	21.4N	118.57E	29,584
Second SPS Engine Cutoff	09:25:23	24,568	2,210,891	26.6N	131.5E	35,040
Pre-Entry Sequence						
Begin Reorientation to CM/SM Separation Attitude	09:25:59	24,532	1,839,953	27.6N	134.7E	35,333
End of Attitude Orientation Coast to CM/SM Separation	09:26:17	24,524	1,670,919	28.1N	136.2E	35,464
CM/SM Separation	09:27:54	12,481	888,787	30.4N	145.5E	36,091
Start CM Attitude Orientation for Entry	09:27:59	12,481	855,539	30.5N	146.0E	36,118
End of Attitude Orientation Coast to Entry	09:28:23	12,472	706,603	30.92N	148.45E	36,241

Apollo 6 Normal Events Summary (Cont'd.)

Event	Time From Lift-Off (Hr:Min:Sec)	Weight (Lbs.)	Altitude (Ft.)	Geodetic Latitude (Deg.)	Longitude (Deg.)	Inertial Velocity (Ft/Sec)
Atmospheric Entry						
400,000-Ft. Altitude	09:29:24	12,400	400,000	31.9N	155.0E	36,500
Enter S-Band Communications Blackout	09:29:48	12,396	303,400	32.15N	157.6E	36,573
Enter C-Band Communications Blackout	09:29:54	12,395	290,410	32.2N	158.1E	36,580
Exit C-Band Communications Blackout	09:32:15	12,141	218,524	32.7N	171.0E	24,846
Exit S-Band Communications Blackout	09:32:46	12,117	235,942	32.6N	173.6E	24,055
Enter 2nd S-Band Communications Blackout	09:37:14	12,038	223,860	29.8N	167.1W	22,461
Exit 2nd S-Band Communications Blackout	09:39:08	11,955	164,618	28.4N	161.0W	15,333
Drogue Parachute Deployment	09:43:39	11,908	23,500	27.2N	157.1W	*434
Main Parachute Deployment	09:44:27	11,606	10,500	27.2N	157.1W	*225
CM Splash	09:49:48	11,004	0	27.2N	157.1W	* 28.6

* Relative Velocity in feet-per-second

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FLIGHT PROFILE AND SEQUENCE OF EVENTS

NOTE: Information presented in this press kit is based on a nominal mission. Plans may be altered prior to or during flight to meet changing conditions.

Launch

The first stage of the Saturn V will carry the vehicle and Apollo spacecraft to an altitude of 32 nautical (37 statute) miles and 46 nautical (53 statute) miles downrange, building up speed to 5,278 nautical (6,194 statute) miles per hour in 2.5 minutes of powered flight. After separation from the second stage, the first stage will continue a ballistic trajectory ending in the Atlantic Ocean some 344 nautical (396 statute) miles downrange from Cape Kennedy (latitude 30.15 degrees North and longitude 74.27 degrees W) about nine minutes after liftoff.

Second Stage

The second stage, with engines running about 6 minutes, will propel the vehicle to an altitude of about 100 nautical (115 statute) miles some 818 nautical (942 statute) miles downrange, building up to 13,381 nautical (15,409 statute) miles-per-hour space fixed velocity. The spent second stage will land in the Atlantic Ocean about 20 minutes after liftoff some 2,314 nautical (2,665 statute) miles from KSC, at latitude 31.75 degrees North and longitude 35.9 degrees West.

First Third-Stage Burn

The third stage, in its 136-second initial period, will place itself and the Apollo spacecraft in a circular orbit 100 nautical (115 statute) miles above the Earth. Its inclination will be 32.73 degrees and orbital period, 88.2 minutes. Apollo 6 will enter orbit at about 55.1 degrees West longitude and 32.6 degrees North latitude at a velocity of 25,570 feet-per-second (17,434 statute or 15,140 nautical miles-per-hour).

Parking Orbit

While in the two revolutions in Earth parking orbit, the Saturn V third stage and spacecraft systems will be checked out in preparation for the second S-IVB burn.

Second Third-Stage Burn

Shortly after coming within range of Cape Kennedy, at the end of the second revolution, the J-2 engine will be re-ignited for 5 minutes 10 seconds. This will send the vehicle into a trajectory similar to the translunar trajectory to be used for manned lunar landing missions. However, in this mission the trajectory will not be in the direction of the Moon.

Following S-IVB cutoff, the vehicle will change spacecraft attitude before the command and service modules separate from the S-IVB in preparation for a retro burn of its Service Propulsion System (SPS).

CSM reaction control system provides the thrust needed for separation after the lunar module adapter is deployed. The third stage will then coast in translunar orbit. The trajectory will take the stage 279,000 nautical (320,000 statute) miles into space.

Orbital Coast and Cold Soak

After the third-stage cutoff, the spacecraft is oriented to an attitude for a first service propulsion system burn, i.e., pitched down about 173 degrees, or 26 degrees from the local horizontal.

Three minutes after third-stage engine cutoff, a programmed separation signal is fed into the Command Module Computer (CMC) to initiate separation of the command and service modules from the Saturn V third stage. The CMC initiates a service module reaction control system burn to achieve a forward thrust. After 1.7 seconds of thrusting, the spacecraft and the launch vehicle third stage separate. Reaction control system thrusting continues for another 8.3 seconds to separate the vehicles at a rate of about 2 feet-per-second.

A 90-second coast phase follows thrust termination of the Saturn third stage.

First SPS Burn

With spacecraft attitude 26 degrees pitched down from the local horizontal, the burn will last 4 minutes 14 seconds and will produce an apogee of 12,000 nautical (13,820 statute) miles, and perigee of 18 nautical (20.7 statute) miles. Inclination will be 32.5 degrees. Reentry velocity and flight path angle, in the event the second service-propulsion-system ignition does not occur, will be 32,813 feet-per-second and 6 degrees below the local horizontal with a resultant maximum load factor of 5.2 g.

Insertion into this new ellipse will occur about 9.3 degrees North latitude, 24.21 degrees West longitude, at service-propulsion-system engine cutoff 3 hours 24 minutes after liftoff.

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Earth Intersecting Coast

After service-propulsion-system cutoff, the spacecraft initiates a programmed reorientation maneuver to reestablish the cold soak attitude. This is a nominal 61-second movement using the RCS. At this time, the command module computer begins calculating the time to free fall to reentry (400,000 feet). The coast phase ends 25 minutes before reentry.

About 2 hours 57 minutes after service-propulsion-system cutoff -- 6 hours 22 minutes after liftoff -- the spacecraft reaches apogee. The coast phase will end about three hours after apogee. At this time the Carnarvon, Australia, ground station will update the CM computer with spacecraft position, velocity and time of free fall to reentry.

Some two minutes after this update is received the CMC schedules the second service-propulsion-system ignition. When time of free fall to reentry reaches 9 minutes, the command and service module reaction control system begins a 30-second ullage maneuver, which is followed immediately by service-propulsion-system ignition. Time from first service-propulsion-system cutoff is 5 hours 57 minutes; from liftoff 9 hours 22 minutes.

Second SPS Burn

The second burn -- 3 minutes 8 seconds -- of the service-propulsion-system is designed to achieve a reentry velocity of 36,500 feet-per-second (24,866 statute, 21,626 nautical miles-per-hour) and a flight path angle of 6.5 degrees below local horizontal. Ignition attitude is pitch 24.8 degrees below the inertial velocity vector, or 45.6 below local horizontal.

Reentry Sequence

At service-propulsion-system cutoff, about 4 minutes remain until reentry begins (400,000-feet altitude). In this period the command and service modules will separate and the command module will be oriented to reentry attitude. These changes occur over the western Pacific in the Guam area.

When time of free fall to reentry equals 3 minutes 5 seconds, the spacecraft will reorient itself so that a crew would be heads-up and facing forward. This attitude remains constant until time of free fall to reentry becomes 1 minute 30 seconds, then physical separation occurs with the reaction control system thrusters providing a rearward push to the service module. These fire until propellant is used up.

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Nominal splashdown for the service module (spin-stabilized non-tumbling reentry) will be about 9 hours 49 minutes after liftoff -- 18 minutes after separation -- 32.8 degrees North latitude and 168.5 degrees East longitude.

Allowing about five seconds after separation for command module stabilization, the guidance and navigation system will reorient the spacecraft to the predetermined reentry attitude. This attitude has an angle of attack 157.5 degrees with the relative velocity vector, with the lift vector up. A crew would be heads down, facing rearward.

Reentry, considered as beginning when the spacecraft reaches 400,000 feet altitude, will occur about 9 hours 29 minutes after liftoff at 31.9 degrees North latitude and 155.0 degrees East longitude, with inertial velocity of 36,500 feet-per-second (24,886 statute miles-per-hour) and inertial flight path angle of 6.5 degrees below local horizontal. Applying a nominal command module lift-drag ratio of 0.334 to the reentry profile, the splash point will be 27.33 degrees North latitude and 157.18 degrees West longitude, some 2,500 nautical (2,877 statute) miles downrange from reentry.

This reentry provides a maximum reentry heat rate of 372 British Thermal Units (BTU) per-square-foot-second, a total heat load of 37,615 BTU per-square-foot, at 9 hours 30 minutes 30 seconds elapsed time, and a maximum reentry load factor of 5.74 g at 9 hours 30 minutes 46 seconds elapsed time. The maximum heat rate will be encountered about 66 seconds after a normal reentry, maximum load will occur at drogue chute deployment.

Communications blackout will occur some 29 seconds after reentry and will last 2 minutes 22 seconds. Drogue parachute deployment takes place 14 minutes 10 seconds after reentry at 23,500 feet; main parachute deployment 59 seconds later at 10,500 feet.

Splashdown for a nominal mission will be 9 hours 49 minutes 43 seconds after liftoff at 27.2 degrees North latitude and 157.1 degrees West longitude, or some 339 nautical (390 statute) miles northwest of Kauai, Hawaii.

APOLLO 6 RECOVERY

Command module landing is planned in the mid-Pacific near Hawaii (Zone 4).

Sea and air recovery vehicles and crews are provided by the Department of Defense. Deployment of forces and techniques of search and recovery will follow those used in previous Apollo missions.

The normal recovery plan calls for splashdown in daylight. Recovery aids activated just before and after landing will, if needed, assist recovery crews in locating the spacecraft in darkness.

Abort Recovery

Mode 1 aborts using the launch escape system occur "off-the-pad" prior to or at liftoff, or at altitudes up to about 300,000 feet. After launch escape system jettison, about 186 seconds after liftoff, Mode 2 abort is accomplished by a full-lift reentry, after a service module reaction control system separation maneuver (see diagram, page).

Some 14 seconds after an off-the-pad (or extremely low altitude) abort is initiated the launch escape system is jettisoned from the command module. For higher altitudes, it is jettisoned at 23,100 feet.

Sequencing of the Earth landing system (ELS) is the same as for landing after orbital flight (see diagram page).

Boundaries of the launch abort landing corridor, beyond the launch site landing area immediately surrounding the launch pad, are the most extreme azimuth ground tracks anticipated. Spotting of recovery forces within this corrider is based on the probability of a landing in or near each particular area.

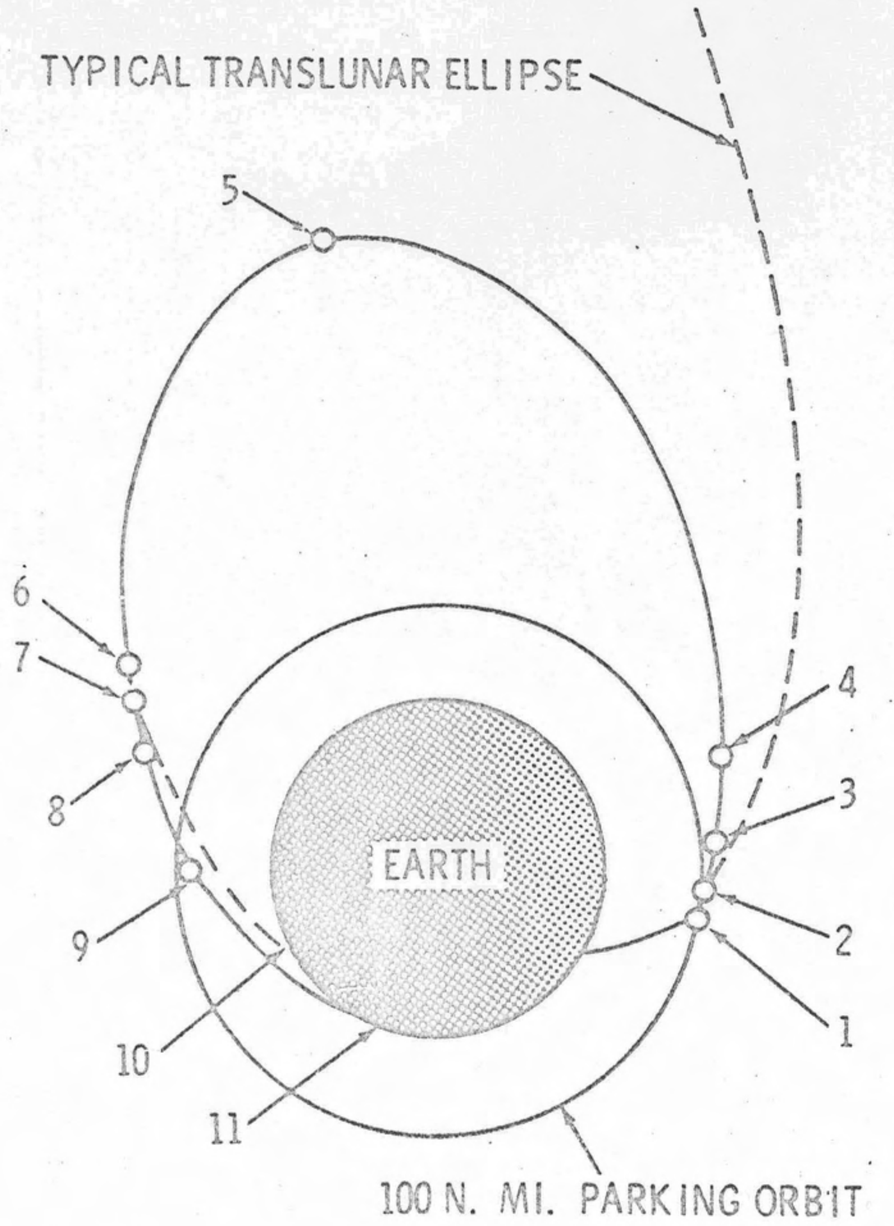
Access time to abort landing points is greater for some areas in the abort corridor than for the planned landing zone for orbital flight. Aircraft access time of four hours maximum to any point in the abort corridor is probable, however.

Post-Recovery

Some 24 hours after recovery of the Apollo 6 spacecraft the recovery ship is scheduled to dock at Ford Island, Pearl Harbor, where the spacecraft will be off-loaded and spacecraft systems deactivated. Deactivation will take about 30 hours.

The spacecraft then will be transferred to Hickam AFB, whence it will be flown by a C-133B aircraft to Long Beach, Calif. It will be trucked from there to the North American Rockwell plant at Downey, Calif.

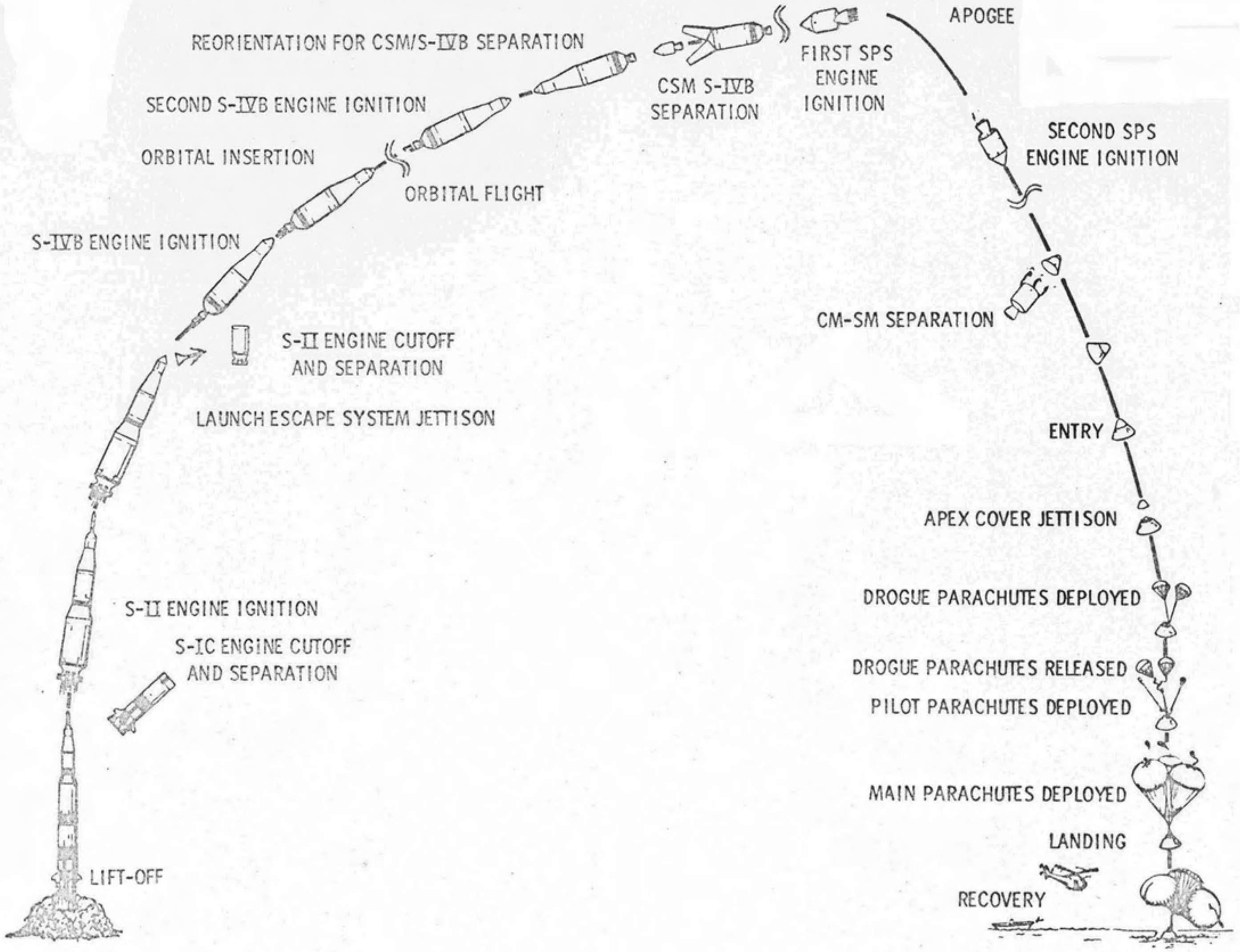
APOLLO 6 MISSION SUMMARY



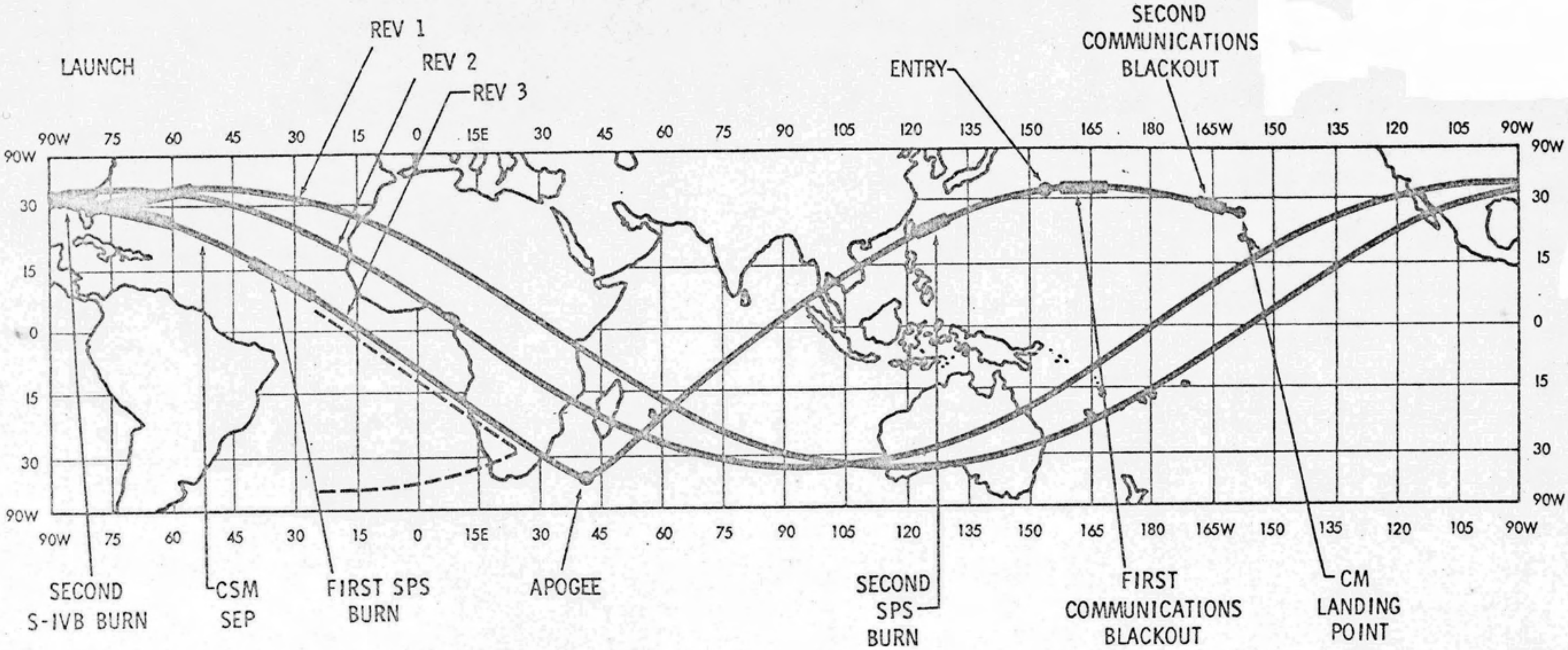
SEQUENCE OF EVENTS

1. INSERTION TO A 100 NAUTICAL MILE CIRCULAR PARKING ORBIT FOR TWO REVOLUTIONS
2. INJECTION ONTO A TYPICAL LUNAR TRANSFER ELLIPSE
3. S-IVB/CSM SEPARATION AND FIRST SPS IGNITION
4. FIRST SPS CUTOFF AND EARTH INTERSECTING COAST
5. 12,000 NAUTICAL MILE APOGEE
6. SECOND SPS IGNITION
7. SPS ENGINE CUTOFF
8. SM/CM SEPARATION
9. ATMOSPHERE ENTRY
10. SPLASH FOR NO SPS BURN
11. NOMINAL SPLASH

MAJOR MISSION EVENTS



APOLLO 6 MISSION PROFILE



NASA HQ MA 68-5859
3/6/68

MISSION CONTROL CENTER (MCC)

The Mission Control Center at the Manned Spacecraft Center, Houston, is the focal point for all Apollo flight control activities. The Center will receive tracking and telemetry data from the Manned Space Flight Network. These data will be processed through the Mission Control Center Real-Time Computer Complex (RTCC) and used to drive displays for the flight controllers and engineers in the Mission Operations Control Room and Staff Support rooms.

The Manned Space Flight Network (MSFN) tracking and data acquisition stations link the flight controllers at the Center to the spacecraft.

For Apollo 6, all stations will be configured as remoted sites without flight control teams. This implies that all uplink commands and voice communications will originate from Houston, and that the telemetry data sent back to Houston will be in the form of high speed (2.4KBS) data and can be either real time or playback information.

Signal flow for voice circuits between Houston and the remote sites is via commercial carrier, usually satellite, wherever possible using leased lines which are part of the NASA Communications Network (NASCOM).

Commands are sent from Houston to Goddard Space Flight Center (GSFC), Greenbelt, Md., lines which link computers at the two points. The Goddard computers provide automatic switching facilities and speed buffering for the command data. Data are transferred from GSFC to remote sites on 2.4KBS high speed lines. Command loads can also be sent on TTY lines from Houston to the remote site at a 100 wpm rate. Again, Goddard computers provide storage and switching functions.

Telemetry data at the remote site are received by the RF receivers, processed by the PCM ground stations, and transferred to the 642B remote-site telemetry computer for storage. Depending on the format selected by the telemetry controller at Houston, the 642B will output the desired format through a 2010 data transmission unit which provides parallel to serial conversion, and drives a 2.4KBS data modem. The data modem converts the digital serial data to phase-shifted keyed tones which are fed to the high speed data lines of the NASCOM Network.

Telemetry summary messages can also be output by the 642B computer, but these messages are sent to Houston on 100 wpm TTY lines rather than on the high speed lines.

Tracking data are output from the sites in both a low speed 100 words per minute TTY format, and a 240 bit block high speed (2.4KBS) format. Data rates are 1 sample/6 seconds for TTY messages, and 10 samples (frames) per second for high speed data.

All high speed data, whether tracking or telemetry, which originates at a remote site are sent to GSFC on 2.4KBS lines. Goddard reformats the data when necessary and sends them to Houston in 600-bit blocks at a 40.8 KBS rate. Of the 600-bit block, 480 bits are reserved for data, the other 120 bits for address, sync, intercomputer instructions, and poly-nominal error encoding.

All wideband (40.8KBS) data originating at Houston are converted to high speed (2.4KBS)data at Goddard before being transferred to the designated remoted site.

MANNED SPACE FLIGHT NETWORK (MSFN)

Ground Systems for Spacecraft Guidance, Command and Control

The Manned Space Flight Network is an around-the-world extension of the Mission Control Center's monitoring and command control capabilities. As in Apollo 5, the network will provide the flight director complete navigational and mission event control through global remote facilities connected by 2 million miles of NASCOM (NASA Communications Network) circuitry.

Geographically, the Manned Space Flight Network for Apollo is similar to that employed in Mercury and Gemini, but the system is more elaborate for Apollo's greater needs.

New Developments

Extensive alterations have been made to network equipment to accommodate the greater volume of information exchanged with ground stations over longer periods of time. A higher degree of reliability has been incorporated by designing redundancy where necessary. New insertion/injection and reentry ships, Apollo range instrumented aircraft and antenna systems for circuits with Intelsat communications satellites have been added to provide maximum spacecraft coverage throughout the mission.

Apollo demands a more compact tracking and communications system of greater power, flexibility and reliability. Ground stations receiving voluminous quantities of mission data are so equipped to display it immediately for control teams.

Apollo consists of four vehicles from which information must be acquired simultaneously, instantly recognized, decoded and arranged in a manner suitable for computer processing and display in the Houston control center. The Apollo Unified S-Band System (USB) was developed for these requirements. It combines in one transmission (uplink-downlink) the multiple functions previously requiring separate systems: tracking, determining flight path and spacecraft velocity; commanding the spacecraft via coded radio signals; and receiving coded radio signals (telemetry) on spacecraft integrity, systems condition, batteries, fuel state, etc.

Sites and Status

Unified S-Band sites are 10 land stations equipped with 30-foot diameter antenna systems, three with 85-foot dishes and a Grand Bahama Island station with a transportable van-mounted system with an erectable 30-foot antenna.

The USB systems have been under engineering evaluation for two years. Network operational experience has been gained with Lunar Orbiter V, Apollo-Saturn 202, Apollo 4 and Apollo 5. The 14-station network team performs daily reliability tests and frequent simulated missionsto increase operational proficiency and readiness. Previous Apollo flights have been controlled largely through a combination of Gemini ground systems and the newer USB equipment. These will provide duplicate (backup) data to the USB systems for both the S-IVB/IU and CSM.

TTS (Test and Training Satellite)

The TTS (Test and Training Satellite) launched last Dec. 13, has proved a valuable training aid of the Manned Space Flight Network. This 40-pound eight-sided spacecraft operatinga 265 by 165 nautical (305 by 190 statute) mile orbit, provides a practice spacecraft to all USB system operators.

As the satellite passes overhead, USB operators transmit various voice and data signals to it. A device on TTS receives the signal, amplifies it and retransmits it back to its source. Upon receipt of their original transmission, MSFN site operators are able to assess the quality and accuracy of their signal. The satellite simulates the passage of an Apollo spacecraft over the station and provides frequent practice for the operators.

With TTS, Apollo USB ground systems operators are able to conduct equipment and crew checkout in real time between missions and immediately before a launch. This has increased site system reliability, better coordination of equipment and more speed in acquisition of the spacecraft.

Participating Stations

For Apollo 6, 17 NASA USB ground facilities, seven Department of Defense associated radar land sites, two instrumented ships and four Apollo instrumented aircraft (ARIA) will provide the required tracking, data acquisition and voice/data communications services.

USB Sites:

NASA 30-Ft. Antenna Sites

Antigua (ANG)
Ascension Island (ACN)
Bermuda (BDA)
Canary Island (CYI)
Carnarvon (CRO), Australia
Grand Bahama Island (GBM)
Guam (GWM)
Guaymas (GYM), Mexico
Hawaii (HAW)
Merritt Island (MIL), Fla.
Texas (TEX), Corpus Christi

NASA 85-Ft. Antenna Sites

Canberra (CNB), Australia (Prime)
Goldstone (GDS), Calif. (Prime)
Madrid (MAD), Spain (Prime)
*Canberra (DSS-42-Apollo Wing) (Backup)
*Goldstone (DSS-11-Apollo Wing) (Backup)
*Madrid (DSS-61-Apollo Wing) (Backup)

*Wings have been added to JPL Deep Space Network site operations buildings. These wings contain additional Unified S-Band equipment as backup to the Prime Sites.

Participating Ships:

USNS REDSTONE - Insertion/Injection-Atlantic
USNS MERCURY - Insertion/Injection-Atlantic (Not required-Test and Evaluation only)
USNS WATERTOWN - CM/SM Separation
USNS TWIN FALLS VICTORY - Powered Flight Pacific

Tracking Third Stage to High Apogee

NASA's Manned Space Flight Network is responsible for transmitting command, communications, tracking and data acquisition signals from the S-IC, S-II, S-IVB/IU and the CSM throughout the Apollo 6 flight.

At approximately 200,000 feet altitude the S-IC stage will separate from the S-II booster. The first S-IVB burn occurs shortly after S-II burn, Launch Escape System jettison and S-II separation from the S-IVB, placing the spacecraft in a near-circular 100-nautical (115-statute) mile Earth orbit.

When the second revolution is completed over Cape Kennedy, Houston Mission Control will initiate a programmed maneuver for the second S-IVB burn of 5 minutes 10 seconds duration, injecting the spacecraft into a translunar-like coast which will carry it some 278,000 nautical (320,000 statute) miles away from Earth but not in the direction of the Moon.

The worldwide Smithsonian Astrophysical Optical Network will keep its telescopic cameras pointed along the predicted paths of reentry to pick up the returning S-IVB. Space position and look angle information will be generated by the Goddard Real Time Computing Center and provided to SAO network sites as required.

Backup Capability at Deep Space Network (DSN) Stations

For finite tracking and data acquisition at deep space ranges,MSFN 85-foot USB antenna systems have been co-located with NASA JPL Deep Space Network 85-foot systems at Goldstone, Calif; Madrid, Spain and Canberra, Australia. Located at 120-degrees apart, these sites will cover translunar and lunar ranges for Apollo missions.

As a reliability-safety factor each DSN site has been equipped with Apollo Unified S-Band ground systems. These systems are housed in a wing added to the DSN operations building -- for this reason they are called "wing sites." MSFN Apollo 85-foot systems are known as prime sites.

Apollo 6 will provide these new network sites an initial opportunity to exercise long range capabilities and Goddard network directors an engineering evaluation of individual and collective site performances.

Canberra and Goldstone will be called-up for the first and second revolutions and Madrid, in the third revolution. Prior to the start of the third revolution, the second S-IVB burn occurs. Before either Madrid prime or wing can acquire CSM/S-IVB, separation has occurred. By the time Madrid does acquire, the S-IVB will have attained an altitude of about 900 miles. Madrid prime or wing will track the S-IVB until the on-board battery dies at an estimated 10 hours GET.

Data During Reentry

Reentry of the CM will begin at 400,000 feet over the western Pacific Ocean. At this point scientists of Goddard will collect data on the reentry characteristics of the spacecraft and the friction-generated super-heated envelope surrounding it. Called plasma, the greatly disturbed atmospheric molecules forming the "sheath" make accurate tracking difficult and communications with the spacecraft virtually impossible.

The 10-man Apollo 6 Reentry Study Group will investigate reentry radar signatures, record spacecraft telemetry (radio) data to measure communications "blackout" times created by the plasma sheath. They will also study plasma penetration seeking an answer to the reentry blackout problem.

Network Support Team

Around-the-clock control of the Manned Space Flight Network is maintained by a 30-man (per 8-hour-shift) team of network systems specialists at Goddard. They will monitor every aspect of the worldwide network. The team reports its status and findings to the mission flight director at Houston but will retain its autonomy for checks, balances and corrections for continuity of coverage.

Testing the Network

Before Apollo 6 is flown, the network will undergo 14 days of checking and testing. Each system and subsystem at each station has its own performance criteria.

At Goddard these criteria are stored in a computer memory system. Each station reports its own system-by-system checks via the NASA Communications Network (NASCOM) high-speed digital circuits. By comparing these reports automatically with the stored values, any variation from the desired, the computer reports a "no-go" condition. If there is no variation, "go" is reported. The process is repeated until the test conductor finds the entire network ready. The procedure known as CADFISS (for Computer and Data Flow Integrated Subsystems Tests), is repeated for each mission.

Final Configuration

The Apollo Manned Space Flight Network will consist of 11 30-foot Earth-orbit USB antenna sites, three 85-foot antenna sites with 85-foot antenna wing sites for deep space tracking and communications; five Apollo ships and eight Instrumented Aircraft (ARIA) with USB facilities. Three ships will be equipped with 30-foot antennas (VANGUARD, REDSTONE, MERCURY) for insertion-injection coverage. Two ships are equipped with 12-foot antennas for reentry coverage (HUNTSVILLE, WATERTOWN). Each aircraft is equipped with a four-foot dish in its nose. In addition to the USB sites listed, other ground stations will provide telemetry, C-Band (space position) radar and voice relay as required.

Computers

Computers are key components in this system. UNIVAC 642 computers at the USB stations sort the data received from Apollo and route it, via telecommunications, to the Mission Control Center. Tracking stations ashore and afloat are linked through dual UNIVAC 418 real time systems that function as communications sub-switchers with the control center at Goddard, which has larger UNIVAC 494 real time Automatic Switching Systems.

Remote Site Data Processing Requirements for Apollo 6 Events

At remote stations the telemetry data processing system will be used to compress and reformat Pulse Code Modulation (PCM) real-time and real-time-playback telemetry data for transmission to the MCC-H computer complex. Telemetry data processing systems will be used to compress and reformat PCM real-time and real-time-playback telemetry data to teletype summary transmissions to the MCC-H computer complex, on-station CRT displays and high-speed print outs. The command data processor will receive and store high-speed and teletype commands loads from MCC-H. The computer also will transmit these commands to the spacecraft via UHF or USB equipment either at an MCC-H or on-station execute signal.

At split-second intervals the digital data processing systems, with the Houston Center as the focal point, talk in computer digital language to each other, or to the spacecraft, in real time.

Commands are thus sent to the Apollo spacecraft rapidly, even though the spacecraft is many thousands of miles from the control center. The command capability is needed for control or orbital guidance, go/no-go decisions, etc.

Before it is sent to the spacecraft, each command is automatically checked with pre-programmed information by the on-station computers to determine validity and thus guarantee that only the correct commands are sent to the spacecraft.

For downward data, sensors built into the spacecraft continually sample fuel state, temperature, attitude, and send these data to the ground. The on-site UNIVAC systems detect changes or variations for comparison with stored data; provide continual displays, and assemble, log and store data for immediate on-call display. They also process and put it into form for transmission to Mission Control Center in Houston.

WEATHER

The Weather Bureau provides operational weather support to the Apollo flight program. In association with other meteorological services, the Spaceflight Meteorology Group of the Weather Bureau monitors and forecasts conditions that might affect the Apollo missions. These include the weather elements important in the launch area, for selected areas beneath the orbital paths planned, and for possible landing and recovery areas.

While the Saturn V is being transported from the Vehicle Assembly Building to the launch pad, and before the actual launch, weather conditions are watched carefully to safeguard personnel and equipment against critical weather such as lightning or strong winds. At launch time, cloud ceilings must be high enough above the ground to allow proper positioning of recovery personnel and equipment for emergency recovery. If certain wind velocities are exceeded in launch and early flight phases, the launch vehicle may fail to perform properly. Engineers need photographs of the vehicle in the early portion of flight, so excessive cloud cover is a hindrance.

Certain experiments on the spacecraft depend on weather conditions along the orbital ground tracks.

The Apollo spacecraft can come down safely on water when wind and sea conditions are favorable. If conditions are poor, it would be difficult to effect recovery. Low clouds or poor visibility also would hamper search and rescue operations.

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APOLLO/SATURN PROGRAM MANAGEMENT

Direction of the Apollo Program, the United States' effort to land men on the Moon and return them safely to Earth before 1970, is the responsibility of the Office of Manned Space Flight (OMSF), National Aeronautics and Space Administration.

NASA Manned Spacecraft Center (MSC), Houston, is responsible for development of the Apollo spacecraft, flight crew training and flight control.

NASA Marshall Space Flight Center (MSFC), Huntsville, Ala., is responsible for development of the Saturn launch vehicles.

NASA John F. Kennedy Space Center (KSC), Fla., is responsible for Apollo/Saturn launch operations.

NASA Goddard Space Flight Center (GSFC), Greenbelt, Md., manages the Manned Space Flight Network under the direction of the NASA Office of Tracking and Data Acquisition (OTDA).

APOLLO/SATURN OFFICIALS

Dr. George E. Mueller	Associate Administrator for Manned Space Flight, NASA Headquarters
Maj. Gen. Samuel C. Phillips	Director, Apollo Program Office OMSF, NASA Headquarters
George H. Hage	Deputy Director, Apollo Program Office, OMSF
William C. Schneider	Apollo Mission Director, OMSF NASA Headquarters
Maj. Gen. John D. Stevenson	Director, Mission Operations, OMSF, NASA Headquarters
Dr. Robert R. Gilruth	Director, Manned Spacecraft Center, Houston
George M. Low	Manager, Apollo Spacecraft Program MSC

Kenneth S. Kleinknecht	Manager, Command and Service Modules, Apollo Spacecraft Program Office, MSC
Donald K. Slayton	Director, Flight Crew Operations, MSC
Christopher C. Kraft, Jr.	Director Flight Operations, MSC
Clifford E. Charlesworth	Apollo 6 Flight Director, Flight Operations, MSC
Dr. Wernher von Braun	Director, Marshall Space Flight Center, Huntsville, Ala.
Brig. Gen. Edmund F. O'Connor	Director, Industrial Operations, MSFC
Dr. Arthur Rudolph	Manager, Saturn V Program Office, MSFC
William D. Brown	Manager, Engine Program Office, MSFC
Dr. Kurt H. Debus	Director, John F. Kennedy Space Center, Fla.
Miles Ross	Dep. Director, Center Ops., KSC
Rocco A. Petrone	Director, Launch Operations, KSC
Dr. Hans F. Gruene	Director, Launch Vehicle Operations, KSC
John J. Williams	Director, Spacecraft Operations, KSC
Paul C. Donnelly	Launch Operations Manager, KSC
Gerald M. Truszynski	Associate Administrator, Tracking and Data Acquisition, NASA Headquarters
H. R. Brockett	Deputy Associate Administrator, OTDA
Norman Pozinsky	Director, Network Support Implementation Division, OTDA
Dr. John F. Clark	Director, Goddard Space Flight, Greenbelt, Md.

Ozro M. Covington	Assistant Director for Manned Space Flight Tracking, GSFC
Dr. Friedrich O. Vonbon	Chief, Mission Trajectory and Analysis Division, GSFC
Henry F. Thompson	Deputy Assistant Director for Manned Space Flight Support, GSFC
H. William Wood	Chief, Manned Flight Operations Division, GSFC
Tecwyn Roberts	Chief, Manned Flight Engineering Division, GSFC
L. R. Stelter	Chief, NASA Communications Division, GSFC
R. Adm. Roderick O. Middleton	Manager, Apollo Program Office, KSC

MAJOR APOLLO/SATURN V CONTRACTORS

Contractor	Item
Bellcomm Washington, D.C.	Apollo Systems Engineering
The Boeing Co. Washington, D. C.	Technical Integration and Evaluation
General Electric-Apollo Support Department, Daytona Beach, Fla.	Apollo Checkout and Reliability
North American Rockwell Corp. Space Division, Downey, Calif.	Spacecraft Command and Service Modules
Grumman Aircraft Engineering Corp., Bethpage, N.Y.	Lunar Module
Massachusetts Institute of Technology, Cambridge, Mass.	Guidance & Navigation (Technical Management)
General Motors Corp., AC Electronics Division, Milwaukee	Guidance & Navigation (Manufacturing)
Avco Corp., Wilmington, Mass.	Heat Shield Ablative Material
North American Rockwell Corp. Rocketdyne Division Canoga Park, Calif.	J-2 Engines, F-1 Engines
The Boeing Co. New Orleans	First Stages (SIC) of Saturn V Flight Vehicles, Saturn V Systems Engineering and Integration Ground Support Equipment
North American Rockwell Corp. Space Division Seal Beach, Calif.	Development and Production of Saturn V Second Stage (S-II)
McDonnell Douglas Co. Huntington Beach, Calif.	Development and Production of Saturn V Third Stage (S-IVB)

International Business Machines Huntsville, Ala.	Instrument Unit (Prime Contractor)
Bendix Corp., Navigation and Control Div. Teterboro, N.J.	Guidance Components for Instrument Unit (Including ST-124M Stabilized Platform)
Trans Word Airlines, Inc.	Installation Support, KSC
Federal Electric Corp.	Communications and Instrumentation Support, KSC
Bendix Field Engineering Corp.	Launch Operations/Complex Support, KSC
Catalytic-Dow	Facilities Engineering and Modifications, KSC

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