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PROJECT: APOLLO 5
(To be launched no
earlier than Jan. 18

contents

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NEWS

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APOLLO 5 FIRST LUNAR MODULE TEST IN SPACE

The first test in space of the Apollo spacecraft lunar module, the vehicle designed to land two astronauts on the Moon, is scheduled to take place no earlier than Jan. 18.

The unmanned Earth-orbital test flight, designated Apollo 5, will be launched from Complex 37 at Cape Kennedy, Fla., by an Uprated Saturn I rocket. The LM will not be recovered.

The lunar module is one of three that make up the Apollo spacecraft. The other two -- the command module and the service module -- have been successfully tested in space in previous unmanned missions and will not be flown in Apollo 5.

The lunar module, weighing 31,700 pounds with propellants, is made up of two stages. The descent stage powers the module from lunar orbit to the Moon's surface. It also serves as a launching pad for the ascent stage, which lifts the module from the Moon back to the command and service modules in lunar orbit.

Objectives of the Apollo 5 flight are to verify operation of the descent and ascent propulsion systems including restart and lunar module structure; evaluate lunar module staging and evaluate launch vehicle performance.

Major events and maneuvers of Apollo 5:

About 54 minutes after launch the lunar module will separate from the second stage of the Saturn and will coast in an orbit of 120-by-93-nautical miles (138-by-107-statute miles). During this and other coasting periods the lunar module reaction control system will maintain vehicle attitude and settle main engine propellants to the bottom of tanks.

The second stage of the launch vehicle will perform a propellant dump test about one revolution after separation from the lunar module. The test is designed to remove the remaining liquid hydrogen and liquid oxygen propellants through the engine.

The descent and ascent propulsion systems in the lunar module will be operated two times each.

The first operation of the descent propulsion system will be about 4.5 hours after lift-off. This will consist of a 26-second burn at 10 per cent of rated thrust of 10,500 pounds and then a buildup to 92.5 per cent. The total burn time, 38 seconds, will change the orbit of the lunar module to 178-by-116-nautical miles (206-by-134-statute miles).

This operation of the descent propulsion is to simulate the Hohmann (minimum energy) burn to be used in the lunar mission to transfer the lunar module from a circular orbit about the Moon to a trajectory toward the lunar surface.

A second descent propulsion system burn takes place some 36 minutes later to simulate the thrust levels planned for the powered descent portion of the lunar landing mission. The system will burn for a total of 12.5 minutes including 10 seconds each at 10, 50, 30, 40 and 20 per cent thrust levels and finishing up with the 92.5 per cent rated thrust level. This burn will place the lunar module in a 172-by-166-nautical mile (198-by-192-statute mile) orbit.

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The ascent propulsion system engine operation will begin simultaneously with termination of the second descent burn. This will be a "fire-in-the-hole" burn (while the descent and ascent stages are still attached) and stage separation will occur. After this 5.25-second burn the descent stage will be in a 172-by-166-nautical mile (198-by-192-statute mile) orbit while the ascent stage will orbit at 172-by-167-nautical miles (198-by-193-statute miles).

The ascent propulsion system will be operated one revolution later. During this burn a test will determine reaction control system operation using propellants from the ascent propulsion system tanks which are interconnected to the reaction control system tanks. The second ascent propulsion system burn will be for 450 seconds to simulate ascent from the Moon's surface in a lunar mission and will place the ascent stage in an orbit at 440-by-170-nautical miles (507-by-196-statute miles).

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Schedule of LM-1 events in Apollo 5:

Time after Lift-off Hrs. Min. Sec.	Event	Propulsion System	Duration of Burn	Orbit Nautical Miles
00:54:00	Separation from Second Stage	Reaction Control	15 Sec. total in two firings	120-by-93
4:00:02	First DPS Burn	Descent	38 Sec.	178-by-116
4:37:12	Second DPS Burn	Descent	12.5 Min.	172-by-166
4:49:25	First APS Burn	Ascent	5.25 Sec.	172-by-167 (Ascent Stage)
6:13:35	Second APS Burn	Ascent	7.5 Min	440-by-170 (Ascent Stage)

The two operations of the descent and ascent propulsion systems will complete the primary mission of Apollo 5 but additional tests may be conducted in the remaining seven-hour lifetime of the lunar module systems. The ascent stage is expected to remain in orbit about two years, and the descent stage about three weeks. The launch vehicle second stage will orbit only about 18 hours.

At the end of their orbital lifetimes the launch vehicle second stage and the ascent and descent stages will reenter the Earth's atmosphere and disintegrate.

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Launch vehicle for the Apollo 5 mission will be the Uprated Saturn I (AS-204) originally scheduled for the first manned Apollo mission in February 1967. Following the fire in which Astronauts Virgil I. Grissom, Edward H. White, II and Roger B. Chaffee were killed, the launch vehicle was demated and removed from Complex 34 and re-erected on Complex 37 for this flight.

The launch vehicle consists of the first (S-IB) stage which develops 1.6 million pounds thrust at lift-off, the second (S-IVB) stage of 200,000 pounds thrust in space, and an instrument unit.

Apollo 5 will not carry the full Apollo spacecraft. Atop the instrument unit is the spacecraft lunar module adapter, which houses the lunar module (No. 1), and a nose cone. Lunar Module 1 will not have its landing gear. It will carry a mission programmer in place of astronauts to control the spacecraft.

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.

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

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

The NASA John F. Kennedy Space Center (KSC), Kennedy Space Center, Fla., has charge of Apollo/Saturn launch operations.

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

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APOLLO 5 BACKGROUND INFORMATION

Spacecraft (LM-1) Apollo 5 Mission

Lunar Module 1 (LM-1) consists of an ascent and a descent stage, the two joined by four explosive bolts and an umbilical. The stages operate as a single unit or the ascent stage functions alone.

Ascent Stage: The ascent stage is divided into five structural areas -- the crew compartment, midsection, aft equipment bay, tank and equipment mountings, and the outer skin and insulation.

The crew compartment is a pressure-tight unit some 92 inches in diameter. Structural interface between the crew compartment and the midsection is the forward midsection bulkhead. These two sections constitute the entire pressurized volume available for crew operation in the LM.

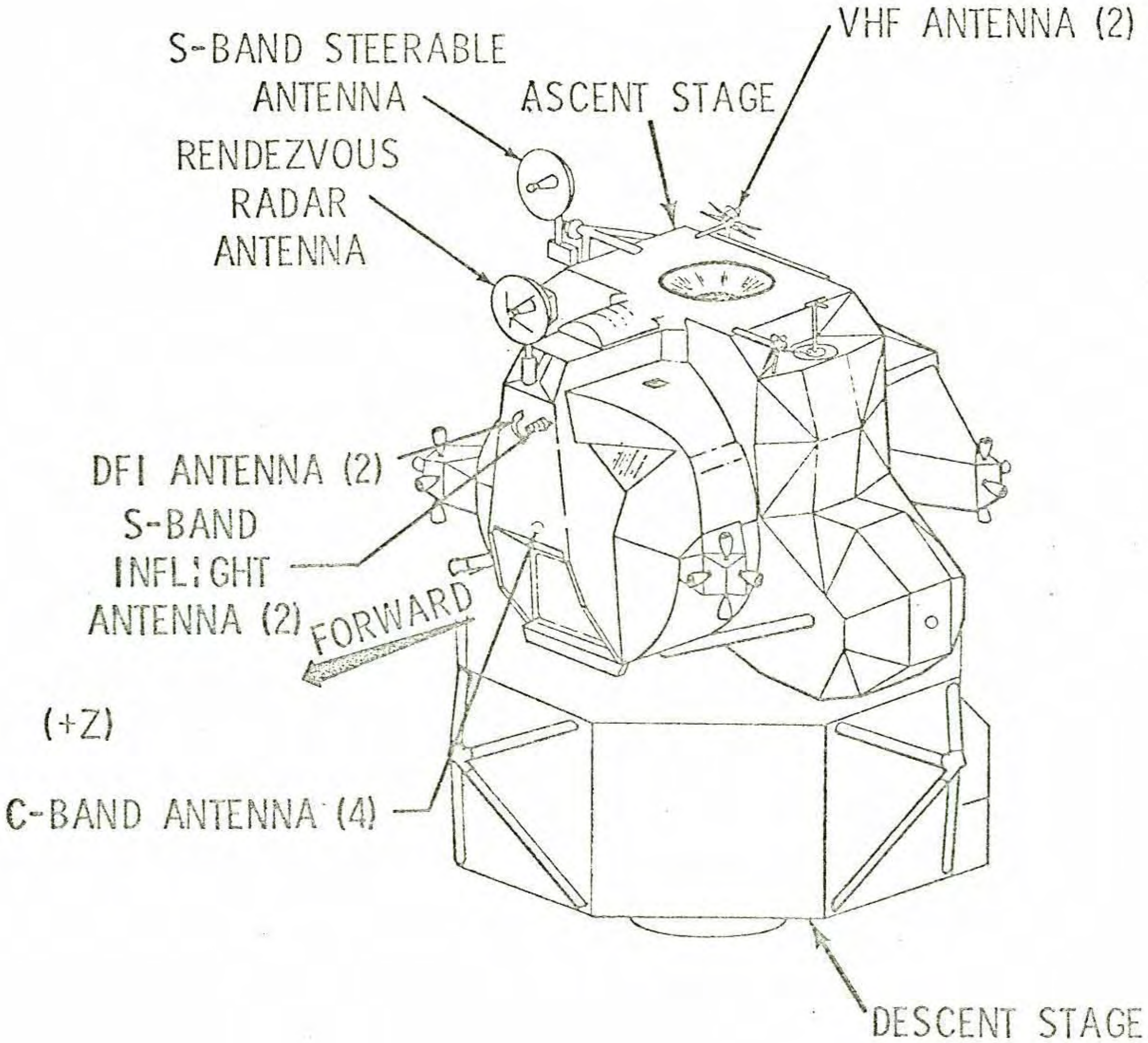
The aft equipment bay is an aluminum alloy frame secured to the aft midsection by aluminum alloy trusswork. The unpressurized compartment contains a series of cold rails for structural mounting and thermal control of electronic equipment, and tubular trusses for tankage support. The complete ascent stage is covered with a thermal and meteoroid shield of thin aluminum or aluminized Mylar or both.

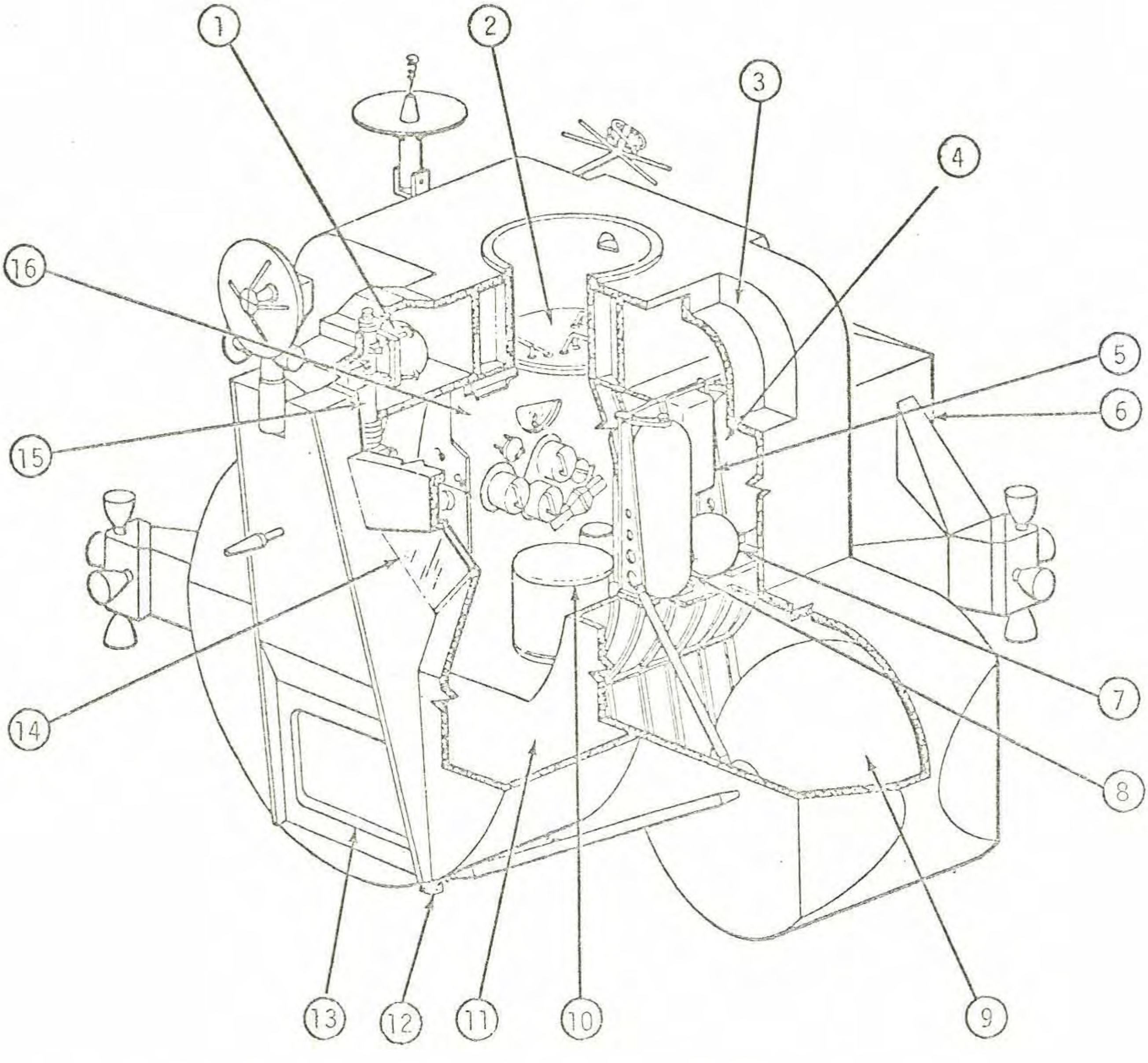
Descent Stage: The main load-carrying structure of the descent stage is two pairs of parallel beams in cruciform arrangement, plus upper and lower decks and enclosure bulkheads of aluminum alloy in conventional skin and stringer construction. The middle compartment, formed by the crossed pairs of beams, contains the descent engine. The areas on each side of the center structure house the four main descent propellant tanks.

Additional support and strut assemblies are secured to the main beams to form diagonal bays or quadrants. Viewed from top or bottom, the stage forms an octagon. Outriggers extending from the ends of each pair of beams provide the four points of attachment to the spacecraft LM adapter (SLA). The landing gear is not carried on LM-1

APOLLO 5 MISSION

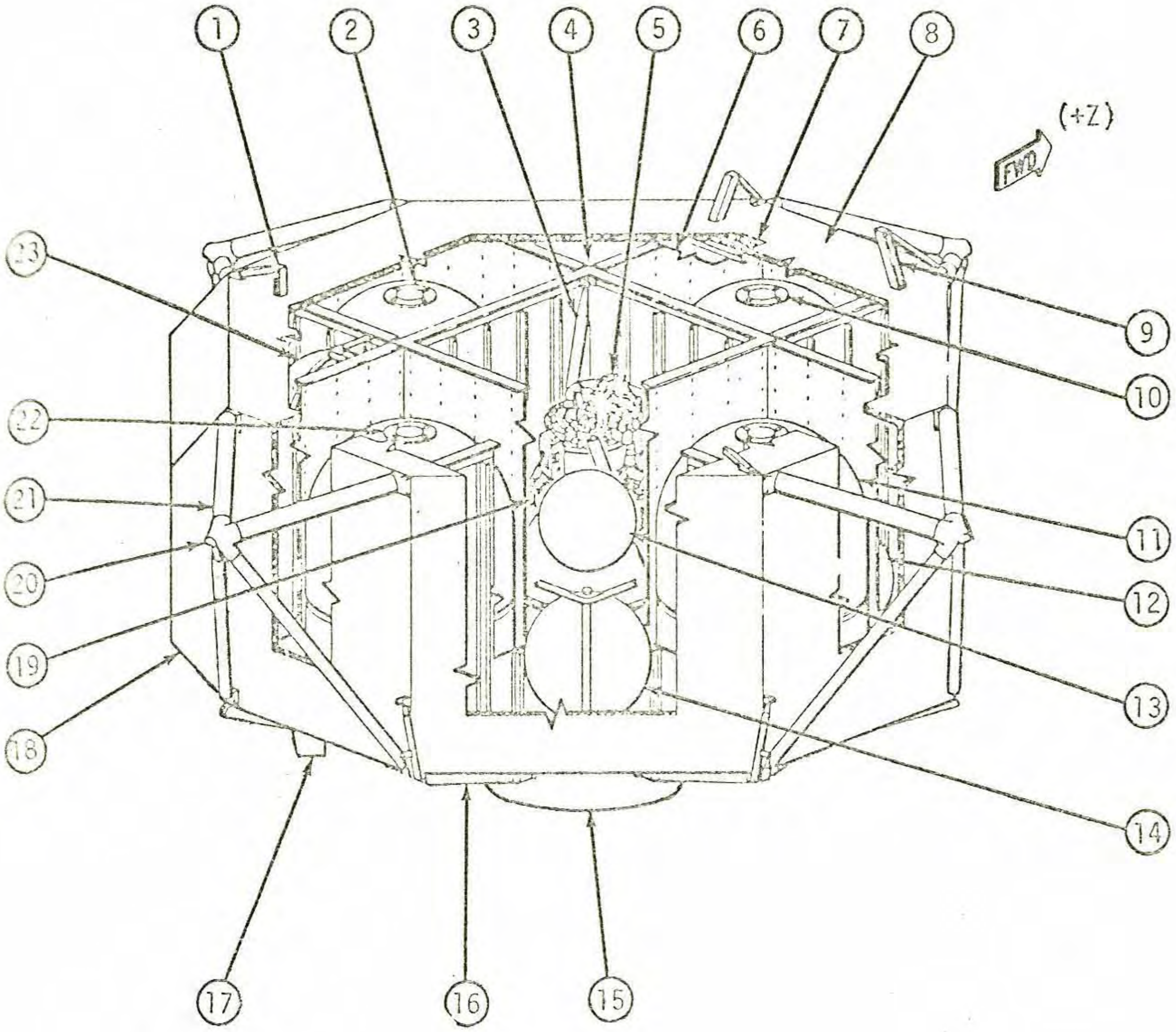
LUNAR MODULE (LM-1)





1. INERTIAL MEASURING UNIT	8. OXIDIZER TANK (RCS)
2. DOCKING HATCH	9. FUEL TANK
3. DOCKING TARGET RECESS	10. ASCENT ENGINE COVER
4. FUEL TANK (RCS)	11. CREW COMPARTMENT
5. HELIUM PRESSURE REGULATING MODULE	12. FORWARD INTERSTAGE FITTING
6. AFT EQUIPMENT BAY	13. INGRESS/EGRESS HATCH
7. HELIUM TANK (RCS)	14. CABIN WINDOW
	15. ALIGNMENT OPTICAL TELESCOPE
	16. MIDSECTION

ASCENT STAGE



1. AFT INTERSTAGE FITTING
2. FUEL TANK
3. ENGINE MOUNT
4. PLSS, S-BAND ANTENNA STORAGE BAY
5. DESCENT ENGINE
6. STRUCTURAL SKIN
7. INSULATION
8. THERMAL SHIELD
9. FORWARD INTERSTAGE FITTING
10. OXIDIZER TANK
11. FUEL TANK
12. BATTERY STORAGE BAY
13. OXYGEN TANK
14. HELIUM TANK/CRYOGENIC
15. DESCENT ENGINE SKIRT
16. TRUSS ASSEMBLY (LDG GR)
17. LANDING RADAR ANTENNA
18. SCIENTIFIC EQUIPMENT BAY
19. GIMBAL RING
20. ADAPTER ATTACHMENT POINT
21. OUTRIGGER
22. OXIDIZER TANK
23. WATER TANK

DESCENT STAGE

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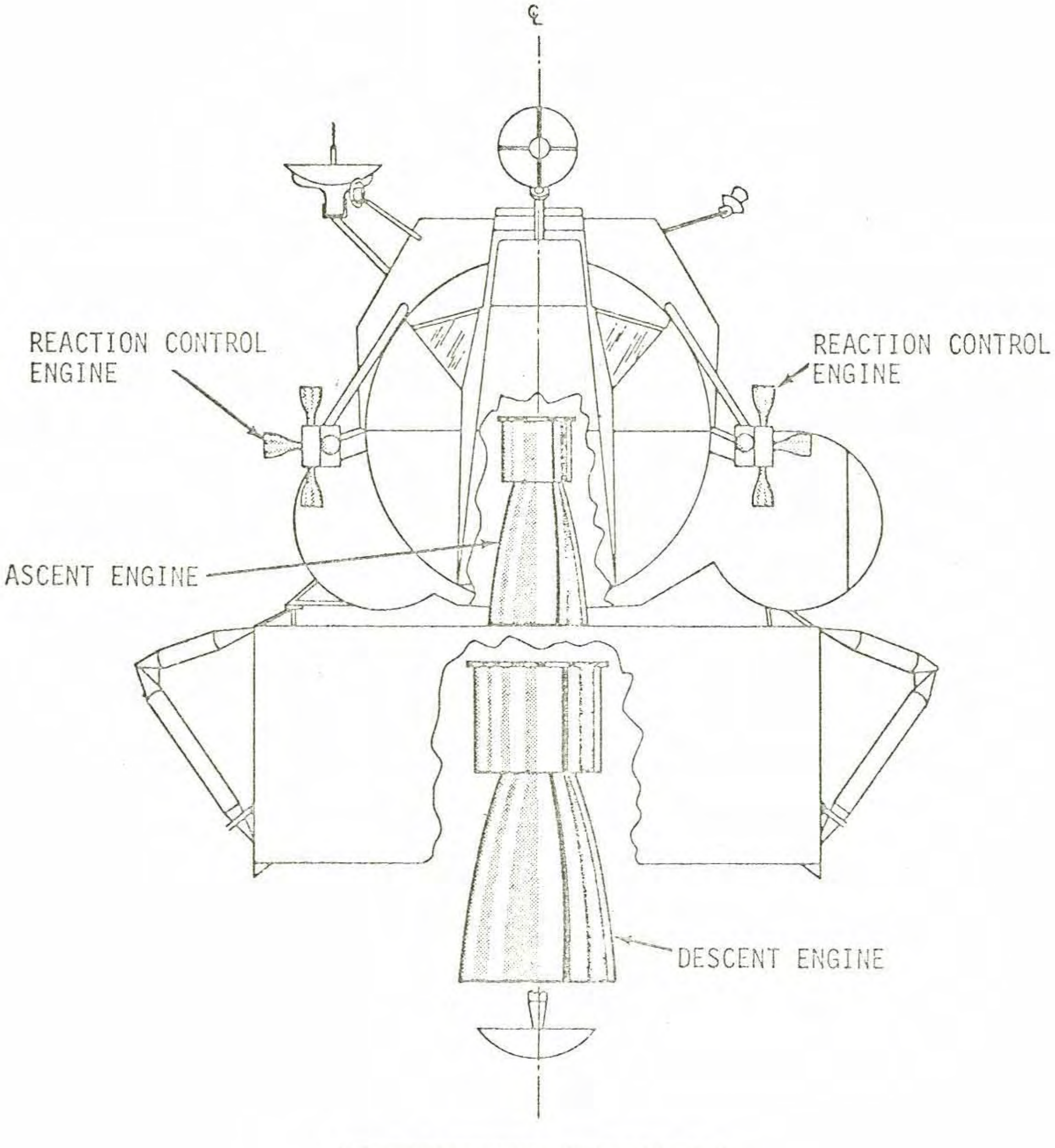


LM ENGINE LOCATIONS

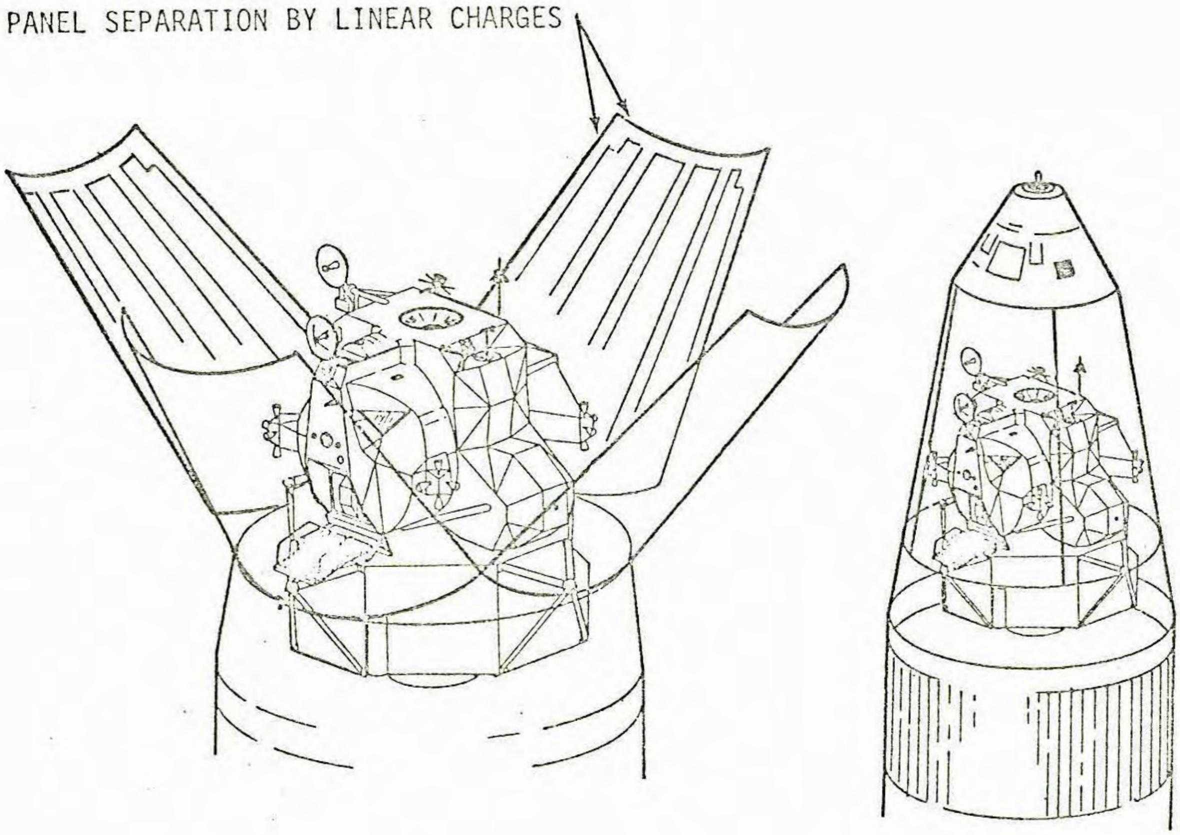
Approximate spacecraft weight at launch is 31,700 pounds, which breaks down as:

Ascent stage (dry)	4,850
Descent stage (dry)	3,650
RCS Propellants	550
DPS Propellants	17,600
APS Propellants	5,050
	31,700

Spacecraft LM Adapter (SLA): The SLA connects the nose cap to the launch vehicle third stage instrumentation unit (IU) and houses the LM, the SLA spacecraft jettison controller (SJC) and power supplies. It is a truncated cone 28 feet high, 12.8 feet in diameter at the top and 21 feet in diameter at the bottom. The SLA weighs 3,950 pounds.

The structure is mainly 1.7-inch aluminum honeycomb bonded to aluminum face sheets of varying thickness. The SLA's four movable panels open on programmed command to allow the LM to deploy from the SLA. The panels open through an arc of 45 +5 or -11 degrees. Opening momentum is applied by the pyrotechnic devices which shear the panels from one another along the seam lines (20 per cent momentum), eight thrusters at the corners of the panels (two degrees of panel movement or another 20 per cent of momentum), and four spring loaded cable and pulley assemblies. Panel movement is stopped by eight attenuator struts with crushable aluminum honeycomb cores.

The panels are held in deployed position by a clutch on each pulley assembly. The LM is held in the SLA by four straps. After panel deployment, LM RCS forward translation is initiated. Five seconds later, pyrotechnic devices sever the straps and a guillotine cuts the electrical connections between the LM and the SLA. Continued forward translation by the LM RCS moves the spacecraft out of the adapter about four feet per second.



LM-1/SLA ADAPTER

SLA Nose Cone: The nose cone, providing aerodynamic continuity to the launch vehicle-SLA structure, is separated from the SLA by 24 springs positioned symmetrically around the base circumference of the nose cone. It is 11.3 feet tall and tapered 25 degrees to a base 12.8 feet in diameter. It weighs 1,067 pounds. The union between the nose cone and the SLA is sheared by a mild detonating fuse. Two transducers, 180 degrees apart near the top of the SLA, sense alternating points of conductivity or non-conductivity along 16 feet of woven glass tape drawn through the transducers as the nose cone separates. Readings of conductivity/non-conductivity points on the tape confirm nose cone separation.

Spacecraft Systems (LM-1) Apollo 5 Mission

Electrical Power System (EPS): The lunar module DC electrical system consists of six silver-zinc primary batteries, four electrical control assemblies (ECA), and two DC buses. Four primary batteries and two ECAs are located in the descent stage, the other batteries and ECAs in the ascent stage. To avoid over-voltage conditions, the primary batteries will be pre-discharged before liftoff.

The AC electrical system consists of two single phase AC inverters and one AC bus, located in the ascent stage. Only one inverter will power the bus at any given time.

Environmental Control System (ECS): The two ascent stage oxygen tanks will be filled partially, to 4.35 psia, to supply oxygen directly to the sensing ports of the primary and secondary water regulators; tank No. 2 will provide reference pressure to the primary regulators, tank No. 1 to the secondary regulator. The oxygen control module, which reduces LM oxygen pressure, and the descent oxygen tank will not be installed in LM-1. The shutoff valve will be closed and the line capped.

The ECS suit loop will be installed but disabled by open circuit breakers. The descent stage water tank will be installed but not loaded. The ascent tanks will supply water to the boiler to allow proper thermal control of the spacecraft.

Both primary and secondary glycol loops will be installed, but only the primary loop will operate on this flight.

Communications System (COMM): The LM communications system consists of two S-band transceivers and power amplifiers, two VHF/AM transceivers, two audio centers, a premodulation processor, and associated antennas. The operational VHF/AM transceivers will not be installed in LM-1, the audio centers will be installed but not used.

In addition, ranging and operational PCM data transmission will be through the S-band system using inflight antenna No. 2 located on the rear or Z axis side of the spacecraft.

Primary Guidance and Navigation System (PGNS): This self-contained system requires no data from a source outside the LM once the system has been initiated. For Apollo 5, provision is made, as a secondary mode of operation, for insertion of navigation, target, and mode control data from the ground via the LM guidance computer (LGC).

The LM-1 PGNS consists of:

1. Inertial subsystem (ISS)
    a. inertial measurement unit (IMU)
    b. inertial system coupling data units (ICDU)
    c. power servo assembly (PSA)
    d. pulse torquing assembly (PTA)

2. Computer subsystem (CSS)

    a. LM guidance computer (LGC)
    b. display and keyboard (DSKY)

Two PGNS subsystems -- the optics subsystem consisting of the alignment optical telescope (AOT), and the radar subsystem consisting of the rendezvous radar (RRCDU) -- have been deleted from LM-1.

For Apollo 5, the LGC will work as an automatic programmer to control onboard functions, with the PGNS automatically accomplishing all guidance, navigation, and control of the spacecraft. Some program change can be provided in real time by ground control through the uplink command circuit.

A major failure in the LGC or the IMU will remove the PGNS from control of the vehicle and force the spacecraft into a program reader assembly (PRA) or ground real time command (RTC) backup control. A major failure of the PGNS will prevent long-duration ascent or descent propulsion system (APS or DPS) tests on LM-1.

Reaction Control System (RCS): Each of the four RCS engine clusters consists of four rocket engine assemblies, each engine delivering about 100 pounds of thrust. The propellant delivery plubming, valves, and pressurizing assemblies are parallel, independent systems. Propellants are hypergolic (spontaneously igniting on mixture of oxidizer and fuel). The oxidizer is nitrogen tetroxide, the fuel Aerozine 50 -- a 50/50 blend of hydrazine and unsymmetrical dimethyl hydrazine. Helium pressurizes the propellant delivery system.

The RCS provides:

1. Small thrust impulses to stabilize the spacecraft during ascent and descent burns;

2. Thrust impulses to control vehicle attitude and translation during maneuvers;

3. Thrust for separation maneuvers, and

4. Thrust for ullage maneuvers to settle propellant in ascent and descent stage tanks.

The system can operate in either a pulsed or a steady-state mode.

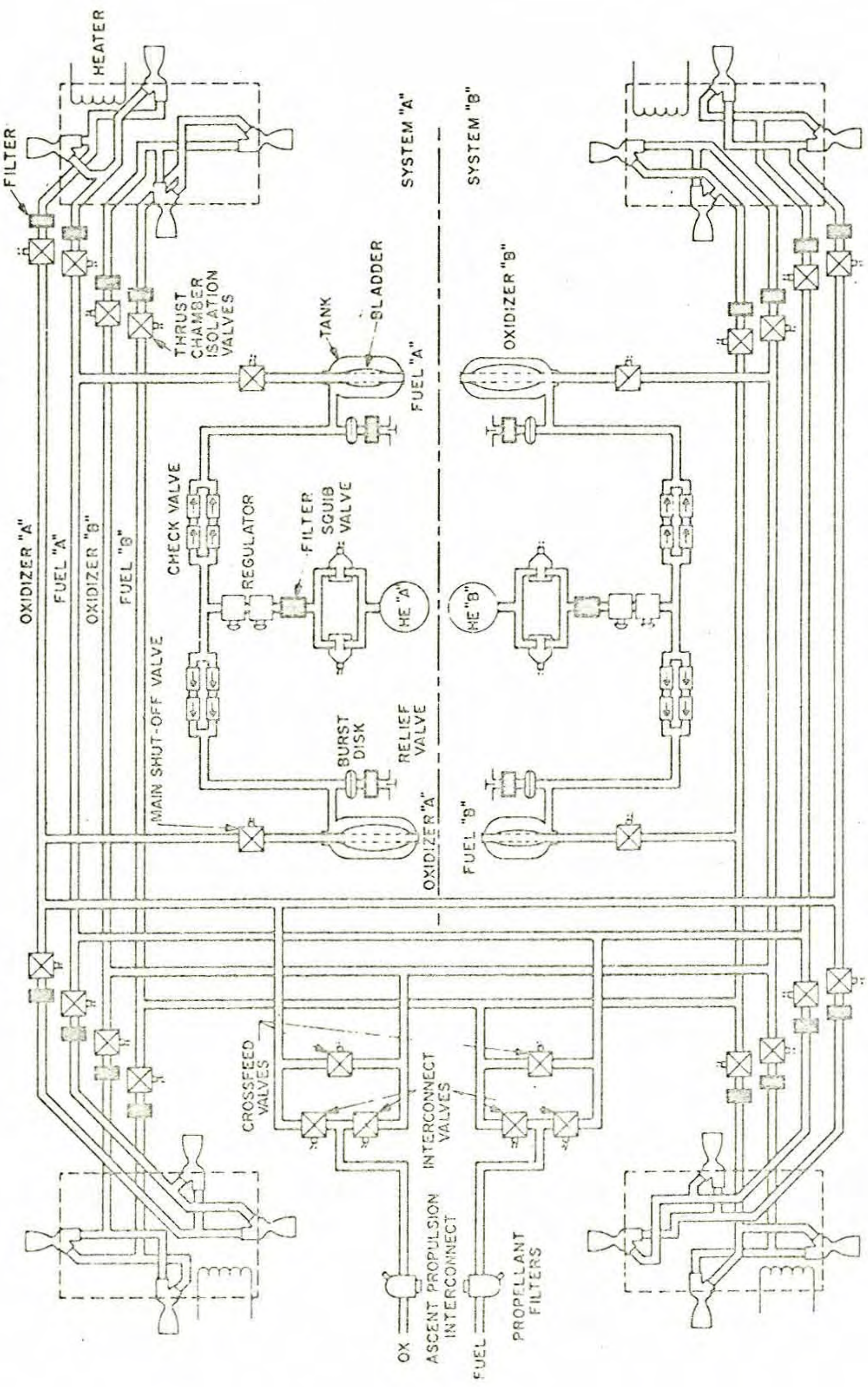
In the Apollo 5 mission, coordinated pitch-roll maneuvers performed by the RCS will be at a maximum rate of five degrees per second and the follow-on yaw maneuver at a rate of two degrees per second.

Descent Propulsion System (DPS): The descent engine has 10,500 pounds maximum rated thrust and is throttleable from 9,710 to 1,050 pounds and can be gimballed + 6 degrees in any direction. Its propellants are Aerozine 50 fuel and nitrogen tetroxide oxidizer. The pressurant is helium.

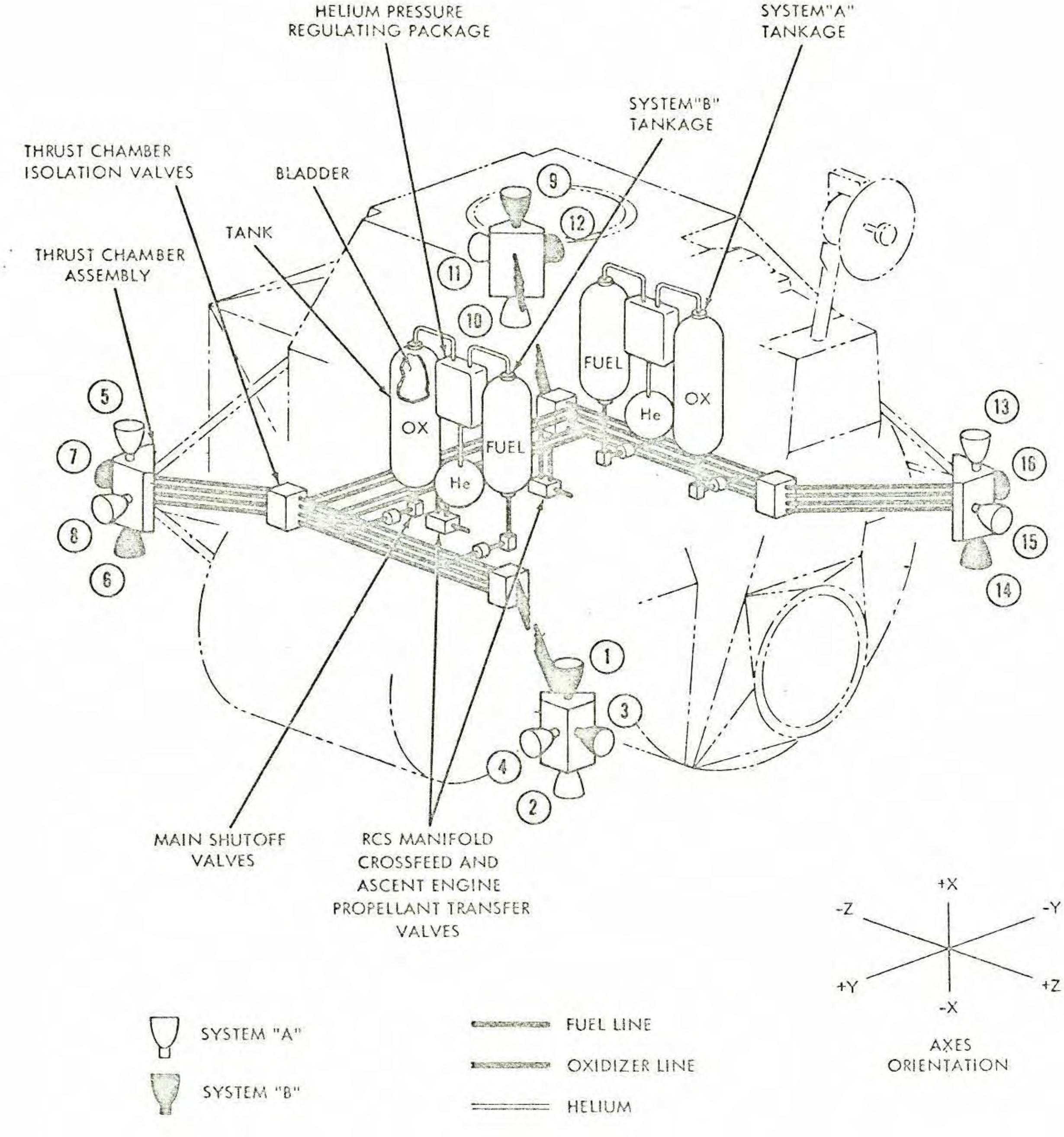
Ascent Propulsion System (APS): The ascent engine is neither throttleable nor gimballed. Its thrust is 3,500 pounds and its propellants the same used in the DPS and RCS. The engine is dormant until the "fire-in-the-hole" burn -- a sequence that separates the ascent stage from the descent stage and ignites the engine.

LM Mission Programmer (LMP): The LMP replaces the human pilot in the unmanned LM-1. It is semiautomatic. It receives commands from the Lunar Module Guidance Computer, Program Reader Assembly or from the Ground Controller. The package consists of four basic units:

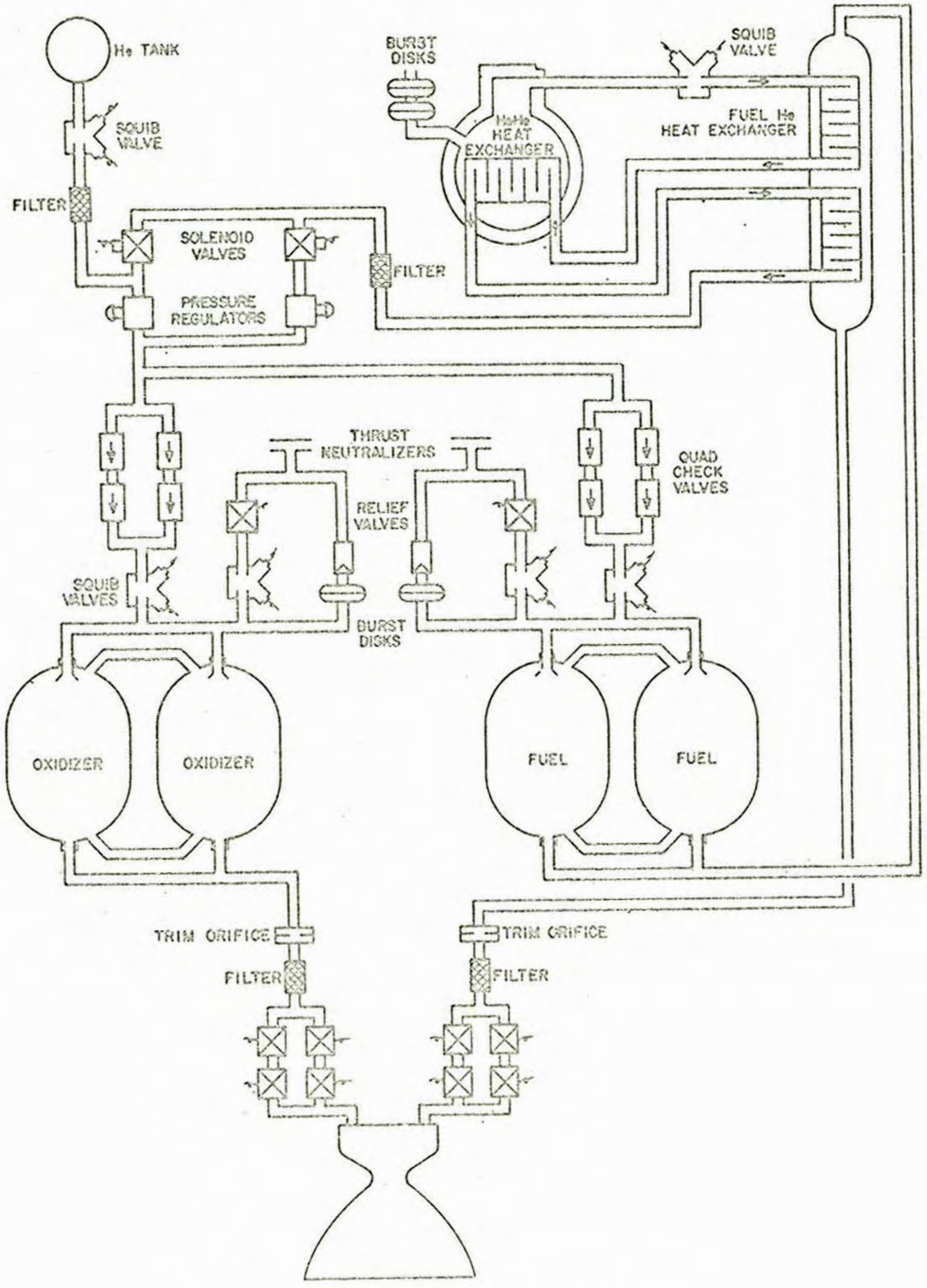
1. The program command assembly (PRA) which contains taped contingency programs to be used in the event of an LGC failure;



REACTION CONTROL SUBSYSTEM SCHEMATIC



RCS INSTALLATION



DESCENT PROPULSION SCHEMATIC

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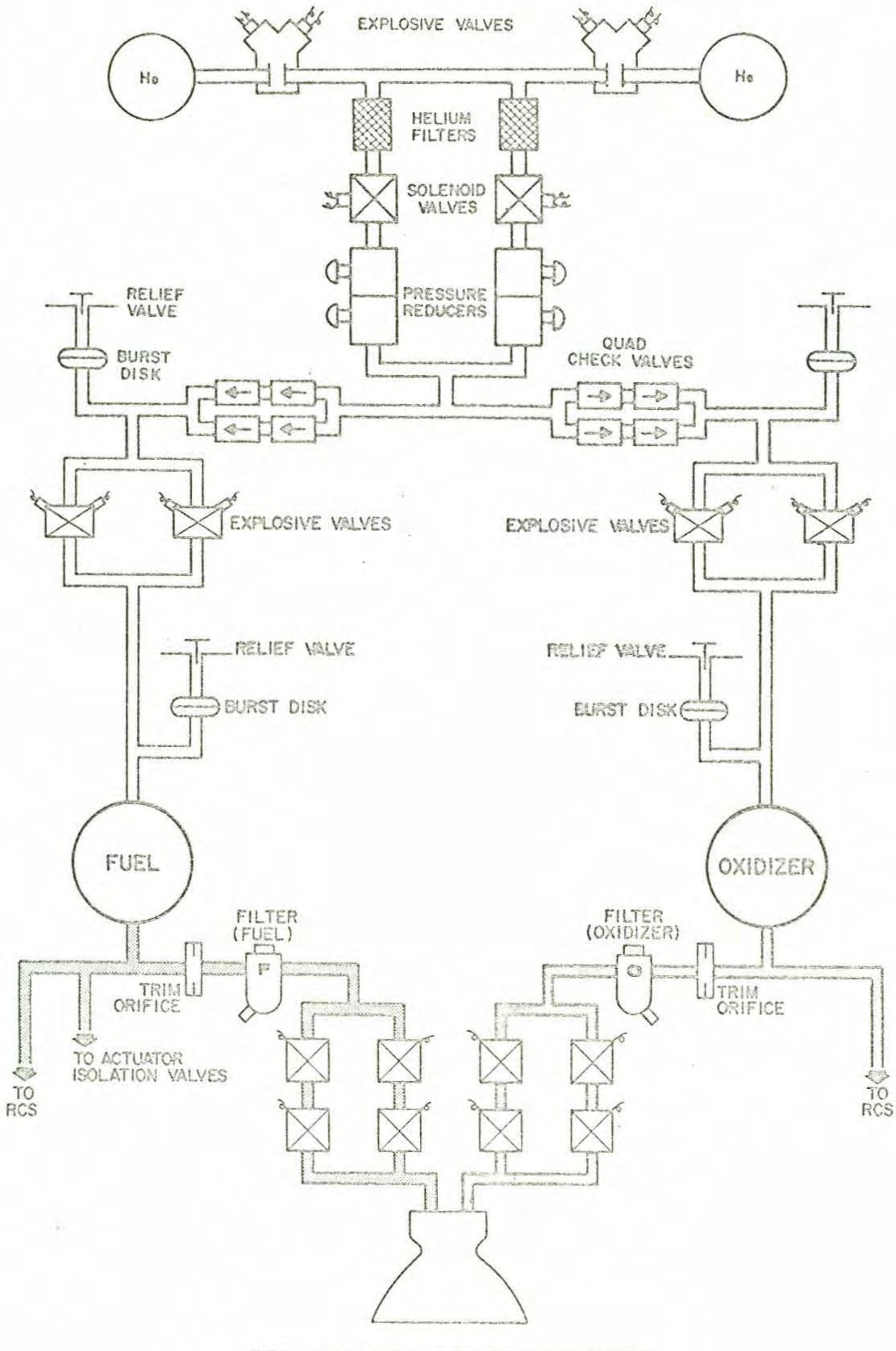

ASCENT PROPELLANT SYSTEM

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2. The digital command assembly (DCA) which provides an uplink capability for routing of ground signals to the LM guidance computer (LGC), the program reader assembly (PRA), the program coupler assembly (PCA), thence to the basic subsystem for control;

3. The program coupler assembly (PCA) which provides coupling of the LGC and PRA commands to control the basic subsystems;

4. The power distribution assembly (PDA) which provides the 28 VDC power distribution and current protection for the LMP components.

THE UPRATED SATURN I LAUNCH VEHICLE

The fourth uprated Saturn I is the 15th in the Saturn series.

Three Uprated Saturns launched in 1966 followed 10 Saturn I successes; they were launched Feb. 26, July 5, and Aug. 25, 1966. The first Saturn V, launched Nov. 9, 1967, was a success.

Rocket designers at the NASA-Marshall Space Flight Center conceived the Uprated Saturn I in 1962 as the quickest, most reliable, and most economical means of providing a vehicle with greater payload capability than the Saturn I for Apollo missions before the Saturn V would be available.

The Saturn program sprang from studies started in April 1957 by the Army Ballistic Missile Agency to establish possible vehicle configurations to launch payloads of 20,000 to 40,000 pounds for orbital missions, and 6,000 to 12,000 pounds for escape missions.

The ABMA rocket development group, later transferred to NASA, sought to demonstrate the feasibility of clustering available hardware and engines to make a booster for a multi-stage launch vehicle. In November 1958, the development of a clustered booster to serve as the first stage of the multistage carrier vehicle capable of performing advanced space missions was approved.

The project, named "Saturn" in Feb. 1959, resulted in 10 of the Saturn I launchings, beginning in Oct., 1961, and ending in July, 1965.

The Uprated Saturn I vehicle consists of two propulsion stages and an instrument unit, all of which are derived from other Saturn configurations.

The first stage, the S-IB, is a modification of the booster or first stage (S-I) of the Saturn I. The second, S-IVB, stage is an out-growth of the Saturn I second stage (S-IV). S-IVB development was originated for the Saturn V, in which the S-IVB serves as the third stage. The third element, the instrument unit, is almost identical to that of the Saturn V.

By bringing these elements together to form a hybrid vehicle, NASA was able to launch manned Apollo spacecraft about one year earlier than with the Saturn V vehicle alone.

The Saturn V vehicle was officially approved in Jan. 1962. The Uprated Saturn I program was announced in July, 1962.

The Uprated Saturn I, in addition to its role as an Apollo carrier, is expected to be used for other assignments in manned and unmanned space work. It is capable of delivering about 40,000 pounds to low Earth orbit.

FIRST STAGE-- The Uprated Saturn I booster (S-IB), built by the Chrysler Corp. Space Division, was redesigned to reduce weight. The stage is 80 feet long, 21.5 feet in diameter and its dry weight is 85,317 pounds or some 20,000 pounds less than the basic Saturn I first stage.

The stage is essentially a cluster of eight modified Redstone tanks (70 inches in diameter) around a Jupiter tank (105 inches in diameter). Four of the outside tanks contain liquid oxygen (LOX) and four kerosene (RP-1) fuel. The large center tank contains LOX.

Eight Rocketdyne H-1 engines power the stage with a total thrust of 1.6 million pounds. The engines are mounted on the stage's thrust structure. The four outboard engines are equipped with independent, closed-loop, hydraulic actuator systems which gimbal the engines as much as eight degrees for vehicle flight direction control.

In approximately 2.5 minutes of operation, the stage burns 43,000 gallons (279,000 pounds) of fuel and 68,200 gallons (632,500 pounds) of oxidizer, to reach an altitude of about 35 miles at engine cutoff.

Eight fins on the stage, equally spaced around the tail unit assembly, increase aerodynamic stability in the lower atmosphere. They also support the vehicle on the launch pad and provide tiedown points for restraining the vehicle momentarily after ignition.

Equipment on the S-IB stage includes a control pressure system, purge systems, a fire detection and water quench system, a flight termination or "destruct" system, electrical power supply and distribution, instrumentation, and telemetry systems.

Chrysler assembles the S-IB stages at the NASA-Michoud Assembly Facility in New Orleans and tests them at the Marshall Center in Huntsville.

SECOND STAGE-- The S-IVB (second) stage, built by the McDonnell Douglas Corp., is 58.4 feet long and 21.7 feet in diameter. One Rocketdyne J-2 engine powers the stage. The stage weighs 23,427 pounds empty.

The cylindrical stage has a liquid hydrogen tank and a liquid oxygen tank separated by a common bulkhead, which isolates the hydrogen at about minus-423 degrees F from the oxygen at about minus-297 degrees F.

The J-2 engine produces about 200,000 pounds thrust for about 7.5 minutes of operation. It will burn some 64,000 gallons (38,000 pounds) of hydrogen and some 20,000 gallons (193,000 pounds) of LOX.

The S-IVB stage is connected to the first stage by an aft interstage. Separation sequence starts immediately after first stage outboard engine cut off. The stages separate by simultaneous operation of the stage separation ordnance system, which severs a plate; four retromotors, which slow the first stage; and three ullage rockets, which impart a slight acceleration on the S-IVB stage and payload.

Douglas builds the S-IVB at Huntington Beach, Calif., and tests it at the Sacramento Test Center.

INSTRUMENT UNIT-- The 4,100-pound instrument unit is 260 inches in diameter and three-feet high.

Electrical and mechanical equipment which guides, controls and monitors vehicle performance from liftoff until after insertion of the spacecraft into orbit is located in the instrument unit. It controls first stage powered flight, stage separation, second stage powered flight and orbital flight until the spacecraft is separated.

Equipment includes guidance and control, electrical, measurement and telemetry, radio frequency, instrumentation, range safety command system, environmental control, and emergency detection systems (EDS).

Systems include the ST-124-M-III inertial platform, the launch vehicle digital computer and the electrical equipment required for launch vehicle performance.

The instrument unit was designed by the Marshall Center. International Business Machines Corp., Federal Systems Division, is the IU contractor for fabrication, systems testing and integration and checkout with the launch vehicle, with major elements coming from Bendix, IBM and Electronic Communications Inc. This instrument unit for AS-204 is the first completely assembled and integrated by IBM.

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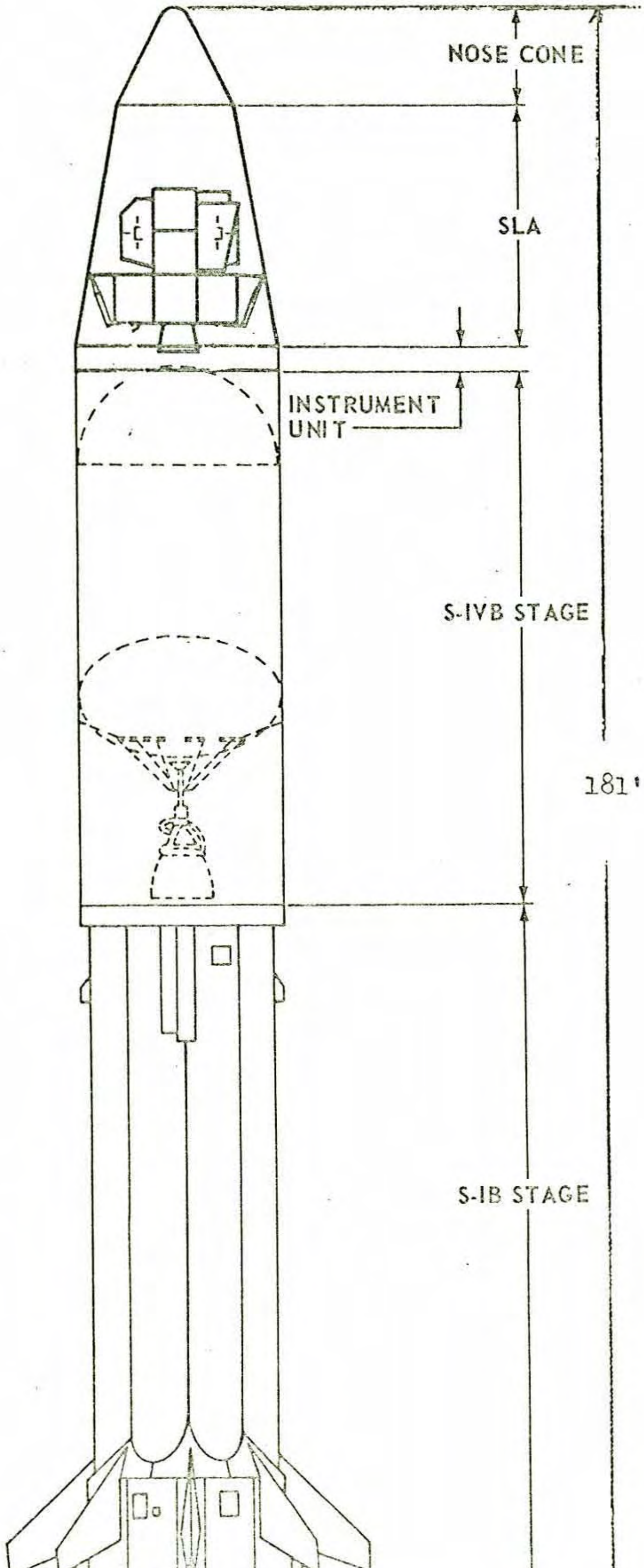

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At insertion into orbit the weight of the orbiting vehicle will be 70,200 pounds. This includes the second stage (S-IVB), instrument unit, spacecraft lunar module adapter, lunar module 1, nose cone and remaining propellant.

Telemetry on AS-204 Launch Vehicle

Instrument Unit

- Total measurements 305
- Telemetry Systems
  - 1 PCM
  - 1 SS/FM
  - 2 FM/MF
  - 1 tape recorder
- Tracking system
  - 1 C Band
  - 1 Azusa
- Tape recorder

S-IB Stage

- Total measurements 400
- Telemetry systems
  - 1 PCM
  - 2 FM/FM
  - 1 SS/FM
- Tracking systems
  - 1 ODOP
- Range Safety systems
  - 2 secure command systems
- Tape recorder

S-IVB Stage

- Total measurements 520
- Telemetry systems
  - 1 PCM
  - 3 FM/FM
  - 1 SS/FM
- Range safety systems
  - 2 secure command systems
- Tape recorder

All telemetry hardware has been flown on three previous missions with success. No special experiments or equipment are being flown.

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WEIGHT (In Pounds)

Spacecraft	36,700*	
Instrument Unit	4,600	
S-IVB Stage (Dry)	23,427	
S-IVB Residual Propellants	2,450	
S-IVB Useable Reserve Propellants	3,386	
Injection Weight		70,580
J-2 Thrust Decay Propellant and LOX Venting	241	
S-IVB Cutoff Weight		70,821
S-IVB Propellant Consumed	224,976	
S-IVB APS Propellant Consumed	6	
Ullage Cases	215	
S-IVB 90% Thrust Weight		296,018
S-IVB Gaseous Hydrogen Start Tank	4	
S-IVB Buildup Propellant Consumed	390	
Ullage Propellant Consumed	176	
S-IVB Detonation Package	5	
S-IVB Stage At Separation		296,593
S-IVB Aft Frame Hardware	31	
S-IVB/S-IB Interstage	6,654	
S-IB Stage (Dry)	85,317	
S-IB Residual and Reserve Propellants	10,843	
S-IVB Frost Consumed	100	
S-IB Frost Consumed	1,000	
S-IB Seal Purge Consumed	6	
S-IB Fuel Additive Consumed	27	
S-IB Gear Box Lubricant Consumed	714	
S-IB Inboard Engine Thrust Decay Propellant Consumed	2,143	
S-IB Outboard Engine Thrust Decay Propellant Consumed (To Separation)	1,653	
S-IB Mainstage Propellant Consumed	880,338	
Vehicle Liftoff Weight		1,285,419
S-IB Thrust Buildup Propellant Consumed		14,015
Ignition Weight		1,299,434

*Spacecraft Weight:

SLA	3,950
LM	31,700
Nose Cone	1,067
	36,700

APOLLO 5 LAUNCH OPERATIONS

A 250-man NASA-Industry team, directed by NASA's Kennedy Space Center, will conduct the Apollo 5 mission countdown from the blockhouse firing room at Cape Kennedy Complex 37.

KSC has charge of all NASA flights at Cape Kennedy and the Kennedy Space Center, including preflight test and checkout of the launch vehicle, spacecraft and support facilities, countdown and launch.

The Apollo 5 flight will mark the eighth from Complex 37 -- six Saturn I and one Uprated Saturn I flights. The first launch, on Jan. 29, 1964, placed 38,700 pounds into Earth orbit.

After completing six flights of the Saturn I program, facilities at Complex 37 were modified for the assembly, checkout and launch of the larger Uprated Saturn I. The Uprated Saturn I test flight series is the second phase of the program leading to the manned Saturn V missions.

The first Uprated Saturn I launch from Complex 37, on July 5, 1966, successfully demonstrated second stage restart capability -- essential to successful lunar flights. It also permitted a more comprehensive evaluation of liquid hydrogen under weightless conditions.

The launch vehicle for Apollo 5 was originally scheduled for the first manned Apollo flight (AS-204) from nearby Complex 34 in February 1967. Following the fire and the death of Astronauts Grissom, White and Chaffee, the launch vehicle was re-erected at Complex 37 for Apollo 5.

The first stage was erected at Pad B, Complex 37 last April 7, the S-IVB stage three days later and the Instrument Unit on April 11. A facilities verification vehicle was mated with the Spacecraft Lunar Module Adapter (SLA) on April 18 and remained mated until June 8.

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The lunar module (LM-1) arrived at KSC June 23, 1967 and the ascent and descent engines were mated for the first time on July 11. A demate was necessary on Aug. 16 in order to repair leaks in the ascent engine. The two stages were remated Sept. 7 and a series of tests conducted until Sept. 19 when it was again necessary to demate and incorporate a leak modification in the propulsion feed system. After demating, several items of LM-1 hardware were shipped back to the contractor for additional work.

The stages were remated Oct. 28 and a series of tests run until Nov. 19 when the spacecraft was taken to the pad and mechanically mated with the booster.

The first mission simulation at the pad was conducted in early December and the Flight Readiness Test (FRT) later in the month. The FRT consists of a series of sequence tests in parallel with the actual countdown and in-flight operations, with participation of tracking stations of the Eastern Test Range and the Mission Control Center at Houston.

The Countdown Demonstration Test (CDDT), a dress rehearsal of the countdown, including propellant loading, is scheduled to start about a week before launch. The test terminates seconds before engine ignition.

When the unfueled spacecraft arrives at the pad, it weighs approximately 8,500 pounds. The ascent stage weighs 4,850 pounds and the descent stage 3,650 pounds. The first manned lunar module will weigh 31,700 pounds when fueled. The unfueled weight of the launch vehicle will total 121,150 pounds.

Complex 37 Facilities

Complex 37 includes two launch pads separated by a 1,200-foot railway. Each launch pad has a launch pedestal, umbilical tower, and automatic ground control station. Both pads are served by a single service structure and launch control center.

The Launch Control Center is a two-story, dome-shaped building located approximately 1,200 feet from the launch pad. The dome (to protect against blast in the event of a launch vehicle explosion) is constructed of reinforced concrete, varying from seven feet at the top to 41 feet thick at the base. The 20,968 square foot building is designed to withstand blast pressures of 2,188 pounds-per-square-inch.

The first floor is used by personnel involved in tracking, telemetry, and closed circuit television communications. Launch control and various monitoring recording consoles are located in the firing room on the second floor.

The Launch Pads

The launch pads at Complex 37 are 300 feet square and have a maximum height of 16 feet above sea level. The pad areas are covered with fire brick to minimize damage caused by first stage engine ignition. Located at each pad is a steel launch pedestal which provides a platform to support the launch vehicle and certain ground support equipment. Each pedestal is 35 feet high and 55 feet square. An opening in the center of the pedestal, 32 feet in diameter, allows access to the first stage of the vehicle and permits passage of exhaust to the flame deflector below. Eight hold-down arm assemblies are bolted around the opening in the top of the launch pedestal to support the vehicle. These hold-down arms hold the vehicle on the pad until all engines are running with full thrust, ready for flight.

There are three 21-foot inverted V-shaped flame deflectors, one at each pad and one held in reserve. They are constructed with a series of steel trusses covered with one-inch thick steel skin, and coated with four inches of special heat-resistant refractory material.

The two steel-trussed umbilical towers are approximately 1,200 feet apart. They are 268 feet high. Four swing arms are attached to each tower by hinged joints. Each swing arm carries links between the space vehicle and umbilical tower which lead to ground-based power, air conditioning, hydraulic, pneumatic, fuel, measuring and command systems.

At the 228-foot level of the umbilical is the spacecraft access arm.

Mounted on the umbilical tower is a boom hoist capable of lifting 2.5 tons, equipped with a trolley that extends 27 feet from the boom pivot. An automatic ground control station, containing digital computers and checkout equipment, is located at the base of the tower.

The RP-1 storage tank, 67 feet long and 12 feet in diameter, has a 43,500-gallon capacity; a fast-fill transfer rate of 2,000 gallons-per-minute, and a slow fill rate of 200 gpm. RP-1 is used in the vehicle's first stage.

Liquid oxygen is stored and transferred at minus-297 degrees F. The liquid oxygen facility includes a 125,000-gallon main tank and a 28,000-gallon storage tank. The main tank measures 42 feet in diameter, the storage tank measures 62 feet long and 11 feet in diameter. LOX is transferred to the first stage at the rate of 2,500 gallons-per-minute; second stage transfer rate is 1,000 gpm.

Liquid hydrogen is stored and transferred at minus-423 degrees F. The fuel for the second stage of the Uprated Saturn I is stored in a 38-foot diameter, 125,000-gallon tank. Liquid-nitrogen is contained in a 125,000-gallon tank and a 35,000-gallon tank. Helium is stored in the helium battery which consists of six clusters of vessels each manifolded together. Both the nitrogen and helium batteries supply gas at a pressure of 6,000 psi.

The Service Structure

The 5,200-ton service structure at Complex 37 provides for vertical erection, assembly and checkout of Uprated Saturn I vehicles. It contains work platforms for personnel, cranes for lifting rocket stages and spacecraft into place on the launch pedestal and provides protection from the weather for both the space vehicle and personnel.

The self-propelled service structure, mounted on four trucks that ride rails, is driven by four 100-horsepower electric motors. The trapezodial structure of rigid-truss construction extends to a height of 300 feet, on a base measuring 120 feet.

There are four elevators in the service structure and a minimum of 10 work platforms at various levels. Each elevator has a 3,000-pound capacity. Access to the service platforms is from individually adjusted platform landings. Weather protection is provided by a hurricane curtain around the launch pedestal which extends from the 35-foot level to the 65-foot level, and split "silo" enclosures that reach to the 248-foot level.

At the launch pad, support points lift the service structure from the trucks and anchor it to the ground. Before the Uprated Saturn I is launched, the service structure moves to its parking position at the opposite pad.

APOLLO 5 COUNTDOWN

The clock for the Apollo 5 countdown will start at T-22 hours. A six-hour built-in hold is included late in the countdown.

On this mission the Lunar Module primary checkout occurs during the countdown demonstration test. The spacecraft is considered essentially ready for launch at the completion of the CDDT.

Following are some of the highlights:

T-21 hr. 30 min.	Install second stage and Instrument Unit batteries
T-17:30	Second stage mechanical closeout
T-13:30	First stage battery installation
T-11:15	Launch vehicle power on
T- 9:45	Launch vehicle flight control system checks
T- 7:30	Range safety command checks
T- 5:50	Launch vehicle ordnance connection
T- 3:30	Start six-hour built-in hold
T- 3:30	Resume count, move mobile service structure to parked position
T- 2:50	Start liquid oxygen loading, first and second stages
T- 2:00	Lunar module telemetry on
T- 1:50	Start second stage liquid hydrogen loading
T- 50 min.	Begin terminal count phase
T- 45	Mission Control Center-Houston launch vehicle command checks, launch vehicle guidance checks
T- 40	Launch vehicle telemetry checks.
T- 30	Launch vehicle range safety checks

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T- 30 min.	Lunar module to internal power
T- 25	Mission Control Center-Houston lunar module update command checks
T- 23	Power transfer test
T- 20	Launch vehicle guidance and control checks
T- 17	Telemetry calibration
T- 6	Final status check
T- 2 min. 44 sec.	Launch sequence start initiate terminal countdown sequence
T- 1:30	Hydraulic pumps on
T- 28 sec.	Launch vehicle power transfer to internal
T- 3 sec.	Ignition
T-0	Launch commit and liftoff

NOTE: These times are approximate and subject to change.

SEQUENCE OF EVENTS

Ascent-to-orbit

Time from Liftoff (GET) (hr:min:sec)	Event
00:00:00	Liftoff
00:00:10	Pitch and roll maneuver initiated
00:00:38	Roll terminated
00:01:14	Maximum dynamic pressure (altitude 7.7 miles, 2.7 miles downrange, velocity 1,668 miles per hour)
00:02:13	Pitch terminated
00:02:19	S-IB Inboard Engine Cutoff
00:02:22	S-IB Outboard Engine Cutoff*
00:02:23	S-IVB Ullage Rocket Ignition
00:02:23	S-IB separates
00:02:24	S-IVB Engine start command
00:02:35	Jettison ullage rocket motors
00:02:39	Initiate active guidance
00:09:40	Guidance cutoff signal
00:09:58	S-IVB shutdown, insertion into elliptical Earth orbit
	S-IVB/SLA/LM Orbital Coast
00:10:43	Jettison aerodynamic shroud
00:11:11	Align and maintain spacecraft X-Axis in local horizontal
00:19:41	Deploy SLA panels
00:50:05	LM separation sequence initiated
	Spacecraft Separation
00:53:55	RCS ignition
00:54:00	Begin LM withdrawal from S-IVB/SLA

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Time from Liftoff (GET) (hr:min:sec)	Event
00:54:05	RCS shutdown
00:54:10	RCS ignition
00:54:15	RCS shutdown
	Orbital Coast to First DPS Burn
00:55:52	Initiate attitude orientation maneuver
	First DPS Burn
00:55:19	Mission phase enabled
03:55:28	Initiate thrust reorientation to second APS burn ignition attitude
03:59:54	RCS ignition
04:00:02	First DPS burn ignition
04:00:02	RCS shutdown
04:00:40	First DPS burn, guidance cutoff command
04:00:40	Insertion into Hohmann Transfer Ellipse
	Second DPS Burn/FITH Abort Test/First APS Burn
04:33:02	Mission phase enabled
04:33:22	Initiate thrust reorientation to second APS burn ignition attitude
04:36:46	RCS ignition
04:37:12	Second DPS ignition
04:36:54	RCS shutdown
04:49:25	Second DPS shutdown/FITH Abort Test/ First APS ignition
04:49:30	First APS shutdown
	Second APS Burn
06:09:12	Mission phase enabled

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Time from Liftoff (GET) (hr:min:sec)	Event
06:09:32	Initiate thrust reorientation to Second APS burn ignition attitude
06:13:32	RCS ignition
06:13:35	Second APS ignition
06:13:36	RCS shutdown
06:20:43	Second APS propellant depletion
06:21:36	End second APS thrust tailoff

Final Orbital Coast

* The First (S-IB) Stage will land in the Atlantic Ocean at 75 degrees East, 29 degrees North.

APOLLO 5 MISSION PROFILE

Orbit: Insertion is scheduled at 10 minutes after lift-off (called Ground Elapsed Time -- GET) at an altitude of 101 statute miles (88 nautical miles). Inertial velocity is 25,685 feet-per-second (17,500 statute miles-per-hour, 15,200 knots), inclination is 31.4 degrees at 31.6 degrees North latitude and 61.5 degrees West longitude. Second stage liquid oxygen venting terminates 10 minutes 38 seconds after lift-off following 40 seconds of venting. Liquid hydrogen venting continues until 30 minutes 58 seconds after lift-off.

The aerodynamic shroud covering the Lunar Module (LM) is jettisoned at 10 minutes 43 seconds GET. The shroud is spring-loaded, the mechanism imparting a seven feet-per-second differential velocity (Delta V) to the shroud to carry the shroud away from the spacecraft. This places the shroud about six miles behind and a half-mile above the spacecraft when it separates from the launch vehicle.

About half a minute after shroud jettison, the launch vehicle second stage maneuvers to maintain the spacecraft +X (top to bottom) axis in the local horizontal plane in the direction of motion, and the -Z axis (front to back) pointing toward the Earth's center. The attitude, maintained until shortly before LM separation in order to enhance ground/spacecraft communications, would place a crew on their backs with heads into the direction of flight in relation to the Earth.

Deployment of the spacecraft LM adapter (SLA) panels occurs about 20 minutes GET southwest of the Canary Islands tracking station. The second-stage/LM combination is in a coast phase until separation near first revolution apogee over Australia some 54 minutes after lift-off.

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Second-Stage/LM Separation: About 50 minutes GET the second stage begins an attitude-hold maneuver to hold a constant inertial attitude during the separation sequence. Three minutes 50 seconds later, the four LM reaction control system (RCS) down-firing thrusters (viewing the LM as it is upright) fire to provide forward translation. Five seconds after thrust initiation, the straps holding the LM in the SLA are severed mechanically and the LM withdraws from the SLA. Thrust continues for another five seconds (10 seconds total firing) and is followed by a five-second coast, then another five-second forward RCS translation.

At RCS shutdown, 15 seconds after the restraining straps are severed, the LM is about 30 feet away from the second-stage/SLA at a relative velocity of four feet per second. After 90 minutes, the LM is about 10 nautical miles behind the second stage and at about the same altitude. The launch vehicle propellant dump test is performed at this time.

First Descent Propulsion System (DPS) Burn: From separation until about three hours 55 minutes GET when the LM is in the third revolution over the Coastal Sentry Quebec tracking ship off the coast of Australia, the spacecraft is in orbital coast. Its pre-programmed inertial attitude for cold soak (+X axis essentially upward, -Y+X RCS quad toward Sun) is maintained in the +5 degree deadband mode; that is, any time the LM shifts more than five degrees from its pre-programmed attitude, the appropriate RCS thruster combination will fire to bring it back into the proper position.

At acquisition by Coastal Sentry Quebec, deadband mode is terminated and a 20-second coast initiated, during which period the time of ignition and initial thrust attitude are automatically calculated by the LM. Some 249 seconds after initiation of the orientation maneuver, or three hours 59 minutes 54 seconds GET, an eight-second RCS forward ullage translation is initiated. The ullage translation ends a half-second after DPS ignition. DPS thrust level is held at 10 per cent for 26 seconds after ignition, then thrust increases to maximum, or 92.5 per cent of rated maximum thrust (10,500 pounds). The buildup to steady thrust at maximum takes 0.34 of a second. Thrust tailoff ends about 0.4 seconds after guidance cutoff, which occurs some 12 seconds after maximum thrust begins. Total DPS burn time is about 39 seconds. The duration of the burn is designed to place the spacecraft on an ellipse with a predicted apogee of 178 nautical miles (205 statute miles), perigee of 116 nautical miles (134 statute miles), orbital period of 90 minutes, and inclination of 31.6 degrees.

Second DPS Burn/FITH Abort/First APS Burn: After the first DPS burn, the spacecraft coasts for some 33 minutes. LM inertial attitude during this coast phase is maintained in the ±5-degree deadband mode.

At acquisition by the Rose Knot Victor tracking ship, about four hours 33 minutes after lift-off, the spacecraft continues its coast for 20 seconds, then initiates a reorientation maneuver to the desired attitude for the second DPS burn.

About 212 seconds after the orientation maneuver initiation, or four hours 36 minutes 45 seconds GET, an eight-second RCS +X (forward thrust) ullage translation is initiated, terminating half a second after DPS ignition.

The second DPS burn represents the thrust profile expected for lunar landing. It includes a random throttling phase with thrust settings of 10 seconds each at 10, 50, 30, 40 and 20 per cent of its rated maximum 10,500 pounds. The throttle position then increases to maximum (92.5 per cent of rated thrust) in preparation for "fire-in-the-hole" (FITH) abort staging. Duration of the nominal burn is 12.5 minutes. The majority of the 7,000-feet-per-second differential velocity is directed out of the orbit plane in order to optimize ground coverage of the second ascent propulsion system (APS) burn.

The orbit resulting from the second DPS burn has a predicted perigee of 166 nautical miles (191 statute miles), apogee of 172 nautical miles (198 statute miles), period of 91 minutes and inclination of about 29 degrees. About five per cent of the DPS propellant available for thrusting remains after this burn. Coverage of this phase primarily will be from continental United States stations.

The "fire-in-the-hole" abort staging begins with the end of the random throttling phase of the DPS burn. DPS shutdown, LM staging, and APS ignition occur simultaneously. Duration of the first APS burn is 5.25 seconds -- 0.04 seconds for thrust buildup, five seconds of steady thrusting, and 0.21 seconds of tailoff. During this burn, the spacecraft +X axis is in the local horizontal and normal to the orbit plane. After the burn the expended descent stage is in an orbit about 166-by-172-nautical miles (224-by-251-statute miles) with an estimated lifetime of three weeks. The ascent stage has a predicted perigee of 167 nautical miles (224 statute miles), apogee of 172 nautical miles (248 statute miles), and inclination 0.03 of a degree smaller than that of the descent stage.

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Second APS Burn: The spacecraft is over the West Atlantic off Florida, entering the fourth revolution, during the "fire-in-the-hole" abort and first APS burn. After the burn, the LM maintains inertial attitude in the +5-degree deadband mode and coasts for about one hour 21 minutes. After acquisition by the Rose Knot Victor in the fourth revolution at 5 hours 10 minutes 45 seconds GET, a 20-second phase enable coast begins. It is followed by the attitude orientation maneuver necessary to place the LM +X axis in the desired thrust direction.

Some 158 seconds after initiation of the maneuver, the RCS thrusters provide +X translation for ullage. APS ignition occurs 12.5 seconds after RCS ignition.

The thrust profile of this second APS burn simulates a lunar ascent. The ascent guidance philosophy is designed to satisfy two requirements: the spacecraft must reach a specific point in space, and this spatial position vector must be achieved at a specific time. Spacecraft attitude, velocity and flight path angle at burnout are determined on the ground to confirm that the intercept requirements are achieved.

Nine seconds after APS ignition, an RCS/APS interconnect test is initiated to determine RCS operation using propellants from the APS tanks. The RCS will be used for attitude stabilization and control during this burn. Total time of the second APS burn is 450 seconds. Most of the 6,075 feet-per-second differential velocity of the burn will be out of plane.

At engine shutdown, the LM is in a predicted orbit 170-by-440-nautical miles (196-by-507-statute miles) with period of about 93 minutes, inclination of 28.6 degrees, and expected lifetime of two years. APS propellants available for impulse have been depleted. The RCS propellant tanks contain some 71 per cent of their original load.

The mission essentially is complete at this time. However, four more revolutions of tracking are planned for any further spacecraft tests which might be feasible or desirable.

A test of propellant removal through the J-2 engine will be conducted for the first time on the Apollo 5 flight. An onboard signal will be given one hour 36 minutes after lift-off to activate the test which will begin 49 minutes later while the vehicle is making its second pass over Australia. The test can be disabled, if necessary, by ground command at any time in the waiting period.

About five minutes before the test begins, the S-IVB/Instrument Unit will maneuver to a local vertical attitude -- pitch 270 degrees (spacecraft/lunar module adapter panels toward earth), yaw zero degrees and roll five degrees -- in preparation for the test. The S-IVB/Instrument Unit will perform continuous roll during the test to point the best portion of the Instrument Unit antenna toward the Carnarvon Station. Pressure will be allowed to build in the propellant tanks.

Shortly after two hours 26 minutes into the mission, the main stage control valve in the J-2 engine will be opened and the liquid oxygen will be vented through the engine for two minutes. This will be followed by a three-minute vent of the liquid hydrogen. This is expected to empty both tanks.

During the first 80 seconds of LOX dump, the J-2 engine will be gimballed to determine how well attitude control in pitch and yaw can be maintained. Then control will be switched back to the auxiliary propulsion system (APS). Successful control by J-2 gimballing would conserve APS propellants.

About 20 minutes after the propellant dump test, while the vehicle is over Hawaii, a cold helium dump will be started. This dump will continue for 22 minutes to deplete the tank pressurization helium supply. During this dump, the main vent valves will be open to allow escape of any gaseous oxygen or hydrogen that might still remain in the tanks.

Helium in a separate system that supplies control valve pressure is to be dumped four and three-fourths hours after launch while the vehicle is making its third pass over the United States.

The propellant dump test is being conducted primarily for two reasons:

(1) Rocket engineers want to ascertain that it is feasible to dump the excess propellants to make the stage lighter and easier to control in orbit. Removing liquids that float about, and reducing overall vehicle weight, would decrease the APS propellant usage rate, they feel, and possibly increase APS lifetime.

(2) Verification that dumping the propellants through the engine would be suitable in passivation of the S-IVB stage to be used on a later flight as an orbital workshop.

MISSION CONTROL CENTER - HOUSTON (MCC-H)

The Mission Control Center at the Manned Spacecraft Center in Houston is the focal point for all Apollo flight control activities. In performing the control function and determining the progress of the flight, the MCC-H will receive tracking and telemetry data from the Manned Space Flight Network. This data will be processed through the MCC-H 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.

A portion of the MCC-H flight control responsibility will be delegated to the flight control teams from Houston manning three of the Manned Space Flight Network stations. These teams will have display and communications capabilities which will permit them to operate somewhat independently. While these stations are operating, remote telemetry data will be transmitted to the MCC-H in teletype form only. Spacecraft commands also may be initiated from the remote stations by the flight control team located there.

THE 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 4 the network will demonstrate its ability to provide the Flight Director complete navigational and mission event control through global remote facilities connected by two million miles of NASCOM (NASA Communications Network) circuit.

Geographically, the Manned Space Flight Network for Apollo is similar to the configuration employed in Projects Mercury and Gemini. As the magnitude and technology of Project Apollo increased, the worldwide ground systems' sophistication increased to fill Apollo's greater needs.

New Developments

Extensive alterations have been made to network equipment to accommodate the greater volumes of astronaut and spacecraft 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.

A New System for the Earth People

Apollo magnitude, complexity and duration posed serious spacecraft on-board weight and space limitations. These constraints demanded a more compact tracking/communications system of greater power, flexibility and reliability. It also meant that ground stations receiving voluminous quantities of mission data be so equipped that the Flight Director and his control teams have it displayed immediately in meaningful form for making decisions.

Prior Mercury and Gemini spacecraft presented tracking and data acquisition requirements from a single spacecraft in Earth orbit. The requirements could be met with known individual ground systems of proved reliability. Apollo constitutes four spacecraft in a package the size of an average locomotive 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.

Out of these requirements, the Apollo Unified S-Band System (USB) was born. This system combines in a single transmission (uplink-downlink) the multiple functions previously requiring the separate systems, as follows:

(a) Tracking, determining flight path and spacecraft velocity.

(b) Commanding the spacecraft via coded radio signals.

(c) Receiving coded radio signals (telemetry) on spacecraft integrity, systems condition, batteries, fuel state, etc.

Some USB ground stations have additional capability to provide tracking and communications data exchange for two spacecraft simultaneously as long as both are within the single-beamwidth of the antenna system.

Sites and Status

The Unified S-Band sites are located and equipped for the duties they perform. Ten land-based stations are equipped with 30-foot diameter antenna systems, three with 85-foot diameter dishes. The Grand Bahama Island station has a transportable van-mounted system with an erectable 30-foot antenna.

The USB systems are under engineering evaluation. Network USB experience to date includes the successful tests with Lunar Orbiter V, Apollo/Saturn 202 and Apollo 4. While prime MSFN participation in early Apollo flights will be through the proved Gemini systems, USB systems will be tested again in Apollo 5 with spacecraft systems that are not astronaut-related.

As the new USB ground systems become fully operational and techniques are perfected, a phase-over from the Gemini systems will be made.

Participating Stations

For Apollo 5, 14 NASA USB stations, seven Department of Defense associated radar land stations, three range instrumentation ships and five Apollo instrumented aircraft (ARIA) will provide the required tracking, data acquisition and voice/data communications services.

USB Sites:

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.

85-Ft. Antenna Sites

Canberra (CNB), Australia.
Goldstone (GDS), Calif.
Madrid (MAD), Spain.

Participating Ships:

USNS REDSTONE-Insertion/Injection-Atlantic.
USNS ROSE KNOT (VICTOR)-Tracking/Data Ship-Pacific.
USNS COASTAL SENTRY (QUEBEC)-Tracking/Data Ship-Indian Ocean.

Apollo 5 is the most complex mission yet planned for MSFN ground station participation. The intricate mission profile requires every available source of command/control, tracking and data acquisition to be utilized so that NASA's Manned Flight Network can respond instantly to any spacecraft variation from the flight plan.

For example, if the LM spacecraft experiences an excessive descent or ascent propulsion system burn period of as little as two seconds, an on-site computer program response must take place without delay in the action ground station -- immediate space position, navigational and command data adjustments must be made to trigger the next mission event correctly.

NASA's Manned Space Flight Network is responsible for tracking and data acquisition from the S-IB, S-IVB and the Lunar Module (LM) throughout the Apollo 5 mission. Department of Defense facilities will provide backup data as required. Cape Kennedy and Patrick Air Force Base radars will track the S-IB until splashdown. Radars of the NASA Manned Space Flight Network will track the Instrumentation Unit beacon located in the S-IVB until battery depletion then skin track* the S-IVB until T plus 14 hours, then NORAD will assume tracking responsibility until S-IVB reentry. NASA MSFN radars will track the LM stage until mission termination at which time tracking of the LM will also be turned over to NORAD. It is uncertain whether the LM beacon can be tracked until S-IVB/LM separation. This is due to the shrouds which partially cover the beacon until that time.

MSFN Telemetry Requirements

The MSFN stations will monitor launch vehicle and spacecraft performance. The data will be received, decommutated, and transmitted to MCC-H via high-speed data lines and teletype lines. Certain specific stations (flight controller-manned) will display data in real time. The following are requirements:

(a) Support from launch through S-IVB burn termination plus 90 seconds;

(b) Monitor spacecraft LEM adapter panel deployment on the first revolution;

(c) Coverage three minutes before, during and two minutes after S-IVB/LEM separation;

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* Radar radiates electrical energy to the spacecraft and receives bounce-back signal. Time up and back gives distance and position.

(d) Coverage two minutes before, during and after confirmation of burn termination of all DPS and APS burns;

(e) Monitor FITH (Fire-In-The-Hole) abort by at least three ground stations to minimize loss of data due to flame attenuation, and

(f) TLM is required on all parking orbits and thermal soaks.

The Network Support Team

Around-the-clock control of the Manned Space Flight Network is maintained by a 30-man team (per eight-hour shift) of network systems specialists housed in a highly instrumented operations room at Goddard Space Flight Center, Greenbelt, Md. The operations room was designed to monitor every aspect of the worldwide network. Formerly located at the Mission Control Center, Houston (MCC-H), the team will continue to report its status and findings to the mission Flight Director in the Houston Mission Operations Control Room (MOCR) but will retain its autonomy for checks, balances and corrections for continuity of coverage.

Testing the Network

Before Apollo 5 is flown, a total of 14 days of checking and testing will have been accomplished. Each system and subsystem at each station has its own performance criteria that must be met before the Manned Space Flight Network is ready to participate in the mission.

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 high-speed digital circuits. These reports are compared automatically with the stored normal values. When any variation from the desired values is detected by the computer, a "no-go" condition exists. If there is no variation from desired norms, "go" is reported. The process is repeated until the test conductor declares the entire network ready. The ritual, known as CADFISS (for Computer and Data Flow Integrated Subsystems tests), is repeated for each mission.

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Final Configuration

When completed, 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 backup sites for deep space tracking/communications; five Apollo ships and eight Instrumented Aircraft (ARIA) with USB facilities. Three of the ships are 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). The aircraft are equipped with a seven-foot dish in the nose. In addition to the USB sites listed, other ground stations providing telemetry, C-Band (space position) radar and voice relay will be used as required. Its staff will total about 2,000.

Computers That Switch

Computers, "electronic traffic policemen," are key components in this system. UNIVAC 642 computers at the USB stations sort the data received from Apollo and route it to on-station displays and, 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 much larger UNIVAC 494 real time Automatic Switching Systems.

Remote Site Data Processing Requirements for Apollo 5 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. At stations manned by flight controllers the telemetry data processing system 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 and on-station CRT display and high-speed print-outs. The command data processor will receive and store high-speed and teletype commands loads from MCC-H. The computer will also transmit these commands to the spacecraft via UHF or USB equipment either at an MCC-H or on-station execute signal.

Real-time Is Now

At split-second intervals the digital data processing systems, with NASA's Manned Spacecraft 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 quickly, even though the spacecraft is many thousands of miles from the control center. The command capability is needed for control of cabin pressure, 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.

Data on Call

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. The computers process data for on-site flight controllers, or if controllers are not there, put the data into form for transmission to Mission Control Center in Houston.

More and More Data

Each new generation of the space program increases requirements. In Project Mercury, for example, the amount of network traffic handled through Goddard amounted to a standard printed page every second. Apollo mission control traffic will approximate an ordinary novel each second, or an encyclopedia of information each minute.

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The Tie That Binds - NASCOM

The NASA Communications Network (NASCOM) ties all these sites together. Headquartered at Goddard, the hub of NASA communications, NASCOM's Automatic Communications Switching Center is the central facility connecting the Mission Control Center instantly with worldwide Manned Space Flight Network stations.

Through two million miles of circuit, the network provides low, medium, and high-speed messages along with voice-grade connections. Circuits between centers are provided by common carriers and local telephone companies in many countries.

Satellite Communications

Circuits will be provided via two Intelsat synchronous communications satellites: one over mid-Pacific and a second over mid-Atlantic, providing alternate and backup communications across both oceans where only cable and radio have been available. The network pioneered use of satellites for space operational use by employment of NASA's Syncom III during the Gemini program.

MAJOR APOLLO/SATURN CONTRACTORS

CONTRACTOR	ITEM
Prime Spacecraft Contractor:	
Grumman Aircraft Eng. Corporation Bethpage, N.Y.	Lunar Module
Spacecraft Sub-Contractors:	
Hamilton Standard Div. of United Aircraft Windsor Locks, Conn.	Environmental Control System
Radio Corp. of America Defense Electronic Products Burlington, Mass.	Rendezvous Radar
Communications Systems Division Camden, N.J.	Communications
Eagle Picher Corporation Couples Division Joplin, Mo.	Electrical Power System
General Motors Corp., AC Electronics Division Milwaukee, Wis.	Guidance and Navigation
The Marquardt Corporation Van Nuys, Cal.	Reaction Control System
TRW Systems Redondo Beach, Cal.	Descent Propulsion Abort Guidance Sub-System
Bell Aerosystems Buffalo, N. Y.	Ascent Propulsion System
Bulova Watch Co., Inc. Systems & Instrumentation Div. Flushing, N. Y.	LM Mission Programmer
North American Rockwell Corp. Rocketdyne Division Canoga Park, Cal.	Ascent Engine Injectors

Spacecraft Sub-Contractors (Continued)

CONTRACTOR	ITEM
American Bosch Arma Garden City, N. Y.	Signal Conditioner Electronic Assembly
Aerojet -General Corp. Downey, Cal.	Propellant tanks, ascent stage
Allison Division General Motors Corp. Indianapolis, Ind.	Propellant tanks ascent stage
AiResearch Manufacturing Co. Division of The Garrett Corp. Los Angeles, Cal.	Supercritical Helium Tanks

MAJOR UPRATED SATURN I CONTRACTORS

S-IB Stage

Chrysler Corporation Space Division New Orleans, La.	First stage
Rocketdyne Division North American Rockwell Corp. Canoga Park, Cal.	H-1 Engines
Ling-Temco-Vought Dallas, Tex.	S-IB Tanks
Hayes International Corp. Birmingham, Ala.	S-IB Fins

S-IVB Stage

McDonnell Douglas Corp. Huntington Beach, Cal.	Second Stage
Rocketdyne Division North American Rockwell Corp. Canoga Park, Cal.	J-2 Engine
TRW Inc. Cleveland, Ohio	150-pound thrust attitude control engine
Vickers Detroit, Mich.	Pumps
Bell-Aerosystems, Inc. Buffalo, N. Y.	Fuel and oxidizer tank assemblies for Auxiliary Propulsion System

Instrument Unit

IBM Federal Systems Division Huntsville, Ala.	Prime Contractor
Bendix Corp. Eclipse Pioneer Division Teterboro, N. J.	St-124M Inertial Platform
Electronic Communication, Inc. St. Petersburg, Fla.	Control Computer
IBM Federal Systems Div. Owego, N. Y.	Digital Computer, Data Adapter

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