L. WHALEY

PROJECT SURVEYOR

SURVEYOR MISSION D HANDBOOK

HUGHES
HUGHES AIRCRAFT COMPANY
SPACE SYSTEMS DIVISION

JULY 1967
SSD 78104

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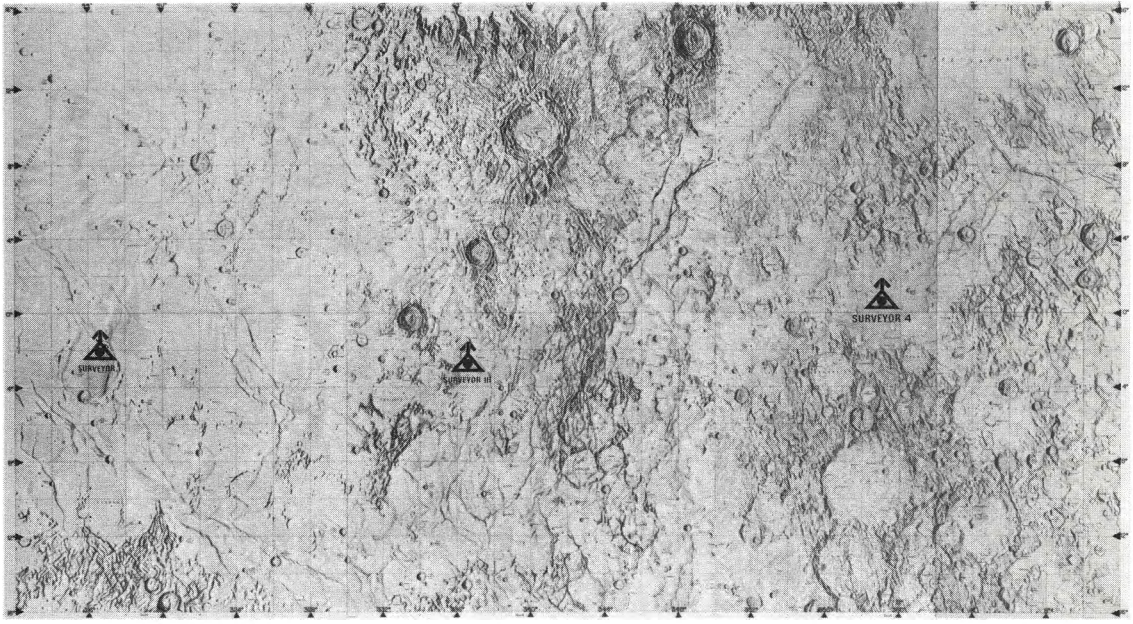

SURVEYOR I
SURVEYOR III
SURVEYOR 4

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

APPLICABLE DOCUMENTS

The following documents were used as references in the preparation of this handbook.

HUGHES AIRCRAFT COMPANY

224847B	Surveyor Spacecraft A-21 Model Description
SSD 68169-3R	Surveyor Mission "D" Post-injection Standard Trajectories
SSD 68256-2R	Appendix "A" of Surveyor Mission "D" Post-injection Standard Trajectories
EPD-391, Vol. III, Book B	Surveyor Mission Dependent Equipment – Operational Procedures
EPD-391, Vol. III, Book C	Surveyor Mission Dependent Equipment – Detailed Operating Procedures
3023300, Revision F	Decommutator Patchboard/Telemetry Overlay Control Specification
3050566	Command Sequence Glossary
3023904	Spacecraft Data Channel Assignments
3023905	Spacecraft Command Assignments

JET PROPULSION LABORATORY

SAO-50650-DSN-A	Design Specification, Surveyor/Centaur Target Criteria, Surveyor Mission "D"
PD No. 5	Surveyor Spacecraft/Launch Vehicle Integration Schedule
PD No. 14	Surveyor Spacecraft/Launch Vehicle Guidance and Trajectory Interface Schedule
PD No. 31	Surveyor Project Objectives and Flight Objectives for Mission "D"
PD-43-S/MD	Surveyor Launch Constraints Mission "D"
PD-58-S/MD	Surveyor Mission "D" OPS Plan
EDP-180-S/MD	Spaceflight Operations Plan, Surveyor Mission "D"
IOM 312.4-502	Revised Trajectory Constraints, S/MD

GENERAL DYNAMICS/CONVAIR

AY62-0047	Centaur Unified Test Plan
AY63-0071-11	Guidance and Control Systems Requirements, Atlas/Centaur AC-11
GDC-BNZ66-042-11	Centaur Launch Countdown Automatic Sequence Functions and Event Times, AC-11
GDC-BPM64-001-1	Centaur Technical Handbook, Revision B
CTP-INT-0004K	Centaur/Surveyor Launch Countdown, 14 June 1967

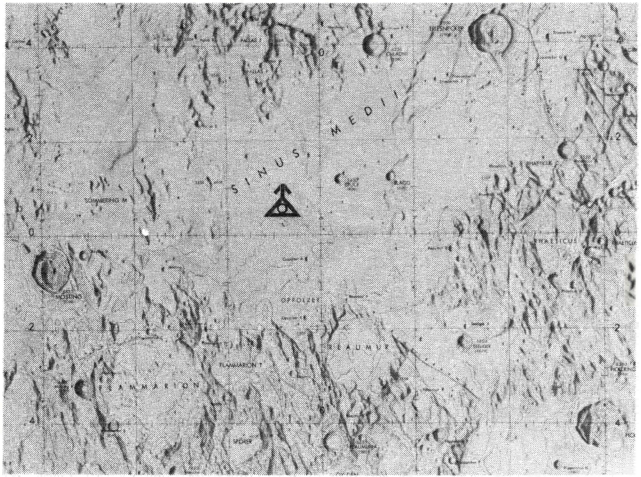


Figure 1. Selected Landing Site for SC-4

The Surveyor Program is under the direction of the Jet Propulsion Laboratory (JPL), California Institute of Technology, and is contracted for by the National Aeronautics and Space Administration (NASA).

Mission D of the Surveyor Program is the fourth operational flight of the Atlas/Centaur/A21 (AC-11 launch vehicle and SC-4 spacecraft) combination designed to soft land scientific equipment on the lunar surface and to expand man's knowledge of earth's only satellite.

For Mission D, the Centaur, in one thrusting period, will loft the SC-4 spacecraft into a direct-ascent trajectory to the lunar surface.

The lunar target for SC-4 is a landing site on Sinus Medii (Central Bay), located at 0.58°N latitude, 0.83°W longitude – approximately 420 statute miles east of the SC-III landing point, and approximately 800 statute miles east of SC-I. Launch-to-landing time of the mission is nominally 62 hours.

In addition to the TV camera and miscellaneous sensing equipment carried, SC-4 is equipped to perform several postlanding experiments, including: soil mechanics/surface sampler (SM/SS) experiment, gas jet firing experiment, magnetic experiment, vernier engines restart (static firing, liftoff, and translation).

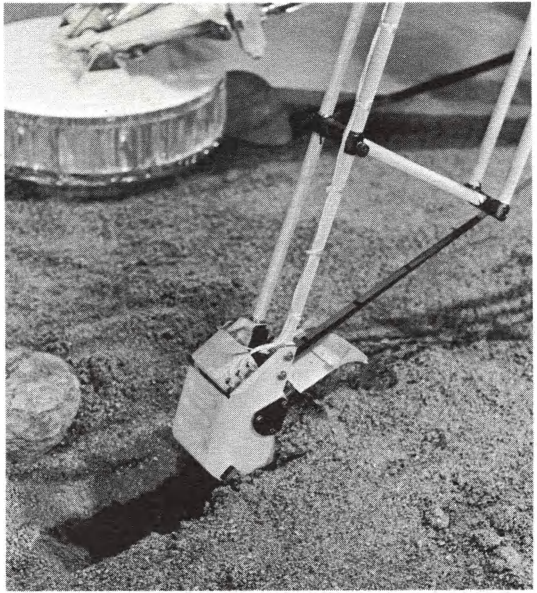


Figure 2. Simulated Lunar Trenching Operation – SM/SS

PRIMARY OBJECTIVES

1) Accomplish a soft landing on the moon at a site east of the Surveyor SC-III landing site

2) Demonstrate the capability of the spacecraft to soft land on the moon, with an oblique approach angle of not greater than 35 degrees.

3) Obtain postlanding television pictures

4) Obtain data on radar reflectivity, touchdown dynamics, thermal characteristics, and other measurements of the lunar surface through the use of various payload equipment, including the soil mechanics/surface sampler

SURVEYOR DESCRIPTION

STRUCTURE

- Triangular (equilateral) spaceframe, truss construction of thin-wall, polished tubular alumirum alloy (7075-T6)
- Deployable landing legs (3), each with shock absorber and crushable foot pad
- Crushable landing blocks (3) provide additional impact cushioning
- Antenna/solar panel positioner mast, strut-braced support collar
- Temperature controlled compartments (2) "A" and "B"

PROPULSION

- Main retrorocket (solid propellant): fixed thrust of 9000 pounds (nominal); 36-inch diameter spherical case, semi-imbedded nozzle; propellant (composite type) — fuel, PBAA; oxidizer, ammonium perchlorate.
- Vernier system (liquid propellant): three thrust chambers (1 gimbaled, 2 fixed), restartable, throttleable (variable) thrust — 30 to 104 pounds per chamber; propellants (hypergolic) — fuel, MMH hydrate; oxidizer — N_2O_2/NO; propellant tanks (6), with positive expulsion bladders actuated by compressed helium (He) — 1290 cubic inch supply tank.

FLIGHT CONTROL SYSTEM (FCS)

- Attitude control system (compressed nitrogen): three attitude control jet assemblies (6 nozzles control Roll, Pitch, Yaw attitudes); one 412 -cubic inch supply tank.
- Inertial reference unit (IRU); rate gyros (P, Y, R); longitudinal accelerometer; inertia switch.
- Sensors (optical acquisition): sun – (2) primary and secondary; Star (Canopus) – (1).
- Sensors (radar): altitude marking radar (AMR); radar altimeter and doppler velocity sensor (RADVS), 4-beam.
- Flight control electronics: AC/DC power converter; control circuits; digital programmer.

ELECTRICAL POWER

- Supply: main battery – 3200 watt-hours, 22 volts (rechargeable); auxiliary battery – 900 watt-hours, 22 watts (nonchargeable); solar panel, 792-cell, 89 watt output (nominal).
- Power management: central power control unit, auxiliary battery control unit.

TELECOMMUNICATIONS (S-BAND)

- Receiver/transponders, redundant (2).
- Transmitters, redundant (2).
- Omnidirectional antennas (2), mounted on deployable booms.
- Planar array antenna, high-gain, single directional, earth tracking.

- Subcarrier oscillators (5); pulse coded modulation (PCM) telemetry transmission at any of 5 bit-transmission rates.
- Subcarrier oscillators (10); for transmission of other than PCM data.

SCIENTIFIC EXPERIMENT EQUIPMENT

- TV camera (1); postlanding survey, capable of two modes of transmission: 200- or 600-lines resolution. Auxiliary view mirrors.
- Soil mechanics/surface sampler (SM/SS); postlanding surface manipulation.
- Magnetic experiment; attraction of nickel-iron particles (if any) in lunar soil.
- Temperature sensors.
- Strain gauges (propulsion, touchdown, etc.)

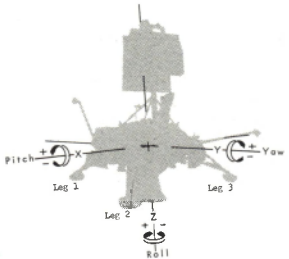
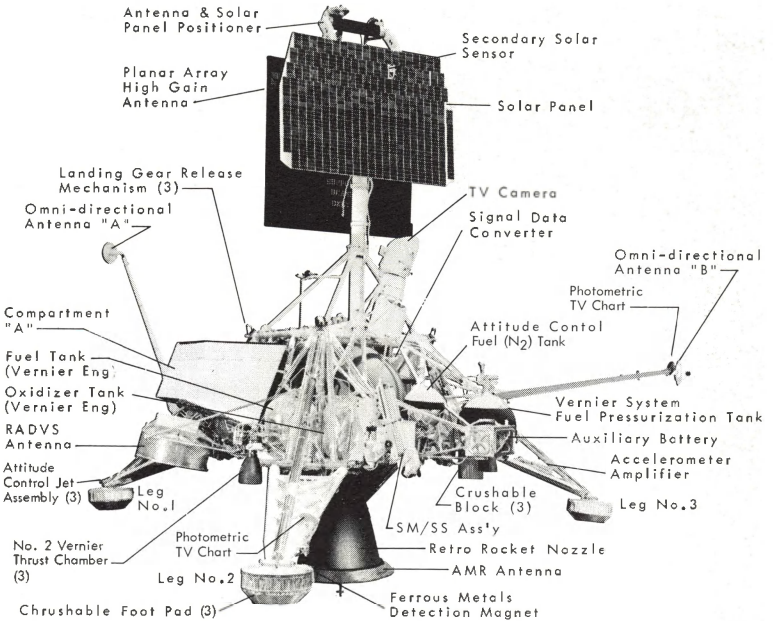
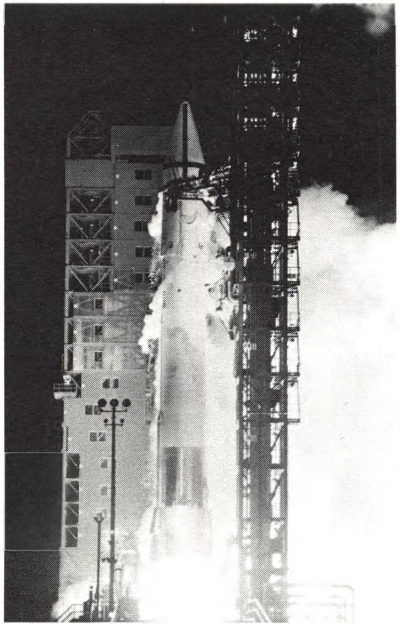


Figure 3.
Surveyor Spacecraft
Configuration





LAUNCH VEHICLE DESCRIPTION

The launch vehicle is comprised of an Atlas first stage and a Centaur second stage, each stage consisting of a constant 10-foot diameter stainless steel shell. The two stages are mated together by an interstage adapter which is permanently attached to the Atlas stage. The Atlas/Centaur launch vehicle was designed by General Dynamics/Convair (GD/C).

Figure 4. Surveyor III Launch from Pad 36

ATLAS STAGE

The airframe (a modification of the Atlas D missile) is composed of two major sections: 1) booster section – containing two gimbaled, liquid propellant engines of 164,400 pounds thrust each, and 2) sustainer section – single (sustainer) engine of 57,000 pounds thrust; two vernier engines of 670 pounds thrust each; and the Atlas autopilot. All engines in the Atlas stage burn a propellant combination of liquid oxygen and RP-1 fuel. All are ignited at the time of launch.

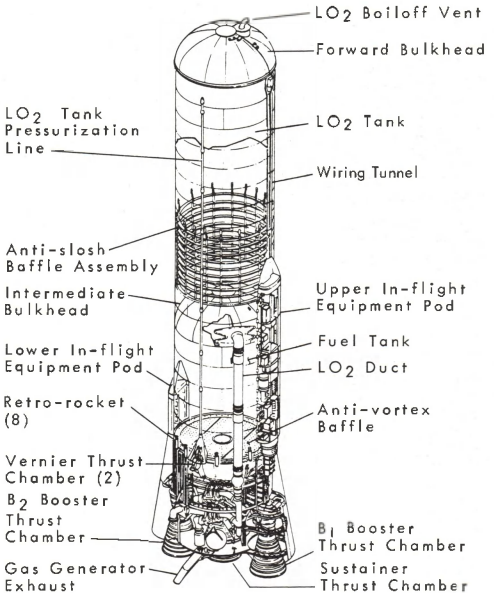


Figure 5. Atlas Vehicle

CENTAUR STAGE

Primary propulsion power is provided by two Pratt & Whitney RL10A-3-3 liquid propellant engines of 15,000 pounds constant thrust each, which are capable of making multiple starts. The engines are regeneratively cooled and utilize a turbo pump propellant feed system (liquid hydrogen and liquid oxygen). Each engine can be independently gimbaled ±4 degrees for attitude control. Thrust to maneuver the vehicle during unpowered flight (during spacecraft separation and Centaur retromaneuver) is provided by a fourteen-jet reaction control system powered by pressure-fed hydrogen peroxide. The system includes four 52.5-pound thrusters, four 3.5-pound thrusters, two 6-pound thrusters, and four 3-pound thrusters.

The Centaur contains its own guidance and flight control system for trajectory steering and attitude control. An inertial platform (consisting of three rate integrating gyros) and three pendulum-type, pulse-rebalanced accelerometers is the heart of the system. A navigational computer and an electromechanical programmer digest the sensed information and route correctional commands to the flight control system.

As a safety precaution in the event the flight might endanger life or property, the Atlas/Centaur vehicle (and the Surveyor spacecraft) can be destroyed by explosive charges on command of the Range Safety officer during any phase of flight.

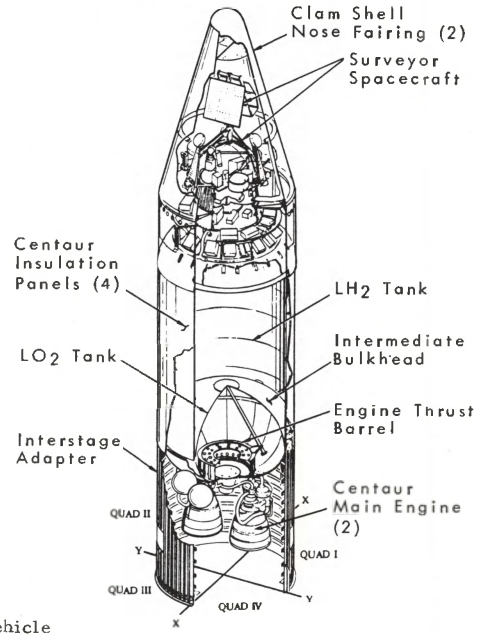


Figure 6. Centaur Vehicle

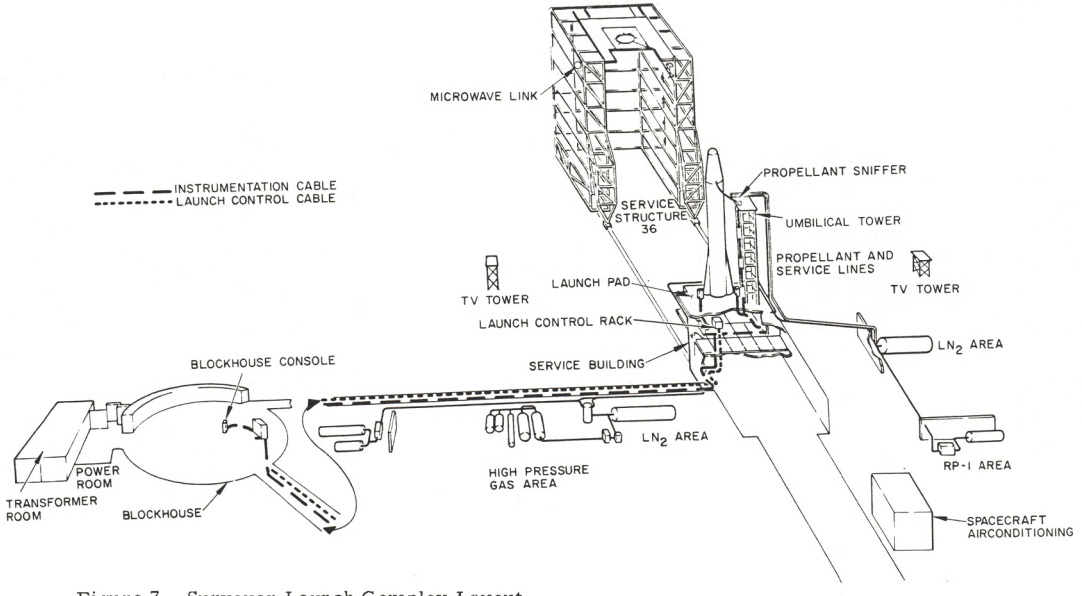


Figure 7. Surveyor Launch Complex Layout

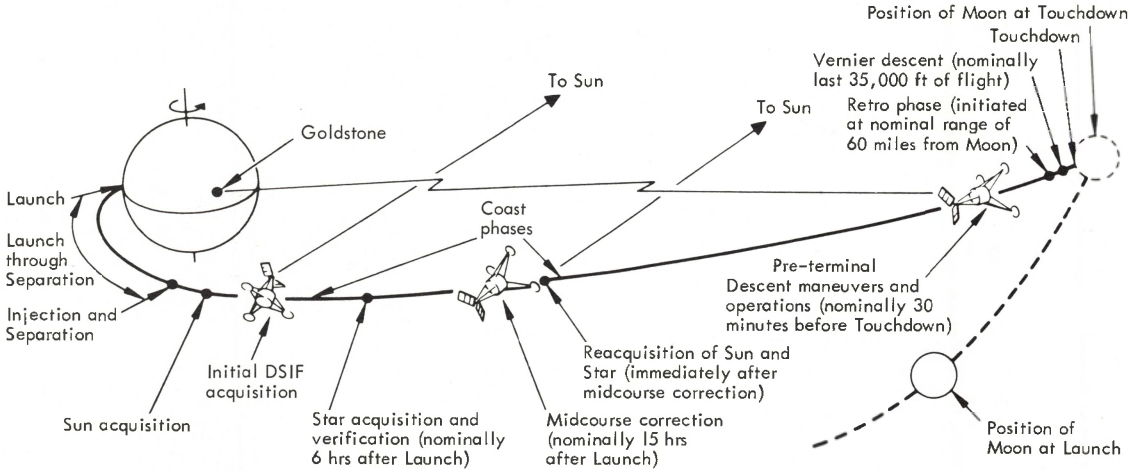


Figure 8. Mission D Flight Profile

After completing the various system and subsystem tests and verifying that all functions in the Deep Space Network and the Space Flight Operations Facility are in an operational status, the SC-4 Surveyor spacecraft, atop the Atlas/Centaur launch vehicle, will be launched from complex 36, pad A, at the Air Force Eastern Test Range, Cape Kennedy.

At liftoff, the launch vehicle rises vertically as the Atlas booster engines develop 389,000 pounds of thrust and vernier engines assist with attitude stabilization. During this initial thrusting period, the launch vehicle performs a programmed roll to a preselected azimuth, following which the vehicle pitches, sending it down range. After a programmed period of firing, the Atlas booster engines are shut down and jettisoned (BECO). As the flight continues, the Atlas sustainer engines provide thrust while the Centaur guidance system supplies steering signals to the Atlas autopilot in a closed-loop system of operation. The Centaur insulation panels and nose fairings (spacecraft shrouds) are jettisoned during this period.

After the Atlas sustainer and vernier engines are shut down (SECO and VECO), the Atlas retrorockets are fired, and the Centaur is separated. A brief chilldown period precedes the start of Centaur's main engines (MES) which inject the vehicle into the translunar trajectory. After a thrusting period of approximately 7 minutes 11 seconds, the Centaur main engines are shut down (MECO) by command from the Centaur guidance system. Shortly thereafter, the SC-4 spacecraft receives signals from the Centaur to deploy omnidirectional antennas and landing legs, and is commanded to switch its transmitter to high power. Approximately 10 seconds later, Centaur and the spacecraft are separated, and SC-4 is on its own. To minimize the possibility of interference (physical or electrical) by the spent Centaur, Centaur performs a 180-degree turnaround, fires its retrorocket placing it into a new trajectory that will cause it to miss the moon), and turns off all electrical power.

After separation, signals from Surveyor's flight control system activate the attitude control gas jets to remove any spacecraft spin, order the solar panel to deploy, and command the spacecraft to search for and lockon to the Sun (providing the spacecraft with a one-point attitude reference). The spacecraft remains in this attitude until further commanded by a deep space station (after initial acquisition).

Initial acquisition of the spacecraft by a ground tracking station occurs nominally at Johannesburg, So. Africa. A network of ground stations provides a command and telemetry link to the spacecraft for purposes of control, as well as to form a two-way doppler tracking loop. For tracking, a transponder mode is achieved, whereby the transmitter is phase-locked to the receiver through sophisticated circuitry, ensuring coherency between received and transmitted signal. During the first phase of the mission, the following maneuvers are performed:

1) Canopus lockon – provides the required celestial third-axis reference (accomplished 6 hours (approximately) after launch by rolling the spacecraft about its longitudinal axis).

2) Midcourse correction – provides the capability to correct initial injection errors (performed 15 hours (approximately) into the mission by vernier engines operation to achieve the desired increment of velocity).

3) Sun and Canopus lockon – returns the spacecraft to its premidcourse maneuver attitude (accomplished by gas jet control immediately after midcourse correction maneuver).

As SC-4 approaches the immediate vicinity of the moon (approximately 1000 miles above the surface), a roll and pitch (or yaw) maneuver is performed to align the thrust axis of the retro engine with the velocity vector of the spacecraft. At a slant range of 60 miles (approximately) the altitude marking radar (AMR) initiates a trigger signal which, after a suitable delay, ignites the vernier engines. One second after vernier ignition, the main retro engine is activated, blowing away the altitude marking radar (AMR) antenna from its position over the retro nozzle. A half-second delay precedes turn-on of the radar altimeter and doppler velocity sensor (RADVS). The vernier engines are fired at low thrust power to stabilize the craft and to dampen any vibrations that could affect the RADVS signals.

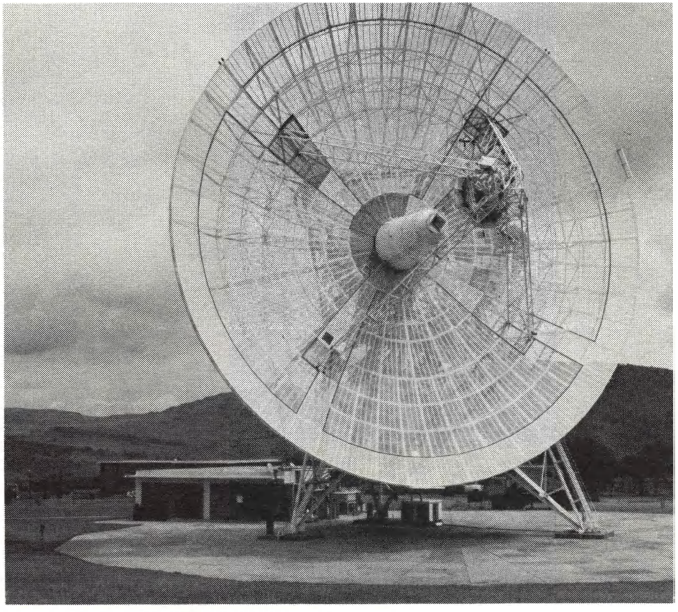


Figure 9. Typical Deep Space Station (Johannesburg, So. Africa)

The thrusting capability of the main retro engine (approximately 9000 pounds) removes most of the incoming velocity of the spacecraft during the retro sequence. As retro fuel depletes, an inertia switch senses a decrease in acceleration to 3.5 g, at which point vernier engine thrusting is increased to further decrease the velocity of the spacecraft and to facilitate retro separation. Upon sufficient reduction of retro thrusting, separation bolts are blown and the retro engine free falls to the lunar surface.

Terminal descent continues with vernier thrust reduced to correspond to an axial acceleration of 0.9 g. The RADVS acquires the lunar surface and provides range and velocity measurements until a preprogrammed range/velocity contour signals the vernier thrust to increase until a descent speed of 10 fps is attained. With the thrust axis of the spacecraft aligned with the vertical, the speed is further reduced to 5 fps and is maintained until the vehicle reaches a vertical distance of 13 feet above the lunar surface. At 1.5 seconds past that mark, vernier engines shutdown occurs and the spacecraft is allowed to free fall the remaining 5.5 feet (approximately) to the moon's surface.

Once a lunar landing has been achieved, all spacecraft flight control equipment is shut down to conserve battery power. The spacecraft is then commanded to orient the solar panel to a spacecraft-sun line in order to ensure optimum battery charging. The high-gain planar array is then aligned to a spacecraft-earth line for data transmission. One of the power modes (high or low) is selected consistent with the usable power available. The survey camera (TV-3) is then activated, and initial lunar TV data transmission is initiated.

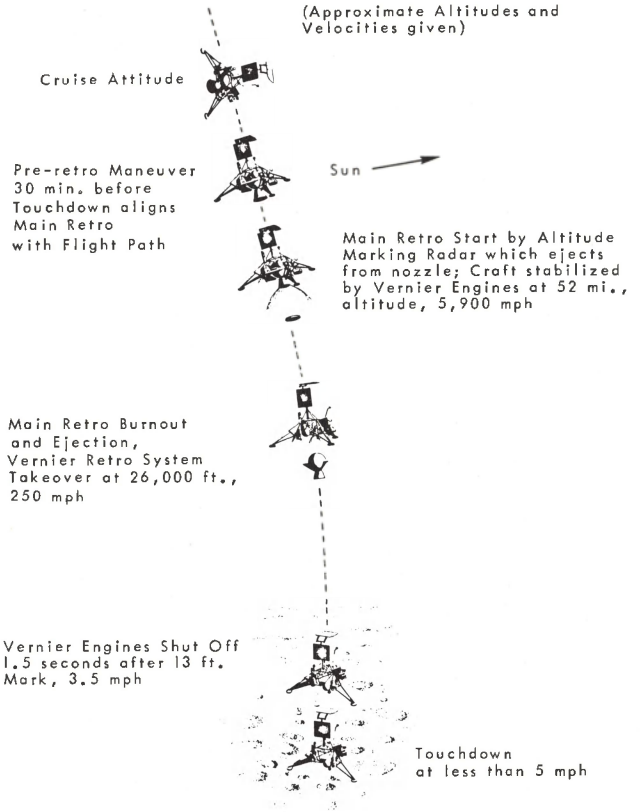


Figure 10. Spacecraft Terminal Descent

POSTLANDING EXPERIMENTS

The SC-4 spacecraft is equipped to perform several postlanding experiments designed to provide additional information about the lunar surface's composition:

TV Camera – Photographs of the lunar surface, the spacecraft itself, and other objects of interest can be taken (in either 200- or 600-line mode). Through the use of color filters, black and white photos can be reconstituted into color prints which accurately depict the subject. Views normally hidden beneath the spacecraft can be photographed by reflection from beryllium mirrors attached to the inner portion of the spaceframe. Photographic documentation of postlanding experiments will include:

Soil Mechanics/Surface Sampler – A 2-inch wide scoop/digger, mounted at the end of a spring-extended scissors-arm, is utilized to press, scrape, pick, trench, and impact the lunar surface. Force measurements and photographs of the operations provide documentation which can be evaluated.

Magnetic Experiment — To assist in the interpretation of lunar surface material, the spacecraft carries a small (1-ounce) magnet mounted on the vertical edge of landing pad No. 2. Surface material is expected to be kicked upon the magnet in the course of landing. (The SM/SS can also be utilized to drop material on the magnet.) If nickel-iron constituents are present in the soil, they will adhere to the magnet. A bar of nonmagnetic metal alongside the magnet will provide nonmagnetic adhesive comparison.

Static Firing – The spacecraft's three vernier engines will be commanded on for approximately 0.5 second, immediately following which photographs will be taken to record the degree of soil disturbance caused by engine exhaust.

Liftoff and Lunar Translation – The spacecraft can be propelled to another position or area close to the initial landing site (range approximately 6 feet) by restarting the vernier engines. Repositioning can provide a stereoptical view of areas photographed from the initial site and permit photos (and soil sampling) of areas initially blind to the equipment.

Gas Jet Experiment – By releasing a known charge of gas downward from attitude control jet No. 2 and photographing the resulting surface disturbance, certain physical characteristics of the lunar surface can be evaluated.

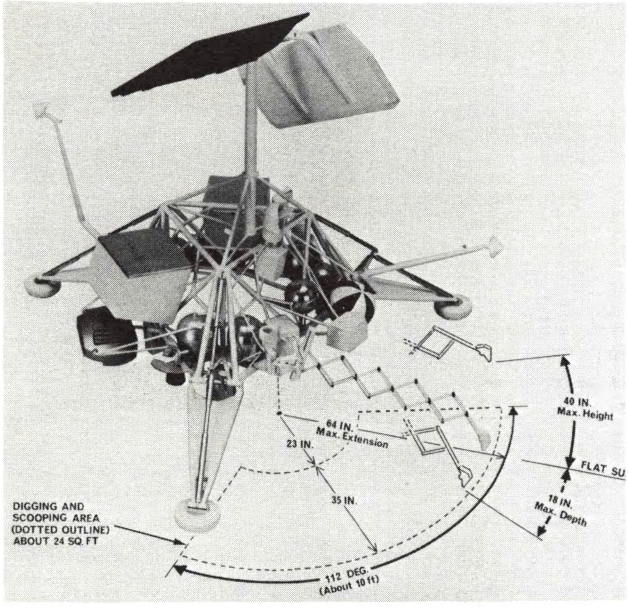


Figure 11. Soil Mechanics/Surface Sampler Experiment General Configuration

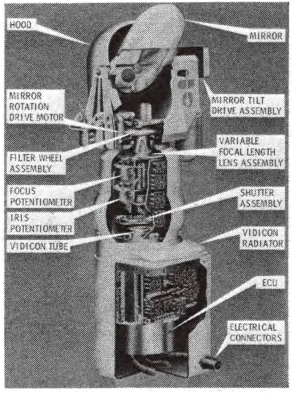


Figure 12. TV Camera Features

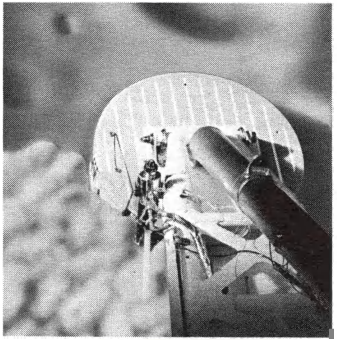


Figure 13.
Gas Jet Experiment

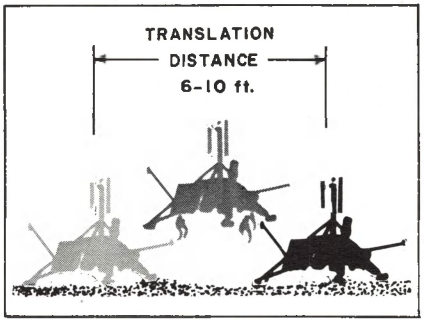


Figure 14.
Lunar Translation Experiment

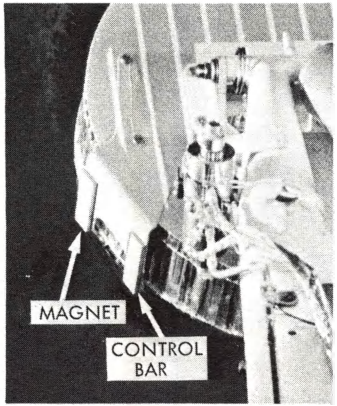


Figure 15.
Magnetic Experiment

TABLE 1. LAUNCH WINDOWS – MISSION D

Launch Date	Launch Window		Window Duration, Minutes	Arrival Date	Arrival Times		Landing Locations	
	Earliest, Hour/Min	Latest, Hour/Min			Earliest, Hour/Min	Latest, Hour/Min	Latitude	Longitude
13 July	4:03	4:07	4	15 July	21:20	21:29	0.58°N.	0.83°W.
14 July	4:41	5:30	49	16 July	18:58	20:27		
15 July	5:32	7:02	90	17 July	19:25	20:55		
16 July	6:32	8:08	96	18 July	20:42	21:00		
17 July	7:33	9:10	97	19 July	21:46	22:03		

Notes:

1. All days and times reference to Pacific Daylight Time. To convert times to Greenwich Mean Time, add 7 hours to Pacific Daylight Time.
2. Midcourse velocity correction will be at approximately L+15 hours.
3. All arrival times reflect a nominal 62-hour transit period.

Table 2. Spacecraft Launch Configuration

Transmitter B low power
Transponder B
Filament B ON
550 bps
Coast phase commutator
A/D Converter No. 1
Phase modulation summing amplifier
Presumming amplifier ON
Omnidirectional antenna B
Low modulation index subcarrier oscillator
Isolation amplifier ON
Flight control ON
Rate mode
Accelerometer amplifier 1, 3, and 4 ON
Overload under voltage trip circuit enable ON
Main battery mode
Battery pressure logic enabled
Optimum charge regulator ON — by pass OFF
Solar panel deployment logic ON
Vernier lines thermal control power ON
AMR heater ON

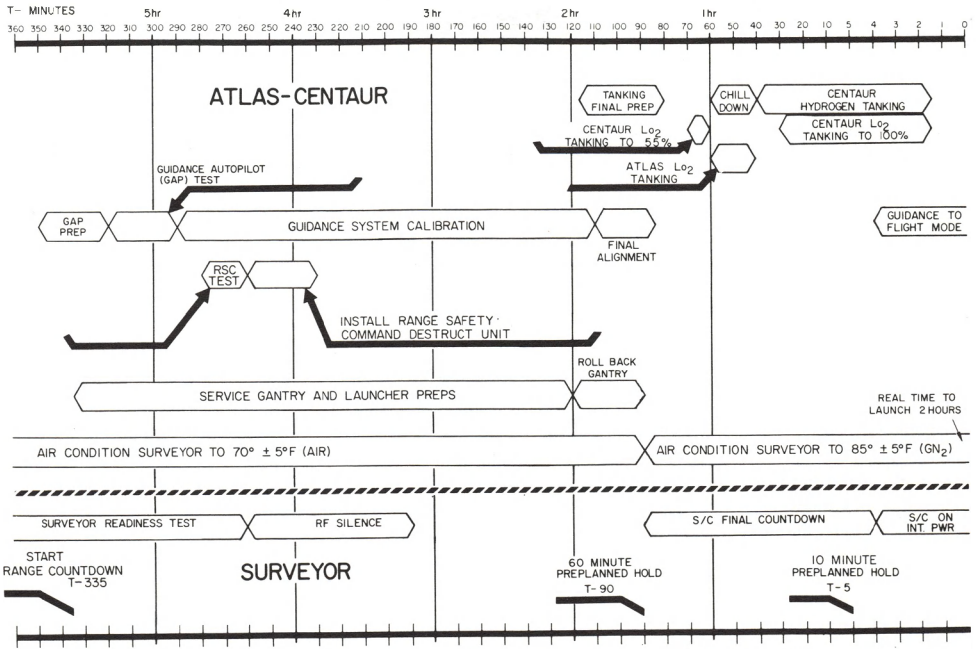
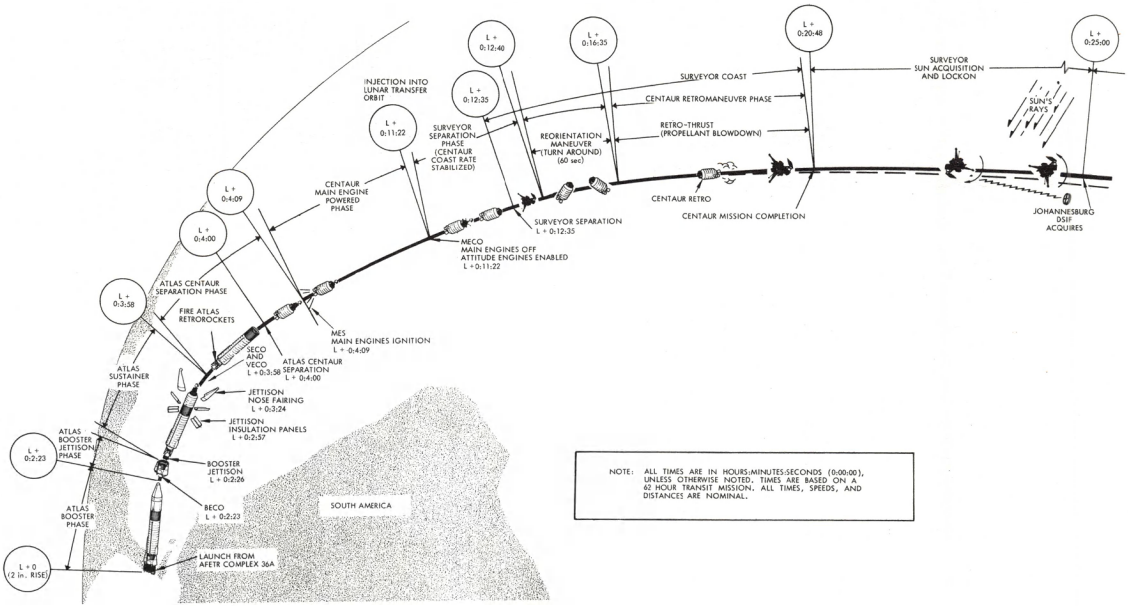


Figure 15. Countdown Major Events, Atlas/Centaur/Surveyor



NOTE: ALL TIMES ARE IN HOURS:MINUTES:SECONDS (0:00:00), UNLESS OTHERWISE NOTED. TIMES ARE BASED ON A 62 HOUR TRANSIT MISSION. ALL TIMES, SPEEDS, AND DISTANCES ARE NOMINAL.

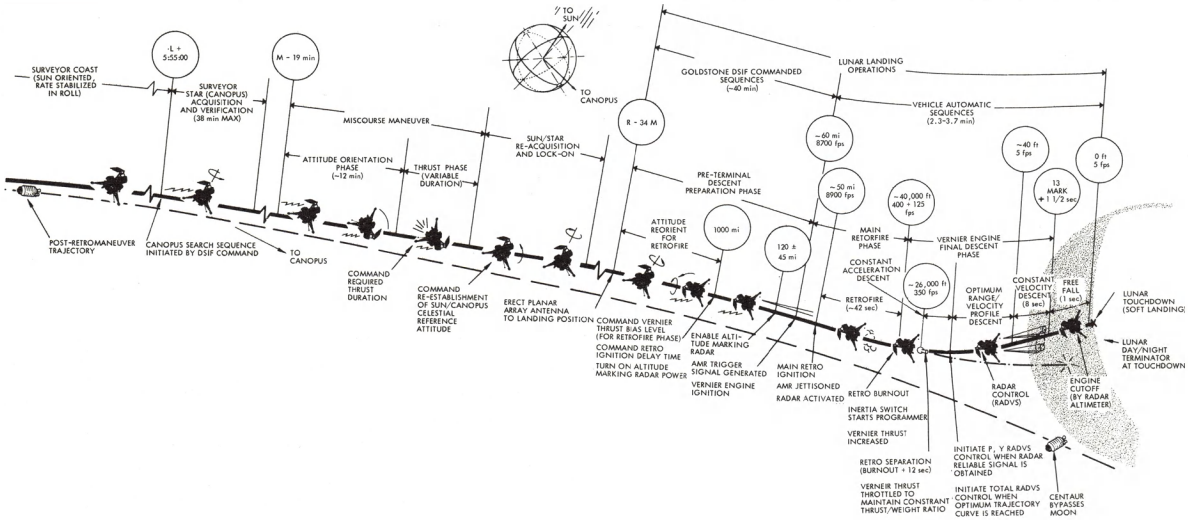


Figure 16. Surveyor Flight Compendium

COUNTDOWN EVENTS

Time T-	Scheduled	Actual	Event
T-5:35:00			Start range countdown
T-4:20:00			SRT complete (started at T-620)
T-2:00:00			Centaur propulsion prep complete, start tower removal
T-1:50:00			Atlas propulsion prep complete
T-1:30:00			Planned 60 minute hold
T-1:30:00			Start spacecraft countdown 30 minutes prior to picking up count
T-1:30:00			Status check, tower removal complete
T-1:23:00			Arm and safe spacecraft retro
T-1:10:00			Spacecraft power and accelerometer checks, start Centaur LO_2 tanking
T-1:00:00			Centaur LO_2 secure at 55 percent, start Atlas LO_2 tanking
T-0:50:00			Start Atlas/Centaur guidance ready preparations
T-0:40:00			Frequency report (transmitter B), Atlas LO_2 tanking complete, start LH_2 tanking
T-0:30:00			Start Atlas/Centaur LO_2 topping

T-Time is in hours:minutes:seconds (0:00:00) before launch.

Countdown Events (continued)

Time T-	Scheduled	Actual	Event
T-0:22:00			Start final range safety check
T-0:20:00			Frequency report, transmitter B
T-0:18:00			Complete RS check
T-0:12:00			Final A/C GAP test complete
T-0:05:00			Planned 10 minute hold
T-0:05:00			Status check (counting)
T-0:04:00			Centaur to internal power
T-0:04:00			Spacecraft to internal power
T-0:02:35			Secure Atlas LO_2 topping
T-0:02:00			Spacecraft retro arm, Atlas to internal power
T-0:01:30			Secure LH_2 tanking
T-0:01:15			Secure Centaur LO_2 topping
T-0:01:00			Set flight azimuth
T-0:00:30			Final status check
T-0:00:10			Engines start
T-0:00:00			Lift off

MISSION EVENTS

	Time	Scheduled	Actual	Event
	L+0:00:02			Start roll to launch azimuth
	L+0:00:15			End roll to launch azimuth; start pitch program
1	L+0:02:23			Booster engine cutoff (BECO)
2	L+0:02:26			Atlas booster engine jettison
3	L+0:02:57			Centaur insulation panel jettison
4	L+0:03:24			Centaur nose fairing jettison
5	L+0:03:58			Sustainer/vernier engine cutoff (SECO/VECO)
6	L+0:04:00			Atlas/Centaur separation
7	L+0:04:09			Centaur main engine start (MES)
8	L+0:11:22			Centaur main engine cutoff (MECO)
9	L+0:11:54			Landing gear deploy command sent; spacecraft preseparation arming
10	L+0:12:04			Omnidirectional antenna deploy command sent
11	L+0:12:25			Spacecraft high power transmitter: ON
12	L+0:12:30			Centaur/Surveyor electrical disconnect
13	L+0:12:35			Centaur/Surveyor separation

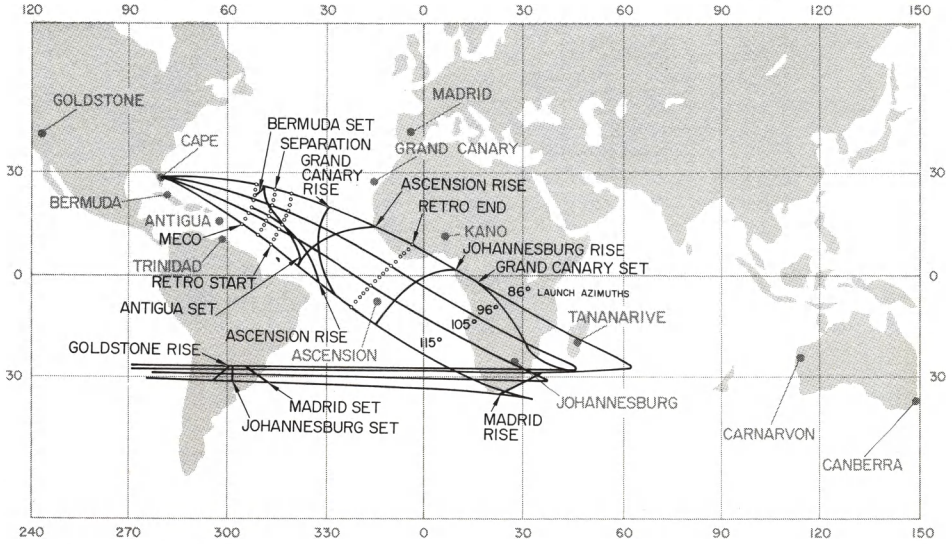
Time is in hours:minutes:seconds (0:00:00). L = launch; M = midcourse maneuver; R = retro ignition; T = touchdown. All times are nominal.

Mission Events (continued)

Mark Event	Time	Scheduled	Actual	Event
14	L+0:12:38			Begin solar panel deployment
	L+0:12:40			Begin Centaur turn-around
	L+0:16:35			Start Centaur propellants blowdown
	L+0:20:45			End Centaur propellants blowdown
	L+0:20:45			Power changeover switch (end of retro maneuver)
The following times are approximate and based on a nominal mission.				
	L+0:32:00			Initial spacecraft operations by DSS-51
	L+6:09:00			Star acquisition and verification by DSS-61
	(Midcourse times)			
	M-0:19:00			First premidcourse maneuver
	M-0:00:00			Midcourse velocity correction
	M+0:07:00			First postmidcourse maneuver
	M+0:20:00			Star acquisition and verification by DSS-11

Mark Event	Time	Scheduled	Actual	Event
The following sequences reflect times before and after retro ignition through touchdown.				
	(Retro ignition times)			
	R-0:05:00			Altitude marking radar: ON
	R-0:00:10			Altitude marking radar mark
	R-0:00:01			Vernier engine ignition
	R-0:00:00			Main retro ignition
	R+0:00:01			RADVS: ON
	R+0:00:40			Main retro burnout (3.5 g) increase vernier thrust output
	R+0:00:48			Main retro eject signal
	R+0:02:15			1000-foot mark
	R+0:02:03			10-feet/sec mark
	R+0:02:11			13-foot mark
	R+0:02:13			Touchdown
	(Touchdown times)			
	TD+0:08:00			Step solar panel
	TD+0:54:00			200-line TV picture
	TD+1:40:00			End of transit mission phase

 NOTE: See Optional Mission Sequences, page 44.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60
30
0
30
60
90
120
150
GOLDSTONE
MADRID
BERMUDA SET
SEPARATION
CAPE
GRAND CANARY
GRAND
CANARY
RISE
ASCENSION RISE
30
BERMUDA
RETRO END
ANTIGUA
KANO
MECO
JOHANNESBURG RISE
TRINIDAD
GRAND CANARY SET
0
RETRO START
86° LAUNCH AZIMUTHS
ANTIGUA SET
96°
TANANARIVE
105°
ASCENSION RISE
GOLDSTONE RISE
ASCENSION
115°
30
JOHANNESBURG
MADRID SET
JOHANNESBURG SET
MADRID
RISE
CARNARVON
CANBERRA
240
270
300
330
0
30
60
90
120
150

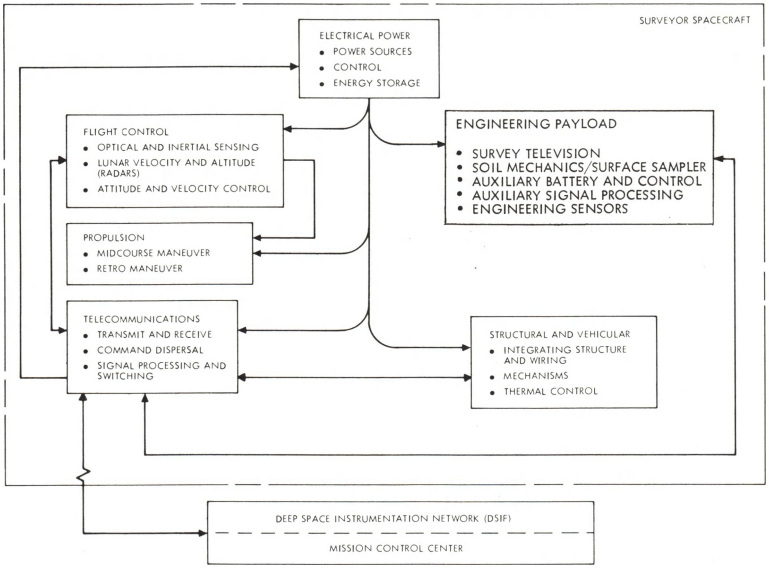


Figure 18. Spacecraft System Block Diagram

Table 3. Command Assignments

CMD	NAME	CMD	NAME
0101	XMTR A LOW PWR ON	0201	A/D CONV 1 PWR ON
0102	XMTR A FILA PWR ON	0202	A/D CONV 2 PWR ON
0103	XMTR HI VOLTS ON	0203	A/D CONV PWR OFF
0104	XMTR B LOW PWR ON	0204	A/D COAST PH CLK RATES
0105	XMTR B FILA PWR ON	0205	A/D CLK RATE 1100 BPS
0106	XMTR HI VOLTS ON	0206	A/D CLK RATE 4400 BPS
0107	XMTR HI VOLTS OFF	0207	PRE SUMMING AMP ON
0110	XMTR FILA PWR OFF	0210	PHASE SUMMING AMP A ON
0111	XMTR LOW PWR OFF	0211	PHASE SUMMING AMP B ON
0112	NARROW BAND VCXO ON	0212	FREQ SUMMING AMP A ON
0113	NARROW BAND VCXO OFF	0213	FREQ SUMMING AMP B ON
0116	XMTR B TO PA	0214	SUMMING AMPLIFIERS OFF
0117	XMTR A TO PA	0215	3.9KC A/D SCO ON
0120	SELECT OMNI A	0216	7.35KC A/D SCO ON
0121	SELECT OMNI B	0217	33KC A/D SCO ON
0122	XPONDR A PWR ON	0220	33, 7.35, 3.9KC SCO'S OFF
0123	XPONDR B PWR ON	0221	GYRO SPEED SIG PROC ON
0124	XPONDR PWR OFF	0222	SELECT NEXT GYRO SPD CNL
0125	SVR SW A HI PWR	0223	GYRO SPEED SIG PROC OFF
0126	XFR SW A LOW PWR	0224	BASIC BUS ACCEL CNLS ON
0127	XFR SW B HI PWR	0225	BASIC BUS ACCEL CNLS OFF
0130	XFR SW B LOW PWR	0226	ENGR CMTR 1 ON
0131	SMSS PWR ON/EXECUTE	0227	ENGR CMTR 2 ON
0132	SMSS DIGITAL 1	0230	ENGR CMTR 3 ON
0133	SMSS DIGITAL 0	0231	ENGR CMTR 4 ON
0134	SMSS AUX PWR OFF	0232	ENGR CMTRS OFF
0135	SMSS AUX HEATER OFF	0233	CMD REJ/ENABLE SCO ON
0136	SMSS AUX HEATER ON	0234	CMD REJ/ENABLE SCO OFF
0200	LOW MOD INDEX SCO ON	0235	A/D ISOLTN AMP ON

CMD	NAME	CMD	NAME
0236	A/D ISOLTN AMP OFF	0412	COMPT A THRM CTRL AUTO
0237	LOW MOD INDEX SCO OFF	0413	COMPT A HTR PWR OFF
0300	FLT CTL COAST PH PWR ON	0414	COMPT B HTR PWR ON
0301	ENABLE BATT PRESS LOGIC	0415	COMPT B THRM CTRL AUTO
0302	DISABLE BATT PRESS LOGIC	0416	COMPT B HTR PWR OFF
0304	BYPASS MAIN OTC	0500	COAST PH I A/D SCO ON
0305	ENABLE MAIN OTC	0501	COAST PH II A/D SCO ON
0306	OCR ON + BYPASS OFF	0502	COAST PH A/D SCO'S OFF
0307	OCR BYPASS ON + OCR OFF	0503	A/D CLOCK RATE 550 BPS
0310	OCR OFF	0504	A/D CLOCK RATE 137.5 BPS
0311	ALL FLT CTRL PWR OFF *I*	0505	A/D CLOCK RATE 17.2 BPS
0314	NON ESSEN LOADS OFF *I*	0506	COAST PH CMTR ON
0315	SP DEPLOYMENT LOGIC ON	0507	THRST PH BACK UP CMTR ON
0316	SP DEPLOYMENT LOGIC OFF	0510	AUX COMMUTATORS OFF
0317	AUX BATT MODE ON	0511	AUX ACCEL AMPS ON
0320	RESTORE MAIN BATT MODE	0512	AUX ACCEL AMPS OFF
0321	DISABLE BATT XFR LOGIC	0513	AUX ACCEL DATA CHAN ON
0322	HI CURRENT MODE ON	0514	AUX ACCEL DATA CHAN OFF
0323	HI CURRENT MODE OFF	0515	TD STRAIN GAUGE PWR ON
0337	COMMAND PULSE TEST	0516	TD STRAIN GAUGE PWR OFF
0401	STEP SOLAR PANEL PLUS	0517	TD STRN GA DATA CHAN ON
0402	STEP SOLAR PANEL MINUS	0520	TD STRN GA DATA CHAN OFF
0403	STEP POLAR AXIS PLUS	0521	PROPUL STRN GA PWR ON
0404	STEP POLAR AXIS MINUS	0522	PROPUL STRN GA PWR OFF
0405	STEP ROLL AXIS PLUS	0530	ENG PAYLOAD TEST CMD
0406	STEP ROLL AXIS MINUS	0600	EXTEND LANDING GEAR
0407	STEP ELEV AXIS PLUS	0601	EXTEND OMNI ANTENNAS
0410	STEP ELEV AXIS MINUS	0604	AMR HEATER OFF
0411	COMPT A HTR PWR ON	0605	UNLK VER ENG, PRESS SYS *I*

Command Assignments (cont.)

CMD	NAME	CMD	NAME
0607	UNLOCK ROLL AXIS *I*	0706	ENABLE GAS JET AMPS
0610	DUMP HELIUM *I*	0707	INHIBIT GAS JET AMPS
0611	VER LINES 2 TCP ON	0710	POSITIVE ANGLE MANEUVER
0612	VER FUEL TANK 2 TCP ON	0711	ROLL
0613	VL 2 + VFT 2 TCP OFF	0712	PITCH
0614	VER LINES 1 TCP ON	0713	YAW
0615	VER OXDZ TANK 2 TCP ON	0714	SUN AND ROLL
0616	VL 1 + VOT 2 TCP OFF	0715	MANUAL DELAY MODE ON
0617	VER LINES 3 TCP ON	0716	MANUAL LOCKON *SUN/STAR*
0620	VER OXDZ TANK 3 TCP ON	0720	RESET SET IV OUTPUTS
0621	VL 3 + VOT 3 TCP OFF	0721	VERNIER IGNITION *I*
0622	BASIC BUS ACCEL AMPS ON	0722	VERNIER THRUST LO
0623	BASIC BUS ACCEL AMPS OFF	0723	VERNIER THRUST HI
0624	AMR HEATER ON	0724	RETRO SEQ MODE ON *I*
0625	AMR POWER ON	0727	FLT CTRL THRST PH PWR ON
0626	ENABLE AMR	0730	EMER AMR SIGNAL
0627	AMR POWER OFF *I*	0731	EMER RETRO IGNITION
0630	RADVS POWER OFF *I*	0732	EMER RETRO EJECT
0631	UNLOCK SOLAR PANEL *T*	0733	EMER START PGRMD THRUST
0632	UNLOCK ROLL AXIS *T*	0734	EMER RADVS ON SIGNAL
0634	UNLOCK ELEV AXIS *I*	0735	EMER VERNIER ENGINES OFF
0635	UNLOCK SOLAR PANEL *L*	0737	THRUST PH PWR OFF
0636	LOCK LANDING GEAR	1100	START FRAME
0637	RADVS POWER ON *I*	1101	TV NULL
0700	INERTIAL MODE ON	1103	SURVEY CAMERA PWR ON
0701	RATE MODE ON	1104	SURVEY CAMERA PWR OFF
0702	SUN ACQ MODE ON	1105	SHUTTER NORMAL
0703	SUN AND STAR ACQ MODE ON	1106	SHUTTER OPEN
0704	CRUISE MODE ON	1107	EMER TV MODE ON

Command Assignments (cont.)

CMD	NAME	CMD	NAME
1110	SET 25 MM FOCAL LENGTH	1124	STEP FOCUS OUT
1111	SET 100 MM FOCAL LENGTH	1125	MULT STEP FOCUS IN
1112	IRIS SERVO ON	1126	MULT STEP FOCUS OUT
1113	STEP IRIS OPEN	1127	STEP FLTR POSITION RIGHT
1114	STEP IRIS CLOSED	1130	STEP FLTR POSITION LEFT
1115	STEP MIRROR RIGHT	1131	SHUTTER INHIBIT OVERRIDE
1116	STEP MIRROR LEFT	1133	SURVEY CAMERA VTC ON
1117	2 STEPS MIRROR RIGHT	1134	SURVEY CAMERA VTC OFF
1120	2 STEPS MIRROR LEFT	1136	SURVEY CAMERA ETC ON
1121	STEP MIRROR DOWN	1137	SURVEY CAMERA ETC OFF
1122	STEP MIRROR UP	3617	INTERLOCK
1123	STEP FOCUS IN		

Table 4. Telemetry Assignments

DES	SIGNAL	DES	SIGNAL
D-1	OMNI A XMTD PWR	EP-11	SLR CLL ARRY CUR
• D-2	XMTR A FILA ON	EP-12	SLR CLL ARRY TMP
D-3	OMNI B XMTD POWER	EP-13	B/R TEMP
• D-4	XMTR B FILA ON	EP-14	REG OUTPUT CUR
• D-5	XPNDR A ϕ LCKD	EP-15	OMITTED
• D-6	XPNDR B ϕ LCKD	EP-16	OCR OUTPUT CUR
D-7	SPE A	EP-17	RADVS & SQB CUR
D-8	SPE B	EP-18	FSC CALIB ESP
D-9	RCVR A AGC	EP-19	MSC CALIB ESP
D-10	RCVR B AGC	EP-20	ZSC CALIB ESP
• D-11	MESS REJECT	EP-21	CMPT A HTR CUR
• D-12	CENTRAL DCDR A ON	EP-22	CMPT B HTR CUR
D-13	XMTR A TMP	EP-23	AUX BAT V
D-14	XMTR B TMP	EP-24	SLR CLL ST4 CUR
• D-15	MESS ENABLE	EP-25	SLR CLL ST6 CUR
D-16	RCVR A AFC	EP-26	AUX BAT TMP
D-17	RCVR B AFC	EP-27	FSC CALIB AESP
• D-18	CNTRL DCDR B ON	EP-28	MSC CALIB AESP
EP-1	29V NONESS	EP-29	ZSC CALIB AESP
EP-2	UNRG BUS V	EP-30	B/R PREREG V
EP-3	MN BAT MAN PRSS	• EP-31	AUX BAT MD ON
EP-4	UNRG OUTPUT CUR	• EP-32	HI CUR MD OFF
EP-5	MN BAT V	• EP-33	RADVS PYRO SW TMP
EP-6	BAT CHRG CUR	EP-34	BAT CHRG REG TMP
EP-7	B/R DIFF CUR	EP-40	FC UNREG CUR
EP-8	MN BAT TEMP	FC-1	RLL GYRO SPD
EP-9	BAT DSCRG CUR	FC-2	PITCH GYRO SPD
EP-10	SLR CLL ARRY V	FC-3	YAW GYRO SPD
		FC-4	NTRGN GS PRSS

• = DIGITAL DATA

Telemetry Assignments (cont.)

DES	SIGNAL	DES	SIGNAL
FC-5	PR SN SNSR P ERR	• FC-34	RODVS
FC-6	PR SN SNSR Y ERR	FC-35	RDR ALT RNG SIG
FC-7	SEC SN SNSR CLL A	• FC-36	10 FT PR SEC MK
FC-8	SEC SN SNSR CLL B	• FC-37	1000 FT MK
FC-9	SEC SN SNSR CLL C	• FC-38	13 FT MK
FC-10	SEC SN SNSR CLL D	FC-39	DPPLR VEL V_X
FC-11	OMITTED	FC-40	DPPLR VEL V_Y
FC-12	CNPS ERR	FC-41	DPPLR VEL V_Z
• FC-13	CNPS L-O	• FC-42	ST RADVS CNT DES
FC-14	STR INTNSTY SIG	FC-43	RLL ACT SIG
FC-15	ACC ERR	FC-44	F/C EL UNT TMP 1
FC-16	PITCH GYRO ERR	FC-45	F/C EL UNT TMP 2
FC-17	YAW GYRO ERR	FC-46	RLL GYRO TMP
• FC-18	MAG REG RDT	FC-47	CNPS SNSR TMP
• FC-19	PROG RLL SIG	FC-48	NIT GS TNK TMP
FC-20	OMITTED	FC-49	RLL PRES CMND
• FC-21	PROG PTCH SIG	FC-50	PTCH PRES CMND
FC-22	OMITTED	FC-51	YAW PRES CMND
• FC-23	PROG YAW SIG	• FC-52	NOM EG TRST BIAS
FC-24	OMITTED	FC-53	SEC SN SNSR C-C
FC-25	TRST CMND V EG 1	FC-54	PTCH GYRO TMP
FC-26	TRST CMND V EG 2	FC-55	YAW GYRO TMP
FC-27	TRST CMND V EG 3	• FC-56	MN DEL MD ON
• FC-28	V IG SIG	• FC-57	GS JT AMP INHIBTD
• FC-29	RET IG SIG	• FC-58	RATE MD ON
• FC-30	RET BRNT SIG	• FC-59	SUN MD ON
• FC-31	RET EJCT SIG	• FC-60	STAR MD ON
FC-32	RET ACC	• FC-61	CRSE MD ON
• FC-33	RORA	• FC-62	RET SEQ MD ON

Telemetry Assignments (cont.)

DES	SIGNAL	DES	SIGNAL
• FC-63	INRTA SW SIG	• M-14	SLR PNL LNCH LK UN
• FC-64	AMR SIG	• M-15	SLR PNL DEP LGC ON
• FC-65	M/C VEL CORR SIG	P-1	HLM PRESS
• FC-66	TRST ϕ PWR ON	P-2	OXD PRESS 3
• FC-67	PROG + ANG MAN	P-3	UPPR RET CASE TMP
FC-68	OMITTED	P-4	VRN LN 2 TMP
• FC-69	PRM SN SNS C-C L-O	P-5	VRN FL TNK 2 TMP
FC-70	ATT GS JT 2 TMP	P-6	VRN OXD TNK 3 TMP
FC-71	RLL ACT TMP	P-7	VRN EG 1 TMP
FC-72	OMITTED	P-8	VRN LN 1 TMP
• FC-73	MN L-O SN/STR	P-9	VRN LN 3 TMP
• FC-74	P GYRO HTR CNT OFF	P-10	VRN EG 2 TMP
• FC-75	R GYRO HTR CNT OFF	P-11	VRN EG 3 TMP
• FC-76	ACQ SN SNSR ILL	P-12	LWR RET CS TMP
FC-77	F/C REF RET	P-13	VRN FL TNK 1 TMP
FC-79	YAW GYRO HTR OFF	P-14	VRN FL TNK 3 TMP
• M-1	OMNI ANT A EXT	P-15	VRN OXD TNK 1 TMP
• M-2	OMNI ANT B EXT	P-16	VRN OXD TNK 2 TMP
M-3	SLR PNL POS	P-17	HLM TNK TMP
M-4	PLR AXS POS	P-18	VRN EG 1 STRN G
M-5	DELETED	P-19	VRN EG 2 STRN G
M-6	EL AXS POS	P-20	VRN EG 3 STRN G
M-7	RLL AXS POS	P-21	DELETED
M-8	PLR ARRY TMP	P-22	RET NZL TMP
• M-9	VCLE SEP	• R-1	AMR ON
M-10	SLR PNL STP MT TMP	R-2	RADVS R AMP
• M-11	SLR PNL LK TRN POS	R-3	RADVS D_1 AMP
M-12	EL AXS STPG MT TMP	R-4	RADVS D_2 AMP
• M-13	RLL AXS LK TRN POS	R-5	RADVS D_3 AMP

Telemetry Assignments (cont.)

DES	SIGNAL	DES	SIGNAL
R-6	AMR ANT TMP (MOD)	• S-6	FF R100 MD C
R-7	AMR EL TMP	S-7	CM UNBLNC VLT AESP
R-8	ALT & DOP KLY ON TMP	• SS-1	SMSS DECODE PWR ON
R-9	RDR SIG DTA CV TMP	• SS-2	CMD ENTERED
R-10	DOPP RDR SNSR TMP	SS-10	MOTOR CURRENT
• R-11	AMR ENBLD	SS-12	AUX TEMP
R-12	AMR PWR OUT	TV-1	CAM ON
R-13	ALT RDR SNSR TMP	TV-2	MRR AZ
R-14	AMR AGC	TV-3	MRR EL
• R-15	RADVS D_1 TRKR LK	TV-4	LNS FCL LGTH STG
• R-16	RADVS D_2 TRKR LK	TV-5	LNS FCS STG
• R-17	RADVS D_3 TRKR LK	TV-6	LNS IRS STG
• R-18	RADVS R TRKR LK	• TV-7	LNS IRS SRV OFF/ON
• R-19	RADVS D_1 GN 1	TV-8	FLTR WHL POS
• R-20	RADVS D_1 GN 2	TV-9	VDCN FCPLT TMP
• R-21	RADVS D_2 GN 1	TV-10	CAM ELCT TMP
• R-22	RADVS D_2 GN 2	• TV-11	SHTTR MD OPN/NORM
• R-23	RADVS D_3 GN 1	TV-12	CLBRT VLT
• R-24	RADVS D_3 GN 2	• TV-13	MTP ST FCS ON/OFF
• R-25	RADVS R GN 1	TV-14	COMP VIDEO
• R-26	RADVS R GN 2	TV-15	OMITTED
R-27	AMR ANT TMP 2	TV-16	SVY CAM ELCT TMP
• R-28	RADVS ON SIG Z23	TV-17	SVY CAM MRR AS TMP
R-29	AMR LT GT SIG	V-1	LNDG GR 1 EXT
S-1	REF VLT	• V-2	LNDG GR 2 EXT
S-2	REF RET	• V-3	LNDG GR 3 EXT
• S-3	FF R500 MD 2 or 3	• V-4	RTRO NOT EJECTED
• S-4	FF R501 MD 3 or 4	V-5	LNDG GR 1 DEF
S-5	CM UNBLNC CUR ESP	V-6	LNDG GR 2 DEF

Telemetry Assignments (cont.)

DES	SIGNAL	DES	SIGNAL
V-7	LNDG GR 3 DEF	V-28	L/SF TMP UND CMP B
V-8	V ACC 1 COL B-LEG 1	V-29	WRG HRNS TMP TRM T
V-9	V ACC 2 COL B-LEG 2	V-30	SHK ABS 1 TMP
V-10	V ACC 3 COL B-LEG 3	V-31	LG 2 UPR WB TMP
V-11	V ACC 4 FC SNSR GRP	V-32	SHK ABS 2 TMP
V-12	SHK ABSBR 1 ST G	V-33	SHK ABS 3 TMP
V-13	SHK ABSBR 2 ST G	V-34	A/SP MST TMP
V-14	SHK ABSBR 3 ST G	V-35	U/SF TMP 2
V-15	CMP A TMP TRML TR TP	V-36	L/SF TMP UND CMP A
V-16	CMP A TMP LWR SUP	V-37	RET ATT PT 1 TMP
V-17	CMP A TMP INS RET	V-38	RET ATT PT 2 TMP
V-18	CMP A TMP CNSTR	V-39	RET ATT PT 3 TMP
V-19	CMP A TMP SW 5 CR	V-40	V ACC 5 A/SD MST
V-20	CMP A TMP SW 5 FR	V-41	V ACC 6 VEL SNS ANT
V-21	CMP B TMP TRY TC	V-42	V ACC 7 CMP A
V-22	CMP B TMP LWR SUP	V-43	V ACC 8 CMP B
V-23	CMP B TMP CNSTR	V-44	CRUSH BLK TMP
V-24	CMP B TMP SW 4 FR	V-45	CMP B TMP SW 1 FR
V-25	CMP A TMP SW 8 FR	V-46	CMP B TMP SW 5 FR
V-26	CMP B TMP SW 4 CR	V-47	CMP A TMP SW 2 FR
V-27	U/SF TMP 1		

Table 5. Major Sequence Index

Major Sequence Number	Description	Major Sequence Number	Description
0040	Initial spacecraft operations	0242	Post-touchdown vernier engine static firing
0041	Star identification and acquisition	0243	Post-touchdown 1-foot liftoff and translation
0042	Premaneuver interrogation	0244	Post-touchdown 6-foot liftoff and translation
0043	Midcourse correction	0245	Gas jet experiment
0044	Terminal maneuver and descent	0246	Spare
0045	Postlanding engineering assessment	0247	Spare
0046	Engineering interrogation	0340	Spare
0047	Spare	thru	Spare
0140	200 line TV to engineering interrogation (PM)	0747	Spare
0141	Engineering interrogation (PM) to 200 line TV	1040	SM/SS initialization and engineering verification
0142	600 line TV to engineering interrogation (FM) (high power) to 600 line TV	1041	SM/SS azimuth right 50 degrees fine
0143	Solar panel/planar array positioning (keyboard)	1042	SM/SS bearing strength test
0144	RF communications test	1043	SM/SS azimuth left 50 degrees coarse
0145	Telecommunications signal processing test	1044	SM/SS extend 18 inches
0146	600 line TV to engineering interrogation (PM)	1045	SM/SS azimuth right 50 degrees coarse
0147	Engineering interrogation (PM) to 600 line TV	1046	SM/SS trenching
0240	Engineering interrogation to standby mode (OCR Off)	1047	SM/SS glossary tape
0241	Standby mode (OCR Off) to engineering interrogation	1140	Spare
		thru	Spare
		3737	Spare

Table 6. Lunar Optional Mission Sequences

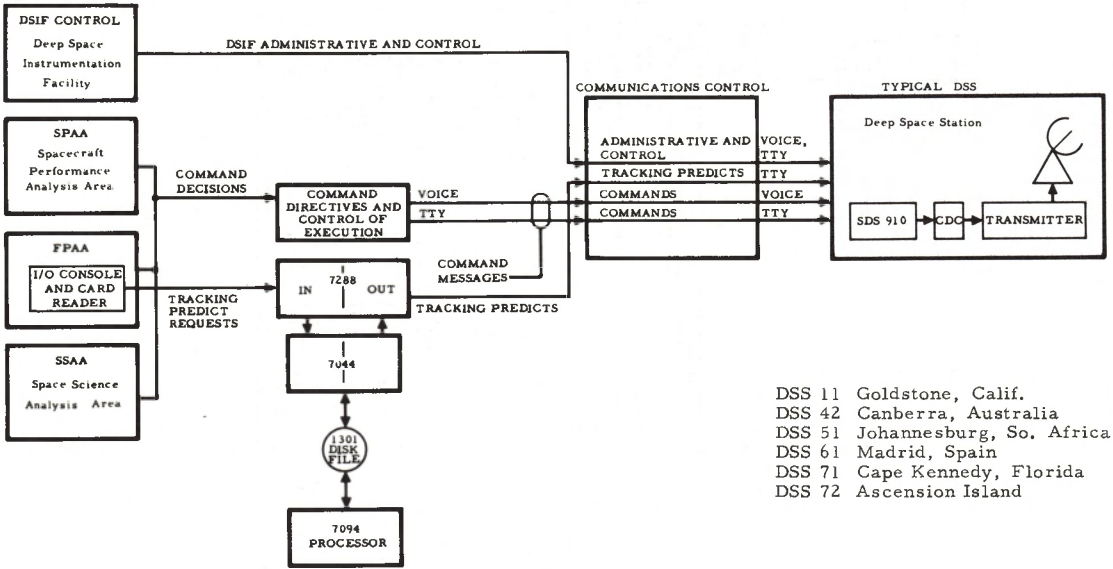
Sequence	Title
1	Pad 3-2 survey wide angle, 200 line Tape No. 101
2	360-degree wide angle panorama, 600 line Tape Nos. 201 and 202
3	Narrow angle segment survey, 600 line Tape No. 241 Tape No. 242 Tape No. 243 Tape No. 244 Tape No. 245
4	Special area surveillance, 600 line Tape No. 801 Photo chart mirror survey, 600 line Tape No. 803
5	Focus ranging profile, 600 line Tape No. 824
6	Wide angle sector survey, 600 line Tape No. 311 Tape No. 312 Tape No. 313 Tape No. 314 Tape No. 315 Tape No. 316
7	Narrow angle sector survey, 600 line Tape No. 411 Tape No. 421 Tape No. 431 Tape No. 441 Tape No. 451 Tape No. 611 Tape No. 621 Tape No. 631 Tape No. 641 Tape No. 651
8	Wide angle constant range survey, 200 line Tape No. 101
9	Surface sampler operations Tape No. 802 narrow angle-wide angle area survey Tape No. 901 SM/SS initial operations Tape No. 902 SM/SS command glossary

Lunar Optional Mission Sequences (Continued)

Sequence	Title	Sequence	Title
10	(Not to be used for Mission D)	18	Engineering interrogation to standby (major sequence 0240)
11	Solar panel/planar array positioning (major sequence 0143)	19	600 line TV to FM interrogation (high power) to 600 line TV (major sequence 0142)
12	Engineering mode to 600 line TV (major sequence 0147)	20	Standby to engineering interrogation (major sequence 0241)
13	600 line TV to engineering mode (major sequence 0146)	21	6-foot translation (major sequence 0244)
14	Engineering mode to 200 line TV (major sequence 0141)	22	Static firing (major sequence 0242)
15	200 line TV to engineering mode (major sequence 0140)	23	1-foot translation (major sequence 0243)
16	RF communications test (major sequence 0144)	24	Post-touchdown gas jet firing (major sequence 0245)
17	Telecommunications signal processing test (major sequence 0145)		

Table 7. Nonstandard Procedures Index

NSP No.	NSP Title
- 1	Landing gear/omnidirectional antenna mechanisms
- 2	Centaur separation
- 3	Flight control cruise mode
- 4	Coast phase roll control
- 5	Flight control programmer
- 6	Spacecraft-DSIF one-way acquisition
- 7	Spacecraft-DSIF two-way acquisition
-10	Solar panel positioning
-11	Conservation of battery energy
-12	Solar panel not in transit position
-13	Sun acquisition
-14	Solar panel electrical
-15	Star acquisition { Part I / Part II
-16	Planar array as roll attitude reference
-20	Flight control thrust phase midcourse velocity correction { Part I / Part II
-21	Attitude maneuvers
-25	Loss of signal from spacecraft
-26	Electrical power { Parts I and II / Parts III through VI
-27	Signal processing
-30	Terminal descent
-31	Loss of carrier upon touchdown
-32	Spacecraft revival



DSS 11 Goldstone, Calif.
DSS 42 Canberra, Australia
DSS 51 Johannesburg, So. Africa
DSS 61 Madrid, Spain
DSS 71 Cape Kennedy, Florida
DSS 72 Ascension Island

Figure 19. Data Flow to DSN

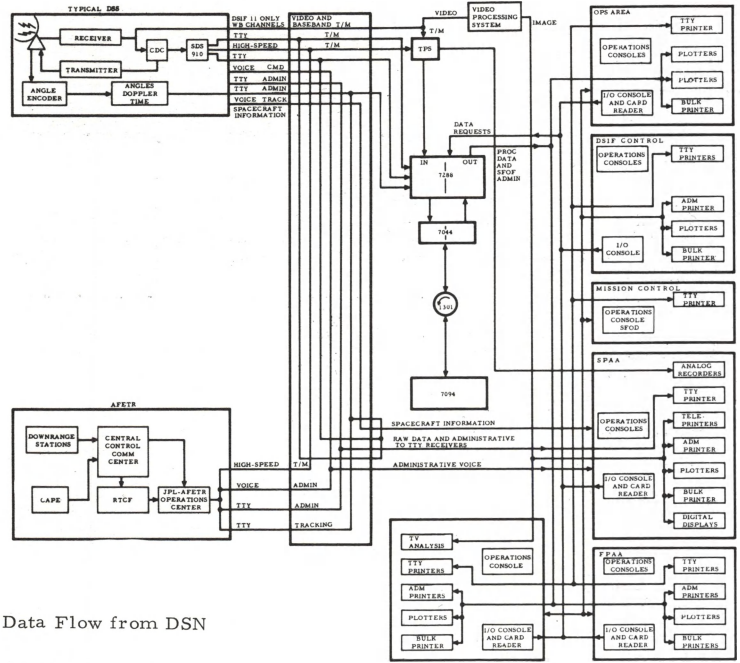


Figure 20. Data Flow from DSN

Table 8. Time Conversion Chart (DSIF)

Los Angeles/ Goldstone		Cape/AFETR		Ascension Island	Madrid	Johannesburg	Canberra
PST* 11	PDT** 11	EST* 71	EDT** 71	(GMT) 72	61	51	42
04:00	05:00	07:00	08:00	12:00	13:00	14:00	22:00
05:00	06:00	08:00	09:00	13:00	14:00	15:00	23:00
06:00	07:00	09:00	10:00	14:00	15:00	16:00	00:00
07:00	08:00	10:00	11:00	15:00	16:00	17:00	01:00
08:00	09:00	11:00	12:00	16:00	17:00	18:00	02:00
09:00	10:00	12:00	13:00	17:00	18:00	19:00	03:00
10:00	11:00	13:00	14:00	18:00	19:00	20:00	04:00
11:00	12:00	14:00	15:00	19:00	20:00	21:00	05:00
12:00	13:00	15:00	16:00	20:00	21:00	22:00	06:00
13:00	14:00	16:00	17:00	21:00	22:00	23:00	07:00
14:00	15:00	17:00	18:00	22:00	23:00	00:00	08:00
15:00	16:00	18:00	19:00	23:00	00:00	01:00	09:00
16:00	17:00	19:00	20:00	00:00	01:00	02:00	10:00
17:00	18:00	20:00	21:00	01:00	02:00	03:00	11:00
18:00	19:00	21:00	22:00	02:00	03:00	04:00	12:00
19:00	20:00	22:00	23:00	03:00	04:00	05:00	13:00
20:00	21:00	23:00	00:00	04:00	05:00	06:00	14:00
21:00	22:00	00:00	01:00	05:00	06:00	07:00	15:00
22:00	23:00	01:00	02:00	06:00	07:00	08:00	16:00
23:00	00:00	02:00	03:00	07:00	08:00	09:00	17:00
Midnight 00:00	01:00	03:00	04:00	08:00	09:00	10:00	18:00
01:00	02:00	04:00	05:00	09:00	10:00	11:00	19:00
02:00	03:00	05:00	06:00	10:00	11:00	12:00	20:00
03:00	04:00	06:00	07:00	11:00	12:00	13:00	21:00

*Standard times – Last Sunday of October to last Sunday of April.

**Daylight Savings times – Last Sunday of April to last Sunday in October.

To find time in another zone, read across (left or right) from time in your zone.

Commonly Used Surveyor Terminology

ACE-1	SFOD
ADM	Administration
AFETR	Air Force Eastern Test Range
AMR	Altitude marking radar
A/SPP	Antenna/solar panel positioner
BECO	Booster engine cutoff (Atlas)
Bus Chief	SPAC Director
Bus-1	SPAC Command Controller
CDC	Command and data handling console
Comm____	Station____TTY operator
CP	Command preparation
Dacon	Data processing project engineer
DOP	Detailed operating procedure
DSIF	Deep Space Instrumentation Facility
DSN	Deep Space Network
DSS	Deep Space Station
DSS 11	Goldstone, Calif.
DSS 42	Canberra (Tidbinbilla), Australia
DSS 51	Johannesburg, So. Africa
DSS 61	Madrid (Robledo), Spain
DSS 71	Cape Kennedy, Florida
DSS 72	Ascension Island
Duce-1	Assistant SFOD
ECPO	Engineering Computer Program Operations
FPAA	Flight Path Analysis Area
FPAC	Flight Path Analysis and Command Group
GAP Test	Guidance autopilot tests
GMT	Greenwich Mean Time (Z, Zulu)
HRM	Hughes Resident Manager
HSDL	High speed data line
L	Time relative to launch
LOX	Liquid oxygen (LO_2)
LH_2	Liquid hydrogen
M	Time relative to midcourse thrust execution
M/C	Midcourse
MDE	Mission dependent equipment
MECO	Main engine cutoff (Centaur)
MES	Main engine start (Centaur)

Glossary (continued)

MIE	Mission independent equipment
Nominal	A value assigned for convenience
NSP	Nonstandard procedure
Omni	Omnidirectional antenna
OSDP	On-site data processor
P	Pitch (around the X axis)
PA	Performance analysis
PAL	Performance analysis leader
R	Roll (around the Z axis); Time relative to retro firing
RADVS	Radar altimeter and doppler velocity sensor
RSC	Range Safety Command
RTCF	Real-time computing function
SCP	Surveyor command preparation
SECO	Sustainer engine cutoff (Atlas)
Selenographic	Having to do with the moon
SFO	Space Flight Operations
SFOD	Space Flight Operations Director
SM/SS	Soil mechanics/surface sampler
SOC	Surveyor Operations Chief
SOCP	Surveyor on-site computer program
SOE	Sequence of events
SPAA	Spacecraft Performance Analysis Area
SPAC	Spacecraft Performance Analysis and Command Group
Squib	Explosive device
SRT	Systems reliability test
SSAA	Space Science Analysis Area
SSAC	Space Science Analysis and Command Group
T	Time prior to launch (countdown)
TD	Touchdown
T/D	Terminal Descent
T-FAG	Trend and Failure Analysis Group
TIM	Tracking Instruction Manual
TLM, T/M	Telemetry
TPS	Telemetry Processing Station
Track	DSS Net Controller
Track Chief	DSS Track Chief
Track Comm	SFOF Track Area Communications Operator
TTY	Teletype
VECO	Vernier engine cutoff
VOS	Voice of Surveyor (JPL running commentary)
Y	Yaw (around the Y axis)