TR-465
October 24, 1966

JOHN F. KENNEDY SPACE CENTER

ATLAS/AGENA-18

LUNAR ORBITER B

OPERATIONS SUMMARY

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AGENA Operations Branch, KSC-ULO

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[redacted]

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MISSION

A. MISSION OBJECTIVES

The primary objective of the Lunar Orbiter program is to obtain topographic data with regard to the lunar surface for use in the selection and confirmation of landing sites for the Apollo mission. This information will also help determine landing vehicle configuration and verify vehicle design. Each flight will provide guidance refinement for succeeding flights of Lunar Orbiter and other spacecraft. These flights will also extend scientific knowledge of the moon's surface, its size and shape, properties of its gravitational field, and lunar environmental data.

Additional specific mission objectives of the Lunar Orbiter program are as follows:

1 To improve the knowledge of the lunar topography and geology in areas within and outside the Apollo area of interest.

2 To provide trajectory information which will improve the definition of the lunar gravitational field.

3 To provide measurements of micrometeoroid and radiation flux in the lunar environment for spacecraft performance analysis.

B. LAUNCH VEHICLE AND SPACECRAFT DESCRIPTION

1. Launch Vehicle. The spacecraft will be placed into orbit by a two-stage ATLAS/AGENA launch vehicle, (ATLAS/AGENA No. 18).

The first stage of the launch vehicle is a General Dynamics/Convair (GD/C) ATLAS booster which is approximately 70 feet in length and 10 feet in diameter. Maximum overall width of the ATLAS across the flared engine nacelles is 16 feet. Propulsion of the ATLAS is provided by an MA-5 Rocketdyne engine group consisting of a booster engine with two thrust chambers, a sustainer engine, and two vernier engines. All are single-start, fixed thrust, liquid propellant engines which provide a combined thrust of 388,340 pounds. Liquid oxygen and RP-1 are used as propellants. Guidance for the ATLAS is provided by the ATLAS flight control subsystem and a General Electric (GE) Mod III ground-based radio command system operating in conjunction with a Burroughs ground-based computer. Velocity and position computations performed by the computer provide the necessary vehicle guidance commands.

The second stage is a Lockheed Missiles and Space Company (LMSC) AGENA which is approximately 23 feet in length and 5 feet in diameter. Propulsion for the AGENA is provided by a Bell Aerospace Company liquid propellant engine. The engine uses unsymmetrical dimethylhydrazine (UDMH) as fuel and inhibited red fuming nitric acid (IRFNA) as the oxidizer to generate a thrust of 16,000 pounds with a burn time of approximately 240 seconds in either one continuous burn or two separate burns. AGENA guidance is provided by a preprogrammed autopilot system using horizon sensors and a velocity meter cutoff.

2. Spacecraft. The Lunar Orbiter spacecraft has a nominal weight of 845 pounds and is designed to be mounted within an aerodynamic nose shroud on top of the ATLAS/AGENA launch vehicle. During launch, the solar panels are folded under the spacecraft base and the antennas are held against the side of the structure. In this configuration, the spacecraft is approximately 5 feet in diameter and 5.5 feet long. With the solar panels and antennas deployed, after injection into the translunar trajectory, the maximum span is increased to approximately 18.5 feet along the antenna booms and 12 feet across the solar panels.

The following subsystems are contained in the Lunar Orbiter spacecraft:

a. Photo Subsystem. The photo subsystem is housed in a pressurized thermal controlled container. The subsystem includes pressure makeup assembly, camera, lens, film storage, development, and readout equipment designed to expose, develop, and read out images for transmission to earth via the communications subsystem.

b. Power Subsystem. Solar panels develop all necessary electrical power during the spacecraft maneuvers or occultation of the sun. Electrical power is supplied by a 28-volt rechargeable nickel-cadmium storage battery. Power regulators and controllers protect the solar panels, battery, and spacecraft subsystems from unusual power fluctuations. The number of solar cells provided allows for the possibility that some cells may fail or be damaged by micrometeoroids during the mission.

c. Communications Subsystem. Reception of command messages and transmission of photographic, performance, and lunar environmental data are accomplished by the spacecraft communications subsystem. The communications subsystem also provides doppler and ranging signals used by the DSIF for tracking purposes.

All incoming signals are received by the low gain antenna. The transponder automatically responds to the RF carrier and range code to assist the Deep Space Stations (DSS) in obtaining doppler tracking and range data. Commands from the DSS are routed to the command decoder and stored. The command, as received, is retransmitted to earth where it is checked for accuracy. If verified an execute command is transmitted to the spacecraft and the information stored in the decoder is advanced to the flight programmer.

Performance telemetry data and data gathered by radiation and micrometeoroid sensors will be encoded, multiplexed, and transmitted to earth continually by means of the low gain antenna and low power transmitter. Whenever photographic data are to be transmitted, the photo subsystem readout mechanism and traveling wave tube amplifier (TWTA) must be turned on by command from earth. The photographic data are transmitted via the high gain antenna.

d. Attitude Control Subsystems (ACSS). Throughout all phases of the mission, the spacecraft attitude is accurately controlled. The sun-Canopus reference attitude provides optimum utilization of solar radiation for spacecraft power and serves as the reference attitude for spacecraft maneuvers. In establishing and maintaining this attitude a sun sensor controls rotation about the pitch and yaw axes and a star tracker controls rotation about the roll axis. Signals from these sensing devices control N_2 gas ejection from attitude control jets to acquire and maintain the necessary spacecraft orientation.

Gyros in the inertial reference unit maintain attitude whenever the sun or Canopus is hidden. When other attitudes are required, a command from a DSS will provide the exact rotation required around each axis and outputs from the rate gyros enable the flight programmer to determine when the new attitude has been reached. The gyros then control the new attitude.

Using a 2688-bit magnetic core memory and 600 microelectronic logic circuits, the highly flexible flight programmer provides spacecraft time, performs computations and comparisons, and controls 120 spacecraft functions through real time, stored, and automatic program modes. A work length of 21 bits and a bit rate of 2.4 kc is used. The unit is capable of controlling all spacecraft functions for extended periods without ground instruction, thus minimizing ground-to-space communications. Access to any word in the 128-word memory is possible from earth during flight, and reprogramming spacecraft events and/or time of execution can be accomplished anytime that the spacecraft is in RF sight. The use of address modification and memory subroutines has resulted in reduced memory storage requirements.

e. Velocity Control Subsystem. The motor consists of two oxidizer tanks, two fuel tanks, and a liquid propellant rocket engine. The propellants utilized are nitrogen tetroxide and aerozine 50. During thrust, the velocity change, as detected by a spacecraft accelerometer, is compared with requirements stored in the flight programmer to determine thrust duration. When the flight programmer commands the rocket engine valves to open, gas pressure, acting on propellant tank bladders, forces the fuel and oxidizer into the engine. No ignition system is required because the propellants ignite when mixed, and thrust will continue until the engine valves are closed. Although the spacecraft trajectory is established by the ATLAS/AGENA launch vehicle, minor changes to the translunar trajectory and the velocity changes required for orbital insertion must be accomplished by the spacecraft. An attitude maneuver establishes the direction of thrust.

f. Structure and Mechanisms. The basic spacecraft structure is of tubular truss design below the tank deck and a semi-monocoque stiffened sheetmetal structure above. Internal equipment is mounted within the frame. Hinged to the lower base are four solar panels, a 3-foot diameter high gain antenna, and a low gain antenna which deploy after injection into the translunar trajectory. In the deployed configuration, the antennas and solar panels are approximately perpendicular to the spacecraft centerline.

C. MISSION PLAN

1. Launch Windows. The applicable Lunar Orbiter launch windows (to the nearest minute) are listed in table 1.

Table 1. Launch Windows

Date	Open (EST)	Closed (EST)
November 6, 1966	1758	2035
November 7, 1966	1923	2159
November 8, 1966	1950	2249
November 9, 1966	2005	2341
November 10, 1966	2058	0040 (11/11/66)

2. Winds.

a. Surface Winds. The maximum allowable recorded surface winds for the Lunar Orbiter vehicle with the service tower removed are listed in table 2. Maximum winds indicated are for an anemometer height of approximately 90 feet above ground and will vary with LOX tank ullage pressure. Gantry tower replacement must be performed if ground winds exceed the limits listed.

b. Upper-Air Wind Shear. The Lunar Orbiter launch vehicle has upper-air wind shear limitations which are complicated by factors dependent upon amplitude, rate of shear, duration of shear, and air density. LMSC-Sunnyvale uses a digital computer program that can evaluate these shear limitations versus vehicle bending moment and control capabilities. The computer response serves as the basis for the determination of the Go/No Go recommendation required for launch. The launch -2 and launch -1 day forecasts, acquired by Rawinsonde technique for the interval from 0-80,000 feet in 2,000-foot increments, will be relayed from Detachment 11, 4th Weather Group, Patrick AFB to the LMSC OCB where the data is key punched and transmitted via Type 103A dataphone to the Computer Operations Center, LMSC/SV. FPS-16/ Jimsphere wind data balloon soundings will also be taken for the interval, surface to 15.3 km in 25-meter increments with the balloon released at T-10, T-4.5 and T-3 hours with an additional sounding at T-0. These data will be transmitted from KSC Central Instrumentation Facility (CIF) to the LMSC/SV Computer Operations Center via Type 202A dataphone. The resultant recommendation derived from the computer process is relayed to the Flight Operations Center (SV) and transmitted by datafax and hotline to LMSC Hangar E Operations Center for relay to the LMSC Test Conductor. The procedure to be used which outlines the data transmission times and sequence of operations should be in accordance with LMSC-A084887-D, Revision 6, NASA Program/ETR Launch Wind Shear Recommendation Procedure, dated 13 May 1966.

3. Launch Vehicle Requirements.

a. ATLAS. The following constraints and criteria apply to the ATLAS vehicle. All inline subsystems and the MOD III guidance system must be operational at launch. Countdown limits and instrumentation criteria must be in accordance with the latest revisions to GD/C document 69-00703-1, Test Parameters, SLV-3. The telemetry system must be operational in accordance with telemetry ground rules delineated in GD/C document BKE65-015, Flight Plan and Instrumentation Summary for ATLAS SLV-3 used for the Lunar Orbiter Program at ETR.

b. AGENA. Landline measurements of subsystem operating parameters will be monitored during the countdown. Deviations from the limits, as stated in the latest revision of LMSC document A815464, NASA/AGENA Program Launch and Hold Limitations for Lunar Orbiter/AGENA SS-01B Vehicles (6630 and up), will be cause for holding the countdown to investigate the discrepancy.

Table 2. Maximum Allowable Surface Winds

Tank Conditions		Wind Velocity Redline (mph)	Remarks
Fill	Lox Tank Pressure (psig)		
SLV-3 and AGENA empty	4.0 4.7 min	30.7 max. 31.9 max.	Separation fittings critical
SLV-3 fueled and AGENA empty	4.0 4.6 6.0	31.0 max. 32.6 max. 36.2	
SLV-3 full and AGENA empty	4.0 min.	40.0	Launcher critical
SLV-3 and AGENA fueled	4.0 4.5 min.	38.8 40.0	
SLV-3 fueled AGENA full	4.0 5.2 min.	35.5 40.0	
SLV-3 and AGENA full	4.0 min.	40.0	

At any time during the countdown prior to T-60 minutes, either loss or indication of malfunction in telemetry channels 9, 12, 13, 14, 15, and 16 will be reason to investigate the cause and consult immediately with the cognizant engineer to establish the action to be taken.

From T-60 minutes to liftoff, proper operation of telemetry channels 14, 15, and 16 landline, and C-band transponder equipment must be verified prior to launch.

4. Spacecraft Requirements. All spacecraft subsystems must be functioning properly prior to launch as required by the operational parameters of the F-0 day countdown. In addition, spacecraft telemetry required for the conduct of inflight operations must be in an operational status at the time of launch.

5. Tracking and Telemetry Requirements for Launch. The mandatory tracking and telemetry coverage for the Lunar Orbiter launch reflect the minimum essential requirements necessary to insure accomplishment and/or verification of the Lunar Orbiter mission.

a. Class I Metric (Launch Vehicle) Tracking Requirements

1 From liftoff to AGENA first burn cutoff plus 10 seconds.

2 Any 60 seconds of continuous tracking between AGENA first cutoff and second ignition (above 5° elevation angle).

3 Any 60 seconds of continuous tracking between AGENA second cutoff and start of retromaneuver (above 5° elevation angle).

4 Any 60 seconds after completion of AGENA retromaneuver.

b. Class I Metric (DSN) Tracking Requirements

1 From first AGENA cutoff to first AGENA cutoff plus 60 seconds.

2 Any continuous 60 seconds between transfer orbit injection and AGENA retro ignition.

3 Any continuous 60 seconds after completion of AGENA retromaneuver.

c. Class I Launch Vehicle Telemetry Requirements.

1 From T-2 minutes to AGENA first cutoff plus 25 seconds.

2 From AGENA second ignition minus 20 seconds to second cutoff plus 20 seconds.

3 From AGENA/spacecraft separation minus 10 seconds to AGENA/spacecraft separation plus 10 seconds.

4 From AGENA retro ignition minus 10 seconds to AGENA retro cutoff plus 10 seconds.

d. Class I Spacecraft Telemetry

1 From launch to AGENA first cutoff plus 20 seconds.

2 From AGENA second ignition minus 20 seconds to AGENA second cutoff plus 20 seconds.

3 From AGENA/spacecraft separation minus 10 seconds to AGENA/spacecraft separation plus 18 minutes or to DSS 51 rise plus 5 minutes whichever occurs earlier.

6. Flight Plan. The ATLAS/AGENA No. 18 launch vehicle will be launched from Complex 13 of the Eastern Test Range (ETR) on a variable launch aximuth of 66 to 114 degrees and will place the AGENA and Lunar Orbiter spacecraft into a 100 nautical mile circular parking orbit. After the correct coast period, the AGENA second burn will inject the Lunar Orbiter spacecraft into the desired translunar trajectory. Near lunar encounter the spacecraft deboost maneuver will inject the spacecraft into an elliptical intermediate orbit about the moon. A subsequent spacecraft maneuver will adjust the perilune altitude from approximately 200 kilometers to approximately 46 kilometers. A nominal sequence of flight events is listed in table 3.

D. POST INJECTION OPERATIONS

1. DSIF. Following DSIF acquisition, which should occur shortly after injection of the spacecraft into its translunar trajectory, the Deep Space Network (DSN) has the responsibility for both tracking and telemetry coverage.

a. Tracking. Sufficient tracking data consisting of a minimum of 1 hour of S-band doppler (two-way lock) from each of two stations must be available at the Space Flight Operations Facility (SFOF) by launch plus 5 hours to determine the trajectory. From plus 5 hours to the end of the photo mission, continuous 2-way doppler is required whenever the spacecraft is in view of the earth, except during video readout.

b. Telemetry. Spacecraft telemetry must be available at the SFOF in near-real time from launch to the end of the photo mission. Command capability from the DSN to the spacecraft must also be available from launch to the end of the photo mission.

Table 3. Nominal Sequence of Flight Events

Event	T+Sec	Min:Sec	Initiated By
Liftoff	T+0	00:00	2-inch rise switch
Start roll program	T+2	00:02	ATLAS programmer
Start booster pitch program	T+15	00:15	ATLAS programmer
Enable guidance steering	T+80	01:20	ATLAS guidance discrete
BECO	T+129.0	02:09.0	ATLAS guidance discrete
Jettison booster	T+132.1	02:12.1	ATLAS guidance discrete
G.E. steering enable	T+138.1	02:18.1	ATLAS guidance discrete
Start AGENA restart timer	T+250.7 (variable)	04:10.7	ATLAS guidance discrete
SECO	T+287.2	04:47.2	ATLAS guidance discrete
Start AGENA sequence timer	T+290.6 (variable)	04:50.6	ATLAS guidance discrete
VECO	T+307.5	05:07.5	ATLAS guidance discrete
Jettison nose fairing	T+309.5	05:09.5	ATLAS guidance discrete
ATLAS/AGENA separation	T+311.5	05:11.5	ATLAS guidance discrete
AGENA first burn ignition*	T+364.5	06:04.5	AGENA D-timer
AGENA first burn cutoff*	T+516.8	08:36.8	Velocity meter
AGENA second burn Ignition*	T+1315.0	21:55.0	AGENA D-timer
AGENA second burn cutoff*	T+1401.5	23:21.5	Velocity meter
Payload separation*	T+1567.7	26:07.7	AGENA D-timer
AGENA retromaneuver*	T+2167.7	36:07.7	AGENA D-timer

* T+ times for these events are variable.

2. Data Handling.

a. Tracking Data. Each DSS will provide on-site recording of trajectory data and will transmit this data to the SFOF in realtime via teletype. If possible, critical injection or transfer maneuvers will be scheduled during periods of simultaneous view by two DSS's, and three-way doppler data will be acquired.

b. Spacecraft Performance. Telemetry on S-band carrier will be provided to the SFOF continuously in real time or near-real time. Data will be used to permit evaluation of specific spacecraft conditions, and provide for control of the spacecraft to attain mission objectives.

c. Video Data. Video data demodulated from the S-band carrier will be processed by the ground reconstruction equipment at the DSS receiving the signal. When it has been reduced to the proper form, it will be photographed.

d. Command and Control Data. Spacecraft command will normally be generated at the SFOF and transmitted to the appropriate DSS. The DSS, following an established procedure, will transmit the commands to the spacecraft for execution.

SECTION II
LAUNCH OPERATIONS PLAN

A. OPERATIONAL AREAS

1. Blockhouse. All Lunar Orbiter launch vehicle and pad operations during the launch countdown are conducted from the blockhouse at Complex 13 by the Launch Conductor. Countdown readiness and status of the ATLAS and AGENA stages are the responsibility of the appropriate contractor Test Conductors. The Spacecraft Coordinator in the blockhouse controls spacecraft activities and reports on the countdown readiness and status of the spacecraft of the spacecraft to the Launch Conductor. Overall management of launch operations is the responsibility of the Operations and Launch Director. The Test Controller functions as the official contact between test personnel and the ETR.

2. Buildings AE and AO. For the Lunar Orbiter mission, major operational areas are located at Building AE (figure 1) and Building AO. These operational areas are the Vehicle Director Center (VDC), (figures 2 and 3), Launch Vehicle Telemetry Ground Station, and Mission Operations Center (MOC) in Building AO.

a. Vehicle Director Center. During Lunar Orbiter launch operations launch vehicle activities are monitored by the Vehicle Project Manager in the VDC. From this monitor post, he is informed and monitors flight readiness of the vehicle and spacecraft. Appropriate prelaunch and real time launch data are displayed to provide a presentation of vehicle launch and flight progress. The VDC also functions as an operation communications center during the final launch countdown.

The front of the center consists of large illuminated displays. The center of the display contains two plotting boards for displaying doppler and Present Position (PP) or Instantaneous Impact Plots (IIP). The doppler plot is a real time graph of the frequency shift of the spacecraft RF carrier recorded by the ULO Satellite Tracking Station (STS). This display, when plotted with the theoretical plot gives an excellent overall picture of the launch vehicle's velocity performance.

Other displays include a personnel locator, a list of tracking stations, Range radars used, and a sequence of events after liftoff. Twelve consoles in the VDC provide two-way communications with any area associated with the launch.

The following information will be displayed in the VDC during Lunar Orbiter launch operations:

(1) Real time vehicle progress (this information is derived from vehicle telemetry)

(2) Doppler plot and present position plot

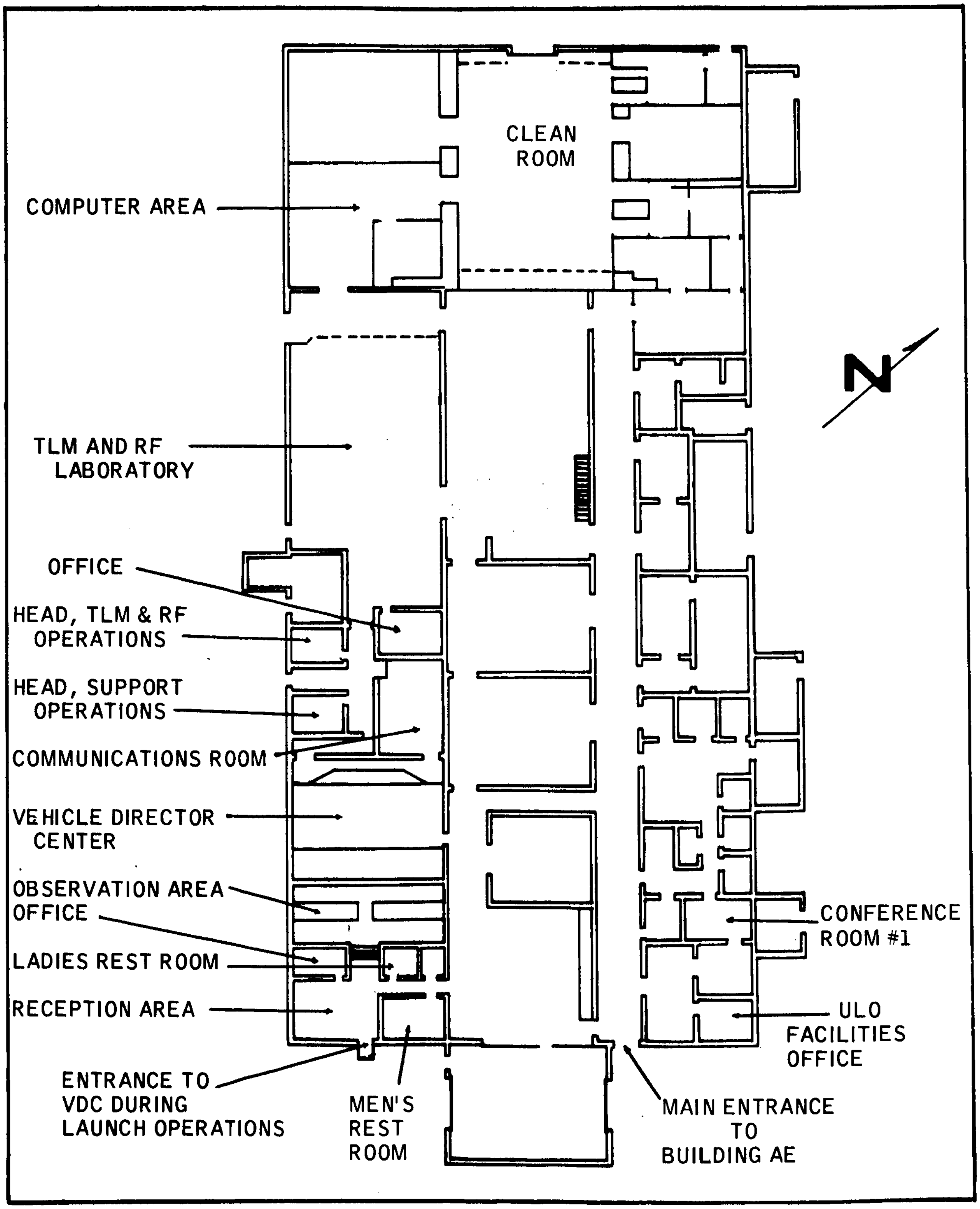

Figure 1. Building AE

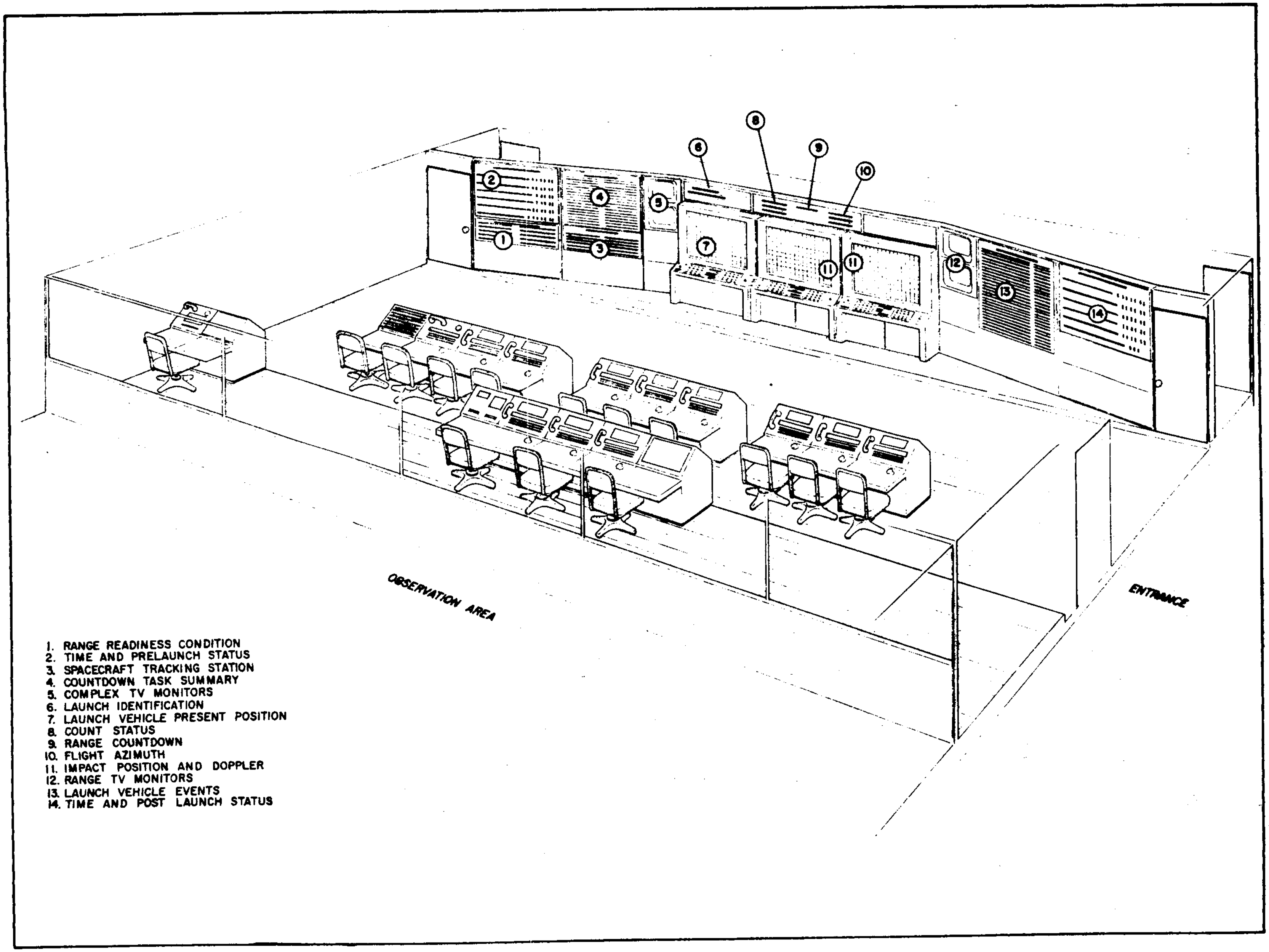

Figure 2. Vehicle Director Center

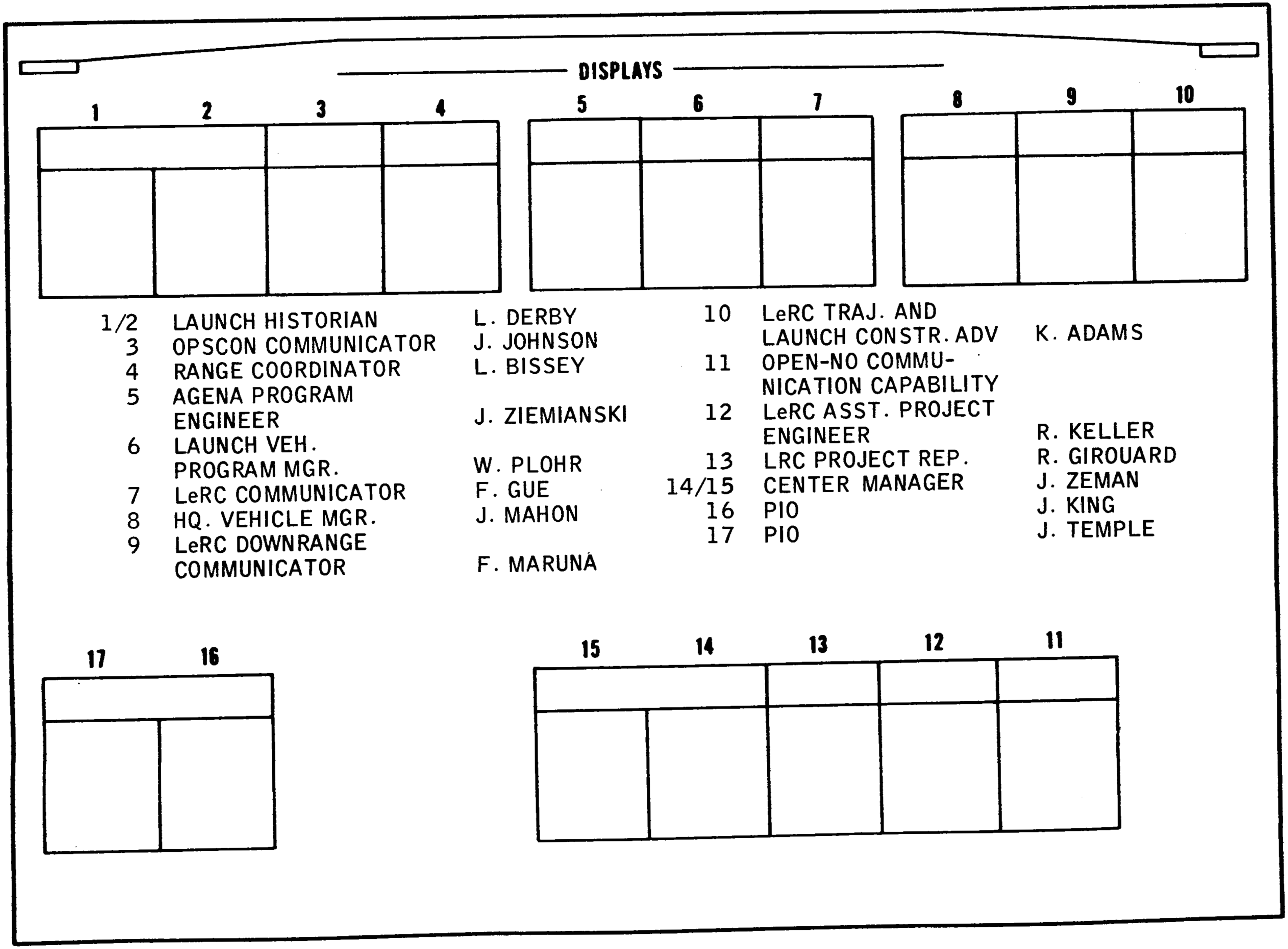

Figure 3. Vehicle Director Center Seating Arrangement

(3) Tracking station readiness

(4) Range readiness

(5) Guidance readiness

(6) Flight line and program television

(7) Range Count

(8) Eastern Standard Time (synchronized to WWV)

(9) Greenwich Mean Time (synchronized to WWV).

The display coordinator monitors communication circuits from outlying data stations in order to display events as they occur.

b. Launch Vehicle Telemetry Ground Station. The Launch Vehicle Telemetry Ground Station receives, monitors, and records launch vehicle signals during prelaunch checkout to assist in determining vehicle launch readiness. After liftoff, real time analysis of telemetry data will be used to aid in displaying vehicle performance in the VDC.

c. Building AO-MOC. Overall direction and coordination of the mission launch operations are conducted from the Mission Operations Center (MOC). Status of all support areas, including DSN, AFETR, and Manned Space Flight Net tracking and telemetry stations and ships is displayed on the master control board. During the countdown and launch operations, the Mission Director and other project office management personnel will be located in the MOC where they will be kept informed of countdown and launch status of all space vehicle systems and all participating support facilities. Program monitoring remains with the MOC until acquisition of the spacecraft by DSN, at which time the Mission Director and other key project personnel will be transferred by aircraft to the Space Flight Operations Facility (SFOF) at Pasadena.

3. Satellite Tracking Station. The Satellite Tracking Station (STS) is the prime doppler tracking facility used for missions at the ETR. In addition to doppler tracking, the STS can receive telemetry and interferometer data. The STS also provides prelaunch spacecraft checkout support including frequency and power measurements, and telemetry acquisition

During launch, the STS will record and measure the spacecraft RF carrier frequency shift (doppler data) to aid in evaluating the velocity performance of the ATLAS/AGENA vehicle. This real time launch phase doppler data will be transmitted to the VDC in Building AE for display. In addition, STS downrange equipment located at Antigua will be used to relay real time doppler data to the STS for transmission to the VDC.

4. DSS-71. The spacecraft countdown will be conducted from this facility. Flight readiness checks, programmer memory loading, and verification of all systems will be accomplished during this prelaunch phase. AFETR launch and spacecraft telemetry which is obtained via AGENA channel F will be received by the mission dependent equipment (MDE) at DSS-71 and after being processed, will be sent to the SFOF at Pasadena.

5. Central Control. Overall management of ETR range support is provided by the Superintendent of Range Operations (SRO) at Central Control (CC). ETR personnel stationed in this facility coordinate Range activities and instrumentation operations required to support Lunar Orbiter launch operations. A ULO project official is stationed at Central Control throughout the launch operation to maintain liaison with Range personnel. The ETR Range Safety Officer (RSO) is also located in Central Control.

6. Guided Missile Control Facility No. 1. Prelaunch checkout of the ATLAS radio command guidance system is conducted by the Guidance Test Conductor at Guided Missile Control Facility No. 1 (GMCF 1). After liftoff, during portions of the ATLAS powered flight, present position and velocity information from the GE Mod III Ground Station is compared with programmed trajectory data stored in the Burroughs guidance computer at GMCF 1. If the vehicle is not traveling the desired course, the computer generates guidance commands which are transmitted to the vehicle via the GE Mod III Ground Station.

B. KEY PERSONNEL

Blockhouse

Launch Director	R. H. Gray
Assistant Launch Director	H. Zweigbaum
Chief Engineer	F. R. Searle
Test Controller	F. C. Drury
Spacecraft Coordinator	J. E. Weir
LOPO Representative	J. B. Lovell

Vehicle Director Center

Launch Vehicle Project Manager	H. W. Plohr
AGENA Program Engineer	J. Ziemianski
LeRC Assistant Project Engineer	R. Keller
Headquarters Vehicle Program Manager	J. B. Mahon
Center Manager	J. Zeman
LeRC Trajectory and Launch Constraint Advisor	K. Adams
LeRC Downrange Communicator	F. Maruna
OPSCON Communicator	J. W. Johnson
LeRC Communicator	F. E. Gue
LRC Project Representative	R. L. Girouard
Range Coordinator	L. J. Bissey

Central Control

Superintendent of Range Operations	G. W. Henry
Project Representative	W. E. Paramore
Assistant Project Representative	F. J. Stevens
Range Safety Monitor	A. C. Litherland
LOPO Representative	G. R. Egan
Cape Network Coordinator (GSFC)	G. E. Tolson

Mission Operations Center - (Building AO)

Mission Director	C. H. Nelson
Mission Operations	D. A. Ward
Mission Coordinator	W J. Boyer
Mission Analyst	E. B. Lightner
Flight Analyst (JPL)	J. Reuyl
Operations Center Coordinator	R. M. Grace
Status Coordinator	P. W. Barnum

DSS-71

Spacecraft Test Manager	I. W. Ramsey
Spacecraft Test Conductor (TBC)	J. Stansell
Spacecraft Communications Subsystem	C. H. Green

Telemetry Ground Station

Station Manager	A. J. Mackey

Tel-4	R. O. Buck

C. DATA ACQUISITION

Telemetry optical and radar data will be provided by equipment located at Cape Kennedy (ETR Station 1), by ETR downrange instrumentation sites (refer to figure 4), and by the Manned Space Flight Net (MSFN) instrumentation stations during the prelaunch, launch, and injection phases of the Lunar Orbiter mission.

1. Telemetry. During launch operations airborne telemetry data will be acquired by four Cape ground stations in real time and on magnetic tape. During flight, telemetry will be recorded by ETR downrange stations, ships, aircraft, and MSFN stations.

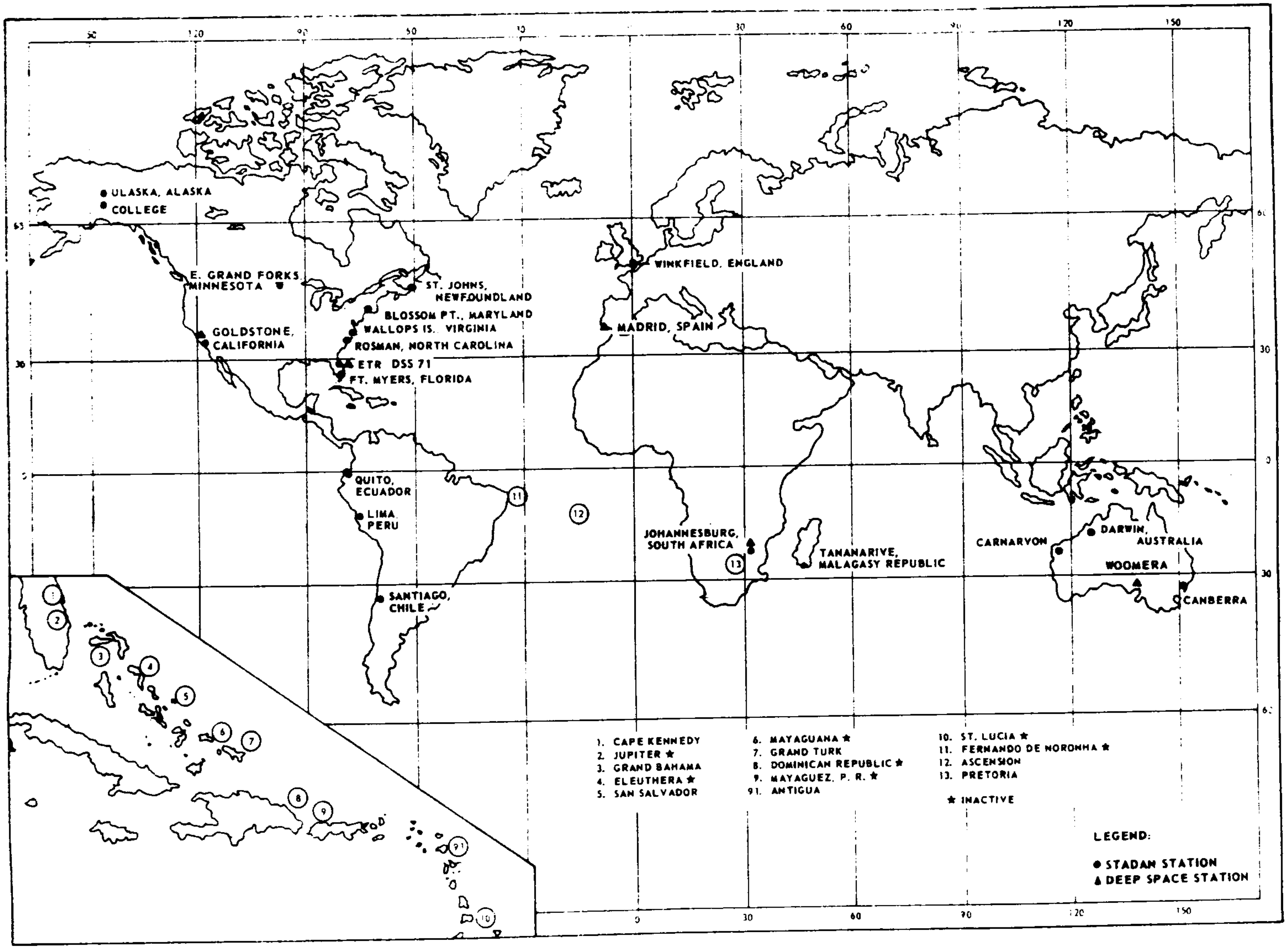

Figure 4. Tracking and Control Stations

a. Uprange Telemetry.

(1) Tel-4. Cape Telemetry Station 4 (Tel-4) is the principal ETR telemetry receiving station and will monitor in real time five commutated and all continuous channels from the ATLAS stage and two commutated and all continuous channels from the AGENA stage. Spacecraft telemetry received via the AGENA link on Channel F is to be retransmitted to DSS-71 for real time and backup retransmission to SFOF. Spacecraft S-band telemetry is to be recorded on magnetic tape.

(2) Building AE. The Building AE ground station will principally concentrate on the AGENA performance in real time and provide playback of all other data for evaluation on a timely basis. The Building AE station will record on magnetic tape for all times the systems are radiating. AGENA telemetry (narrow-band, 3-40 kc) as received at ETR stations through Antigua Island will be provided in real time at Building AE, for display of AGENA functions also.

(3) Hangar J. The GD/C telemetry stations in Hangar J will provide support as required in monitoring and recording ATLAS telemetry data.

(4) Hangar E. The LMSC telemetry station in Hangar E will provide support as required in monitoring and recording AGENA telemetry data to determine flight readiness of the AGENA. AGENA telemetry (narrow band, 3-40 kc) as received at ETR stations through Antigua will be provided in real time at Hangar E.

b. Downrange Telemetry.

(1) AFETR Stations. Class 1 requirements for telemetry placed on the ETR are from T-120 seconds to AGENA first burn cutoff plus 25 seconds, from AGENA second ignition minus 20 seconds to second ignition plus 20 seconds, from AGENA/spacecraft separation minus 10 seconds to AGENA/spacecraft separation plus 10 seconds, and from AGENA retro ignition minus 10 seconds to AGENA retro cutoff plus 10 seconds. Spacecraft data received via the AGENA link Channel F will be retransmitted from ETR stations to DSS-71 for real time and backup transmission to the SFOF.

(2) MSFN Stations. The MSFN stations at Bermuda, Grand Canary Islands, Kano, Tananarive, and Carnarvon, will receive and record AGENA telemetry from acquisition to Loss of Signal (LOS) of each station depending on the launch azimuth.

(3) Ships and Aircraft. Three ships and two aircraft will be used by ETR in the Atlantic Ocean area. Ships and aircraft will record telemetry data. Ships will also retransmit spacecraft data received via AGENA link Channel F to DSS-71.

2. Optics.

a. Land Bases.

(1) Metric. Six fixed cameras (ribbon frame) located on Complex 13 will provide position and time derivatives from liftoff to T+27 seconds. Five cinetheodolites at Station 1 will provide position data and time derivatives from T+23 seconds to T+120 seconds. The cinetheodolites will track from first acquisition to Loss of Vision (LOV). One metric tracking camera will provide relative roll from liftoff to T+15 seconds.

(2) Engineering Sequential. Nineteen fixed engineering sequential cameras will provide coverage from T-4 minutes to T+10 seconds. Four long focal length cameras (MITTS, ROTI, IGOR) will be tracking from acquisition through LOV. Three tracking engineering sequential cameras will provide coverage from liftoff until LOV.

b. Airborne. The NKC-135 Airborne Light Optics Tracking System (ALOTS) aircraft is expected to be available to support this launch on an engineering test basis and scheduled separately. The instrumentation includes a Range timing station and the ALOTS. The primary function of ALOTS is photo coverage in the high dynamic pressure region shortly after space vehicle liftoff and the first staging event.

3. Tracking.

a. AFETR Radar. ETR C-Band radars 0.18 Patrick AF Base, 1.16 CKAFS, 19.18 KSC, 3.18 and 3.16 Grand Bahama, 7.18 Grand Turk, 19.18 Antigua, 12.16 and 12.18 Ascension, and 13.16 Pretoria, will use beacon and/or skin track to provide vehicle position and velocity data, real time position and velocity information for Range Safety inputs to the RTCS for determination of powered flight impact prediction and post-test determination of the trajectory. One C-Band radar must be in operation at each of the downrange stations and two of the three mainland radars must be in operation. The XX.18 type radars are preferred for those stations having the capability; but the backup XX.16 type radars are acceptable where the station is so equipped.

The Class I requirement for ETR radars is from AOS when the flight is down the ETR through AGENA first burn cutoff plus 10 seconds, any 60 seconds of continuous tracking between AGENA first burn cutoff and second ignition, any 60 seconds of continuous tracking between AGENA second cutoff and start of the retromaneuver, and any 60 seconds after completion of the AGENA retromaneuver. In addition, ETR is to provide orbital elements and injection conditions and inter-range vector information during the parking orbit, pre-retro transfer orbit, and radar tracking data in real time, or near real time, to the DSN. In addition, computed acquisition data for data for selected DSN and MSFN stations are provided. Computed orbital parameters will be retransmitted by teletype from Building AO to Building AE.

b. Satellite Tracking Station. The ULO STS will track the spacecraft S-band transponder and provide doppler information for display in the VDC.

c. MSFN Radar. MSFN stations at Bermuda (BDA), Grand Canary Islands (CYI), and Carnarvon (CRO) will support the launch. Radar data from ETR stations will be transmitted through MCC-K at Telemetry 3 to Goddard Space Flight Center (GSFC) for computation of acquisition messages to BDA and CRO. Bermuda will track the C-band radar beacon from Acquisition of Signal (AOS) to LOS, record, and transmit radar data to GSFC and MCC-K. CYI will track the beacon from AOS to LOS and will record and transmit real time radar data to GSFC for computation of orbital parameters. CRO will track the beacon from AOS until released by the MSFN network controller and will record and transmit real time radar data to GSFC for computation of orbital parameters.

4. Other Data. A Preliminary Test Report (PTR) will be prepared by the Range within 2 hours after test termination.

5. Range Safety. Two video skyscreens will provide flight line and program deviation information to the Range Safety Officer at his console. These presentations are also remoted to the VDC. A wire skyscreen will be used to obtain program deviations. The electronic mobile telemetry receiving vans (Tel-ELSSE) will operate from site 12-110-F, using the 244.3 mc AGENA telemetry link. A chart presentation of flight deviation will be provided to the Range Safety Officer (RSO).

D. METEOROLOGICAL PLAN

Arrangements have been made for LMSC-ETR to receive forecast and upper-wind data directly from CKAFS Weather Station for transmittal to LMSC-SV and LeRC. The AGENA Missions Office (AMO) will provide forecast and upper-air wind data on F-3, F-2, and F-1 days to the Manager, ATLAS/AGENA Operations. The AMO representative will provide weather information to project and operations personnel on OIS Channel 17 or green phone as received.

1. Forecasts. Severe Weather Warning (SWW) notifications will be made when surface winds are forecast to exceed 35 knots steady state or in gusts, or electrical storm activity is expected within 5 nautical miles of Complex 13. All SWW forecasts will be telephoned to the Blockhouse Monitor.

2. Long Range. A forecast will be provided by 1600Z on F-3 day of the general surface conditions for the Cape Kennedy area, valid for T-0.

3. Planning. A forecast will be provided by 1600Z on F-2 day of surface conditions and upper-air winds for the Cape Kennedy area, valid for T-0. The forecast of surface conditions will include wind direction and speed, pressure, temperature, humidity, cloud cover, ceiling visibility, and precipitation. The upper-air wind forecast will predict the direction and speed for each 2,000 feet from the surface to 80,000 feet.

4. Operational. By 1600Z on F-1 day, the forecast issued on F-2 day will be modified or confirmed. At T-8.5, -3.5, and -1.5 hours, the Assistant Staff Meteorologist (ASM) will provide to the AMO Representative comments on any conditions that might affect the launch.

5. Observations. Routine surface observations will be made at hourly intervals from T-12 hours to T+1 hour, and the wind speed and direction at Complex 13 will be recorded from T-6 hours through T-0.

a. Tabulated upper-air wind data from the ETR Rawinsonde system will be provided LMSC-ETR at T-8.5, T-3.0, T-1.5, and T+1.5 hours. These data will be transferred to cards and transmitted via data phone from the LMSC Off-Site Building to LMSC-SV for computation of shear and bending moment information.

b. At T-10, T-4.5, T-3, and T-0 hours, a C-Band radar will track a Jimsphere balloon to approximately a 15.3 kilometer altitude. Data from the radar will be transmitted to the CIF Building at KSC for reduction to card format. Data phone circuits will be used to transmit card data to LMSC-SV and Lewis Research Center (LeRC). This data will also be used to compute the shear and bending moment information. Computers at LeRC and LMSC-SV will provide information from which a Go/No-Go determination can be made based on the shear and bending moment analysis. The Go/No-Go data will be provided to LeRC representatives in the VDC by telephone and datafax.

6. Minima. Ceiling and visibility minima will be as prescribed by Range Safety. Upper-air wind shear limitations which depend on shear amplitude, rate, duration, and air density will be evaluated as indicated above.

7. Consultation Services. The ETR Weather Station will provide consultation services as requested by the AMO representative in Central Control.

SECTION III
COMMUNICATIONS

A. GENERAL

The Lunar Orbiter communications facilities which will be available for support of this mission are described in this section. These facilities will be used for prelaunch operations and early postflight intercommunications. The communications center will be located in the VDC, Building AE.

B. VEHICLE DIRECTOR CENTER

The consoles in the VDC provide the assigned VDC personnel with the communications systems required to monitor and participate in vehicle and mission progress. The center's communications facilities provide the means for communicating with Cape stations (blockhouse, STS, Central Control, etc.), downrange stations, NASA Headquarters, GSFC, and the worldwide tracking stations. Communications systems available at the consoles in the VDC are described below.

1. Administrative. The black telephones used in this system are special dial phones installed in the consoles and enable VDC personnel to place or receive local and long distance calls. Individuals assigned to consoles may establish, listen to, or participate in conference calls on the black telephone system.

2. Green Telephone System. The ETR green phone system utilizes manually operated key panels at each console, limiting the number of users. This provides rapid, direct communications between all sites participating in this launch operation. The key cabinets provided for this system have both visual and audible signaling. The system has standby batteries to prevent its becoming incapacitated by commercial power failure. Table 4 shows the green telephone network for Lunar Orbiter launch operations.

3. Station Conferencing and Monitor Arrangement (SCAMA) Telephone System. The SCAMA telephones provide direct dialing contact with the GSFC SCAMA switchboard at Greenbelt, Maryland, for instantaneous long distance communications with the NASA global satellite tracking networks. SCAMA, originally designed to support the manned spacecraft network, has been extended to include the STADAN network (formerly called Minitrack), and the Deep Space Instrumentation Facilities (DSIF). SCAMA can now link any combination of 51 communications points in NASA's global satellite tracking networks.

4. Operational Intercommunications System (OIS). The OIS is a Range intercom system which operates on a channel select basis rather than on an individual station-to-station basis. (This system was formerly called the MOPS network and most consoles still display that designation. The designation MOPS and OIS are synonymous.) All related operating positions, such as those for telemetry, are connected in parallel and

Table 4. Green Telephone Network

	Building AE, Room 125	Building AE, Room 109A	Hangar J TLM Lab	BH 13 Water Panel	Pumphouse 4	BH 13 Advisors Console	SRO	GMCF 1 ULO Rep.	GMCF 1 GE TC	GMCF 1 Data Eval.	GMCF 1 Power House	GMCF 1 Communications	GMCF 1 A-1 Computer TC	GMCF 1 A/C Room	Burroughs TC	Building AO, Room 207	DSS-71 Room 100	Tel-2 Range User Rep.	RTCF Range User Rep.	DSS-71 STC Console	DSS-71 MIAD Room	CKAFS Coord. (GSFC) CC	JPL/LRC Proj. Reps. CC	ULO Proj. Console CC	Hangar E, Room 107	AF Weather Off. RCC	Hangar E, TLM Room 108	STS
Building AE, Room 125		x	x			x																		x			x	
Building AE, Room 109A	x					x										x						x		x				x
Hangar J TLM Lab.	x																											
BH 13 Water Panel					x																							
Pumphouse 4				x																								
BH 13 Advisors Console	x	x					x	x								x	x			x				x				
SRO						x			x							x								x				x
GMCF 1 ULO Rep.						x																						
GMCF 1 GE TC							x			x	x	x	x	x	x													
GMCF 1 Data Eval.									x																			
GMCF 1 Power House									x																			
GMCF 1 Communications									x																			
GMCF 1 A-1 Computer TC									x																			
GMCF 1 A/C Room									x																			
Burroughs TC									x																			
Building AO, Room 207		x				x	x										x	x	x		x	x	x	x				
DSS-71 Room 100						x										x												
Tel-2 Range User Rep.																x				x								
RTCF Range User Rep.																x												
DSS-71 STC Console						x												x										
DSS-71 MIAD Room																x												
CKAFS Coord. (GSFC) CC																x								x				
JPL/LRC Proj. Reps. CC																x												
ULO Proj. Console CC	x	x				x	x									x						x	x		x	x		x
Hangar E, Room 107																								x				
AF Weather Off. RCC																								x				
Hangar E, TLM Room 108	x																											
STS		x					x																	x				

the end instruments may communicate only with the channels to which connected. Rotary selector switches are used to select the desired channel on all end instruments except those on consoles which use key switches. Access to individual channels may be limited to certain operators. When an operator selects a channel and talks, all other operators who have previously selected the same channel will hear him; conversely, he will hear all other operators talking on that same channel.

During the Lunar Orbiter launches, various operations are assigned specific OIS channels. Because of this assignment system and the limited number of channels available at some of the outlying stations, it is mandatory that only assigned channels be used. Table 5 shows the OIS system.

Additional range user OIS circuits for the Lunar Orbiter launch are as follows:

JPL IPP TTY Coord. Net	-RTCF/CNC/AO
Metric Data Coord. Net	-JPL/ETR at RTCF
BDA and CRO Voice	-CNC/RTCF
Tel 2 Coord. Net	-Tel 2/DSS-71
MSFN Conf. Net	-CNC (Monitor only)
MSFN Status Net	-CNC/AE/AO
NC/RCO Coord. Net	-CNC/Proj. Rep. CC/JPL Rep. CC/RCO CC
Computer Coord.	-CNC/RTCF

5. Leased Voice Circuits. Five NASCOM voice circuits between ETR and the SFOF are used for voice communication in support of the launch operations. Switching and control of stations that have access to these nets are maintained at both terminals. Operations usage of these nets is defined as follows:

a. Status Net. This net will be used to keep various SFOF stations informed of the operational status of the AFETR stations, launch vehicle, spacecraft, the mission readiness to launch, progress through the countdown, and the occurrence and time of inflight events. Stations normally active on this net are the Status Coordinator at ETR (Building AO) and the Assistant Space Flight Operations Director at the SFOF.

Table 5. OIS System

Blockhouse 13 Channel Assignment		Console and Location																										
		GMCF 1	Hangar J	Tel-4	Building AE	Hangar E	Hangar H	Hangar K	Building AO	ESA 5/6	SRO	Hangar S	DSS-71	RTCF Range User Rep	RTCF ETR Data Coord	ULO Project Console CC	LRC Project Console CC	JPL Project Console CC	GSFC Project Console CC	Tel-2 ETR Coord.	IOC	Roof Speakers CC VIP Area	ULO RSO Observer	Program Manager Console	DC/T Console	SAC Liaison Console	DTC, E & A Building	BRRS
Launch Conductor	1	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x		x	x	x			x	x
GD/C Test Conductor	2	x	x		x	x	x	x	x		x													x			x	
GD/C Propulsion	3				x																						x	
SRO	4				x				x		x					x		x						x	x	x		
GD/C RF System	5	x	x		x	x	x	x	x		x					x						x					x	
GD/C Autopilot	6				x			x																			x	
GD Guidance	7	x			x	x			x		x																x	
LMSC Test Conductor	8			x	x	x			x		x													x				
GD/C Landline	9				x																							
Complex Facilities	10				x																							
Test Stand Operator	11				x																							
LMSC Test Operations	12			x	x	x			x		x																	
LMSC Propulsion	13				x	x																						
LMSC Electrical	14				x	x																						
LMSC Guidance	15				x	x																						
LMSC Telemetry & Beacon	16			x	x	x			x		x					x	x	x	x									
NASA Engineering	17	x	x	x	x	x	x	x			x					x							x	x				
SC Test Conductor #1	18				x				x	x	x	x	x				x			x				x				
SC Test Conductor #2	19				x				x	x	x	x	x				x											
SC Operations	20				x				x	x		x	x				x											
JPL Operations	21				x				x	x		x	x			x		x										
NTC	22				x											x												
LRC Engineering	23				x				x	x		x	x				x	x										
Mission Director	24				x				x		x	x	x			x	x			x			x	x				

b. ETR/RTCC Net. This net will be used for detailed discussion pertaining to the condition and flow of tracking and computed data from AFETR to the SFOF. These discussions, pertaining to the condition and implications of the data are participated in by: the Flight Chief at the SFOF and ETR, by the JPL Data Coordinator at TRCS, the Operations Center Coordinator, Flight Analyst, and Mission Analysts at Building AO. The Mission Director and other project officials in the MOC have access to both the status and ETR/RTCC nets.

c. DSS-1 Net. This net will be used by personnel at the SFOF to keep the Mission Director at the MOC informed as to the status of the DSN. Stations normally "active" on this net are the Assistant Space Flight Operations Director (PRIME-2) at the SFOF, and the Mission Coordinator at Building AO. The Mission Director will also use this net to contact the Assistant Mission Director, Spacecraft Manager, Tracking and Data Systems Manager, and the Assistant SFOD (ACE-2).

d. DSS-2 Net. This net will be used by the Spacecraft Test Coordinator (STC) at DSS-71 and the Spacecraft Performance Group at the Space Flight Operations Facility for the purpose of verifying the spacecraft programmer memory loading and for the purpose of keeping the STC informed of the status of the spacecraft as indicated by telemetry at the SFOF. The Mission Director and other project personnel located at Building AO have monitoring capability of this net.

e. Flight Control Net. This is the in-house net for the Flight Performance Group (FPAC) at the SFOF. The Mission Director and other project personnel at Building AO have monitoring capability of this net.

f. Additional Leased Lines. Two additional GSFC leased lines are provided for the purpose of keeping NASA Headquarters informed of the mission status during both the minus and plus counts.

(1) Vehicle Status. (ETR termination at Building AE). Provides headquarters with launch vehicle status in the minus count and in-flight events after liftoff.

(2) Spacecraft Status. (ETR termination at Building AO Program Managers Console). The Program Manager provides Headquarters with a running account of spacecraft status plus implications to mission posture.

(3) MFSN Launch Net. This line is used to obtain launch vehicle telemetry from the various MFSN tracking stations.

6. Post Liftoff Channels.

a. Channel 1. After liftoff, flight performance data will be summarized in real time at the VDC on this channel.

b. Channel 5. This channel will be used for a telemetry commentary from Building AE.

c. Channel 16. Liftoff time and mark event times will be called out on this channel by LMSC, SRO, and GSFC.

d. Channel 17. This channel will be used by the Range Safety Monitor for IIP commentary.

SECTION IV
TEST OPERATIONS

The ATLAS/AGENA and spacecraft operations to be performed during the launch countdown are summarized in table 6.

Table 6. F-0 Day Operations

Time (EST)*	Count (Min)	Event
0941	T-460	Man countdown stations
0946	T-455	Start countdown
1009	T-432	Start spacecraft power turn on preps
1011	T-430	Radiation clearance required
1041	T-400	Project Rep at Central Control console and check all communications lines (1, 2, 5, 10, 17, 24) with blockhouse (NTC)
1046	T-395	Start spacecraft subsystem checks AGENA ordnance delivered to pad
1056	T-385	Local RF silence until T-315 (Spacecraft in low power mode) Start mechanical installation of vehicle pyrotechnics
1206	T-315	Range countdown starts Ordnance installation complete. RF silence released
1211	T-310	Start AGENA TLM and beacon checkout
1246	T-275	Range Safety command test
1306	T-255	Local RF silence until T-230 (Spacecraft in low power mode) Start electrical hookup of pyrotechnics (ATLAS and AGENA)
1346	T-215	Spacecraft subsystems test complete Spacecraft programmer memory loading

Table 6. F-0 Day Operations (Cont'd)

Time (EST)*	Count (Min)	Event
1436	T-165	All personnel not involved in AGENA tanking clear the pad area and retire to roadblock
1441	T-160	Pumphouse No. 4 manned and operational
1446	T-155	Start AGENA fuel (UDMH) tanking
1451	T-150	ATLAS TLM warmup
1455	T-146	Guidance command test No. 1
1506	T-135	AGENA fuel tanking complete Pad area clear for essential work Spacecraft programmer memory loading complete
1516	T-125	Remove service tower
1541	T-100	Range T-0 pulse checks
1551	T-90	Start AGENA oxidizer (IRFNA) tanking AGENA beacon range calibration check
1616	T-65	AGENA oxidizer tanking complete
1621	T-60	Build-in hold (50 minutes nominal) Clear all private vehicles and nonessential support vehicles from parking and pad area
1711	T-60	Build-in hold ends Start spacecraft internal power checks
1720	T-51	Start guidance command test No. 2
1721	T-50	Spacecraft internal power checks complete
1736	T-35	Start LOX tanking
1741	T-30	All systems verify no outstanding problems Photo subsystem final preps

Table 6. F-0 Day Operations (Cont'd)

Time (EST)*	Count (Min)	Event
1749	T-22	Start final Range Safety committment
1804	T-7	Built-in 10 minute hold
1814	T-7	Built-in hold ends AGENA to internal power
1816	T-5	Spacecraft to internal
1818	T-3	Spacecraft programmer clock running
1819	T-2	ATLAS commands to internal
1821	T-0	Launch

*EST times are valid only for expected opening of launch window on November 6, 1966.