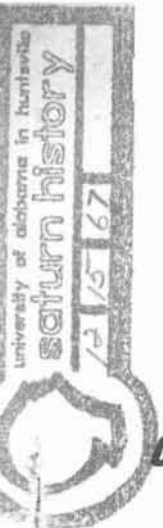


Jones

X 111.1

R-ASTR-S-67-63
December 15, 1967



SATURN HISTORY DOCUMENT
University of Alabama Research Institute
History of Science & Technology Group

Date ----- Doc. No. -----

TECHNICAL INFORMATION SUMMARY

APOLLO 5 (AS-204/LM-1)

APOLLO SATURN 1B FLIGHT VEHICLE

PREPARED BY:
R-AERO-P
R-ASTR-S
R-P&VE-VNC

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



AS-204/LM-1

TECHNICAL INFORMATION

SUMMARY

This document is prepared jointly by the Marshall Space Flight Center Laboratories R-AERO-P, R-ASTR-S, and R-P&VE-VN. The document presents a brief and concise description of the AS-204/LM-1 Apollo Saturn Space Vehicle. Where necessary, for clarification, additional related information has been included.

It is not the intent of this document to completely define the Space Vehicle or its systems and subsystems in detail. The information presented herein, by text and sketches, describes launch preparation activities, launch facilities, and the space vehicle. This information permits the reader to follow the space vehicle sequence of events beginning a few hours prior to liftoff to its journey into space.

1. Mission Purpose:

The basic purpose of the AS-204/LM-1 mission is to launch and test an unmanned Lunar Module (LM) for verification of crew safety items and to verify the launch vehicle's systems performance in preparation for subsequent operational manned space vehicle missions.

2. Mission Objectives:

Mission Objectives Categories:

The objectives listing is according to the objective category (primary vs. secondary).

Primary Objectives - Are those which are mandatory. Malfunction of launch vehicle systems, ground equipment, or instrumentation which would result in failure to achieve these objectives will cause a "hold" or mission cancellation until the malfunction has been eliminated.

Secondary Objectives - Are those which are desirable but not mandatory. Malfunctions, which would result in failure to attain these objectives, may cause a hold or mission cancellation as indicated in the Mission Rules.

Mission Primary Objectives - AS-204/LM-1 - As listed in the Flight Mission Assignments Document:

- a. Verify operation of the following LM subsystems:
 - Ascent Propulsion System (APS).
 - Descent Propulsion System (DPS) (including restart).
 - Structure.
- b. Evaluate LM staging.
- c. Evaluate S-IVB/IU orbital performance.

Detailed LV Primary Objectives:

Evaluate S-IVB/IU orbital performance.

Specifically:

- a. Evaluate the LV attitude control and maneuvering capability.
- b. Verify the S-IVB LH₂ and LOX tank boiloff characteristics.
- c. Demonstrate nose cone separation from the S-IVB/IU/SLA.
- d. Evaluate the operational adequacy of the launch vehicle systems; including guidance and control, electrical, mechanical and instrumentation.

Launch Vehicle - Secondary Objectives:

- a. Evaluate S-IVB forward skirt in-flight panel flutter.
- b. Evaluate V-2 engine crossover duct temperature experiment.
- c. Evaluate S-IVB LH₂ and LOX propellant dump experiment.
- d. Evaluate Launch Vehicle orbital coast lifetime capability.

3. Mission Profile:

The Apollo Saturn-204/Lunar Module-1 will be launched at Cape Kennedy, Launch Complex 37, Pad B. Vehicle will be launched on a 90° E of N launch azimuth and will be rolled to a flight azimuth of 72° E of N by the launch vehicle control system based on signals from the control computer. The S-IB phase utilizes a preset time-tilt program to produce a gravity turn trajectory. Guidance commands, during the S-IVB portion of the ascent-to-orbit, will be generated in the Iterative Guidance Mode (IGM) which will navigate and guide the S-IVB/IU/SLA into an 85 x 120 nautical mile elliptical orbit. Insertion should occur 10 seconds after guidance cutoff or 602.26 seconds after liftoff.

Resulting Orbit will be:

Inclination --- 31.6143°
Period --- 88.2785 min.
Apogee --- 123 nautical miles
Perigee --- 88 nautical miles
Velocity --- 7828.77 m/sec.

Shortly after insertion the S-IVB attitude control system will execute maneuvers to place the longitudinal axis of the vehicle along the velocity vector and subsequently will maintain that attitude in an

orbital rate mode. The nose cone will be jettisoned and the SLA panels will be deployed after orbital insertion.

The LM will remain attached to the S-IVB/IU/SLA for approximately 45 minutes and the S-IVB/IU will provide attitude stabilization for LM separation.

Approximately 1 1/2 hours after LM separation a S-IVB LOX and LH₂ propellant dump experiment will be performed. This experiment will be completed approximately 4 1/2 hours after orbital insertion.

SA-204/LM-1 S-IVB LOX and LH₂ Propellant Removal Test

The propellant removal test on SA-204/LM-1 will dump LOX and LH₂ propellant through the J-2 engine on the second revolution over Australia during the cold soak of the LM.

At 1 hour and 36 minutes from liftoff, an on-board signal is given which enables this test.

The propellant test does not start for 49 minutes after the on-board signal is given. During this time, the test can be disabled by ground command if necessary.

In preparation for test, (approximately 2 hours and 20 minutes after liftoff), the S-IVB/IU will maneuver to a local vertical attitude - pitch 270°, SLA panels toward earth, yaw 0°, and roll 85°. In order to point the best portion of the IU antenna pattern toward the Carnarvon station, the S-IVB/IU will perform continuous roll during the Propellant Removal Test.

Shortly after 2 hours and 26 minutes into the mission the main-stage control valve in the J-2 engine will be opened and the LOX tank will vent through the engine for 2 minutes. This action will be followed immediately by a similar 3-minute vent of the LH₂ tank. Attitude control in pitch and yaw will be attempted by gimbaling the engine for the first 80 seconds of LOX dump after which it will switch back to APS control.

Approximately 20 minutes after the fuel dump test, while the vehicle is over Hawaii, the Launch Vehicle starts a cold helium dump. This dump continues for 22 minutes during which time the vent valves are also open which depletes the tank pressurization helium supply.

Helium which supplies control valve pressure is dumped 4 and 3/4 hours after liftoff while the vehicle is passing over the United States for the third time.

LIST OF FIGURES

| FIGURE | TITLE | PAGE |
|-----------------------|---|------|
| <u>GENERAL</u> | | |
| 1 | AS-204/LM-1 Space Vehicle | 6 |
| 2 | Launch Complex 37 | 7 |
| 3 | LC 37, Pad B Configuration | 8 |
| 4 | LC 37B Integrated Launch ESE Block Diagram | 9 |
| 5 | LC 37B Propellant and Pressurization Subsystems | 10 |
| <u>LAUNCH VEHICLE</u> | | |
| 6 | S-IB Stage Flight Sequencing | 12 |
| 7 | S-IVB Stage Flight Sequencing | 13 |
| 8 | Secure Range Safety System | 15 |
| 9 | Emergency Detection System | 17 |
| 10 | Trajectory Information | 18 |
| 11 | Guidance and Control System - Block Diagram | 21 |
| 12 | Network Coverage Constraints | 24 |
| 13 | Tracking Network | 27 |
| 14 | Tracking, Telemetry and Range Safety Coverage | 28 |
| 15 | Orbital Ground Protection | 29 |
| 16 | Space Vehicle Weight vs Flight Time | 31 |
| <u>S-IB STAGE</u> | | |
| 17 | S-IB Stage Configuration | 33 |
| 18 | H-1 Operational Sequence | 34 |
| 19 | H-1 Engine System | 35 |
| 20 | S-IB Stage Propellant System | 37 |
| 21 | S-IB Stage Thrust Vector Control System | 39 |
| 22 | S-IB Stage Measuring System | 40 |
| 23 | S-IB Stage Telemetry System | 41 |
| 24 | S-IB Stage Electrical Power and Distribution System | 42 |

LIST OF FIGURES (continued)

| FIGURE | TITLE | PAGE |
|--------|--|------|
| | <u>S-IVB STAGE</u> | |
| 25 | S-IVB Stage Configuration | 45 |
| 26 | J-2 Engine System | 47 |
| 27 | S-IVB Stage Propellant System | 49 |
| 28 | S-IVB Stage Propellant Utilization | 51 |
| 29 | S-IVB Stage Thrust Vector Control System | 53 |
| 30 | Auxiliary Propulsion System | 55 |
| 31 | S-IVB Stage Measuring System | 56 |
| 32 | S-IVB Stage Telemetry System | 57 |
| 33 | S-IVB Stage Electrical Power and Distribution System | 58 |
| | <u>IU</u> | |
| 34 | IU Configuration | 61 |
| 35 | IU Measuring System | 62 |
| 36 | IU Telemetry System | 63 |
| 37 | IU Electrical Power and Distribution System | 64 |
| 38 | IU/S-IVB Environmental Control System | 67 |
| | <u>SPACECRAFT</u> | |
| 39 | SLA Configuration | 69 |
| 40 | Lunar Module | 71 |
| 41 | Interface - IU/SLA Jettison Controller | 72 |

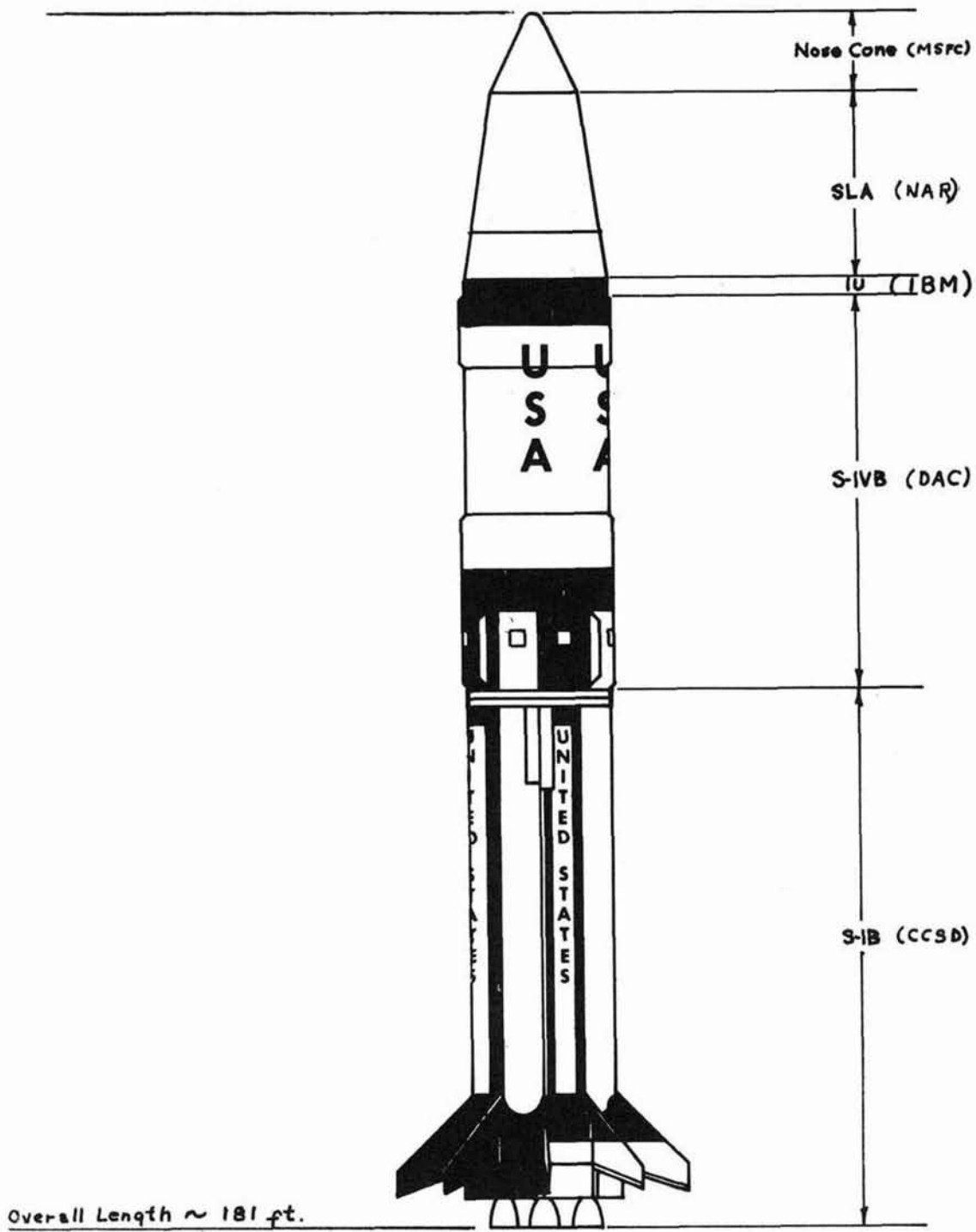


Figure 1

SA-204/LM-1 Profile

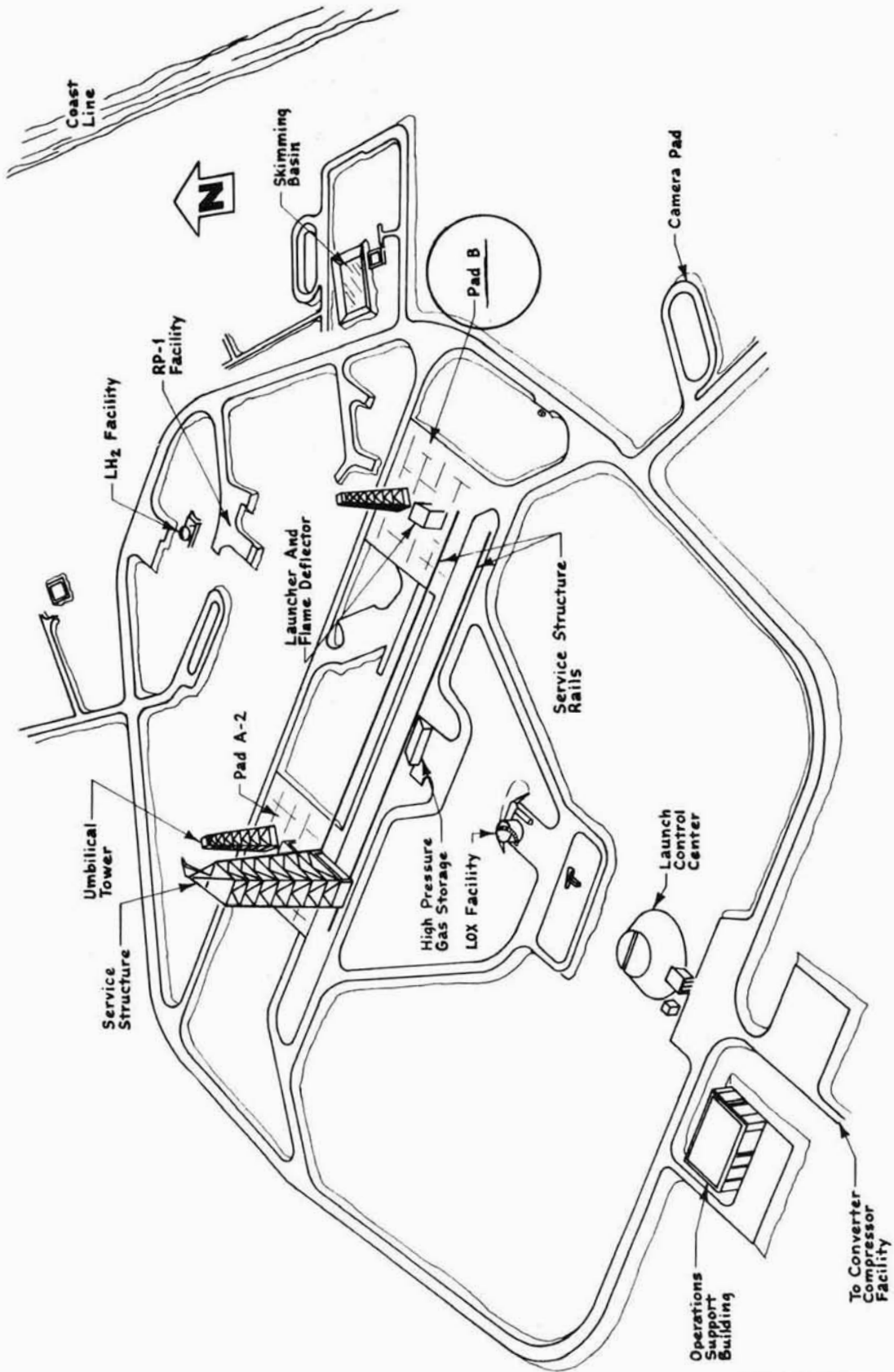
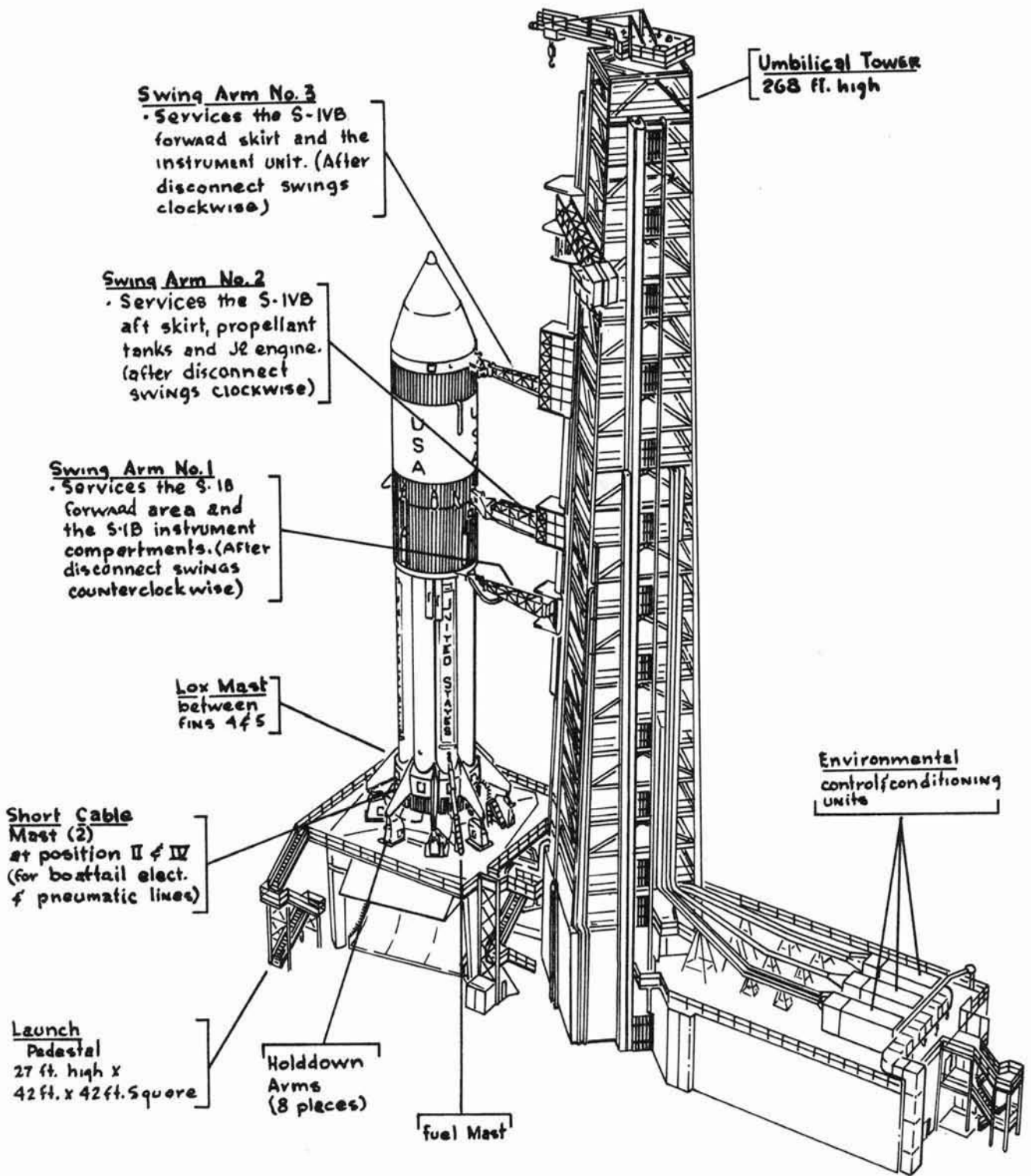


Figure 2

Launch Complex 37



Note: Paint pattern intentionally omitted.

Figure 3

LC-37 (pad B) Configuration

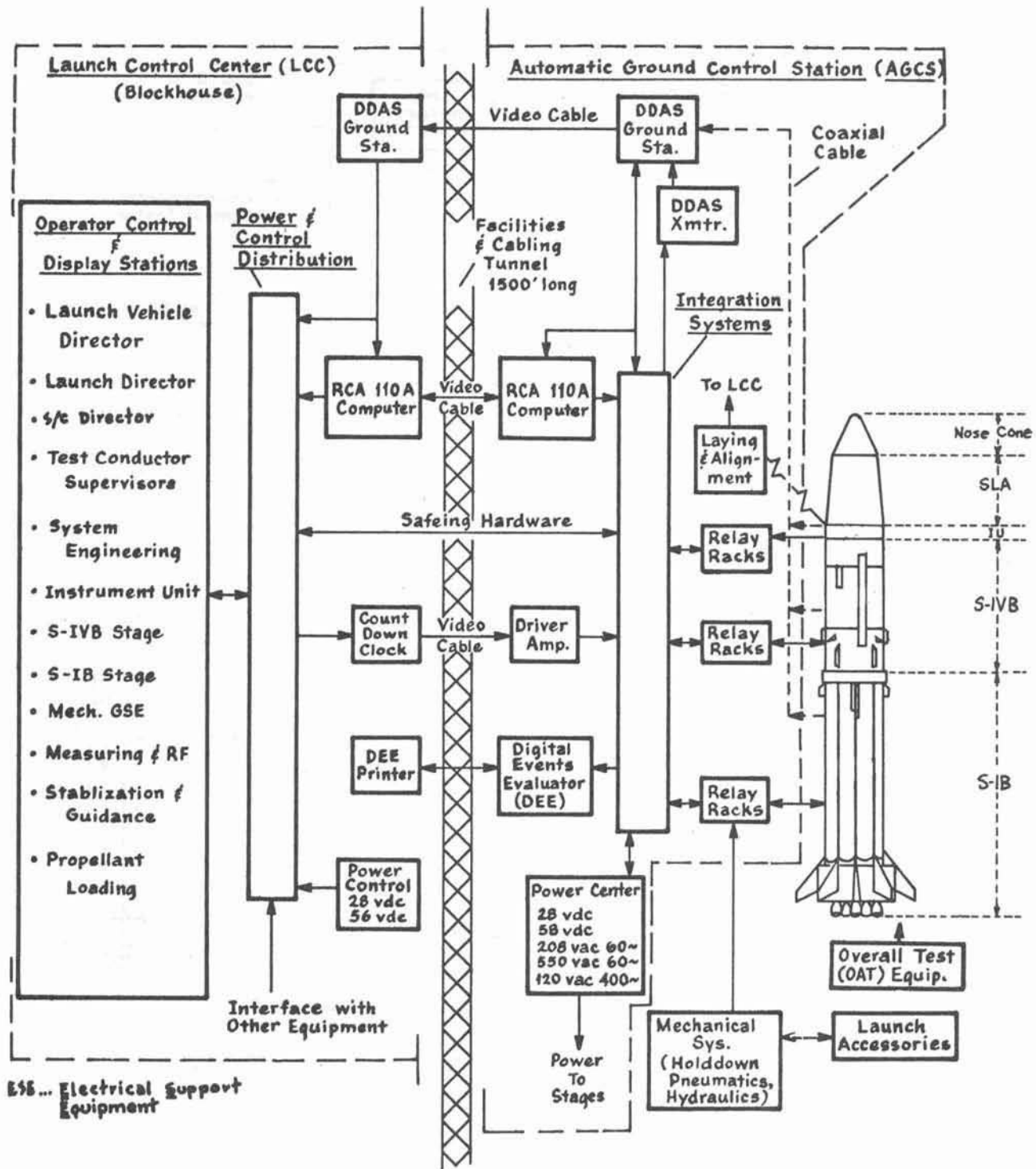
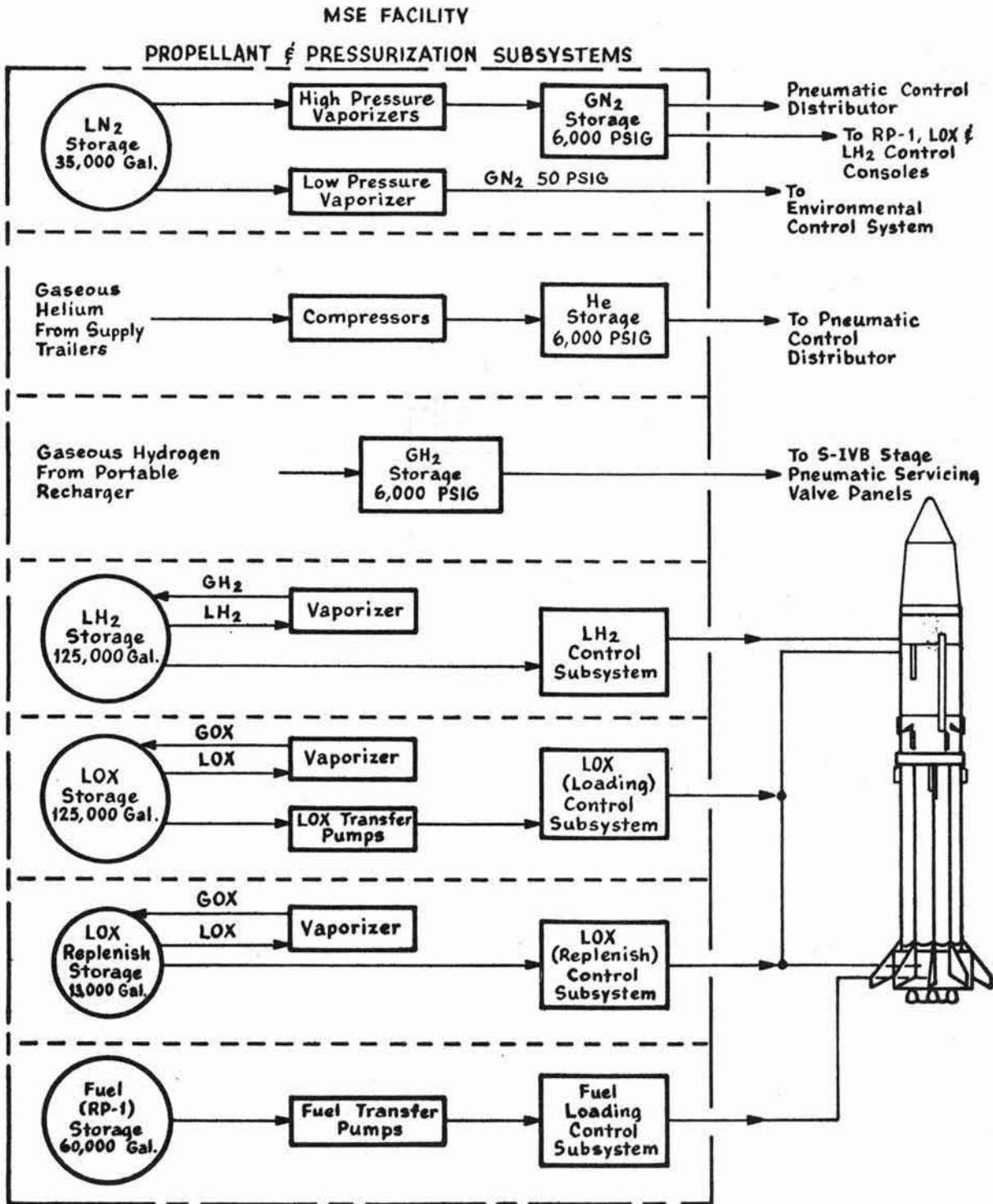


Figure 4

LC-37B Integrated Launch ESE Block Diagram



MSE... Mechanical Support Equipment

Figure 5

LC-37B Propellant and Pressurization Subsystems

Definition - Flight Sequence Program (AS-204/LM-1)

Four primary Time Bases are used in this Vehicle Flight Sequence Program to achieve optimum vehicle mission with a suitable sequential operation and timing of flight events.

In addition to these 4 time bases, one alternate time base is provided for LEM abort capability.

Safeguards have been established wherever necessary to prevent premature initiation of time bases.

Proper establishment of time bases provides a safe and reliable vehicle on the pad and in flight.

If any one of the four primary time bases (T_1 , T_2 , T_3 , or T_4) is not established, subsequent time bases cannot be started and the vehicle mission cannot be completed.

To further increase mission reliability in the absence of normal time base signals, backup methods have been devised to establish these time bases.

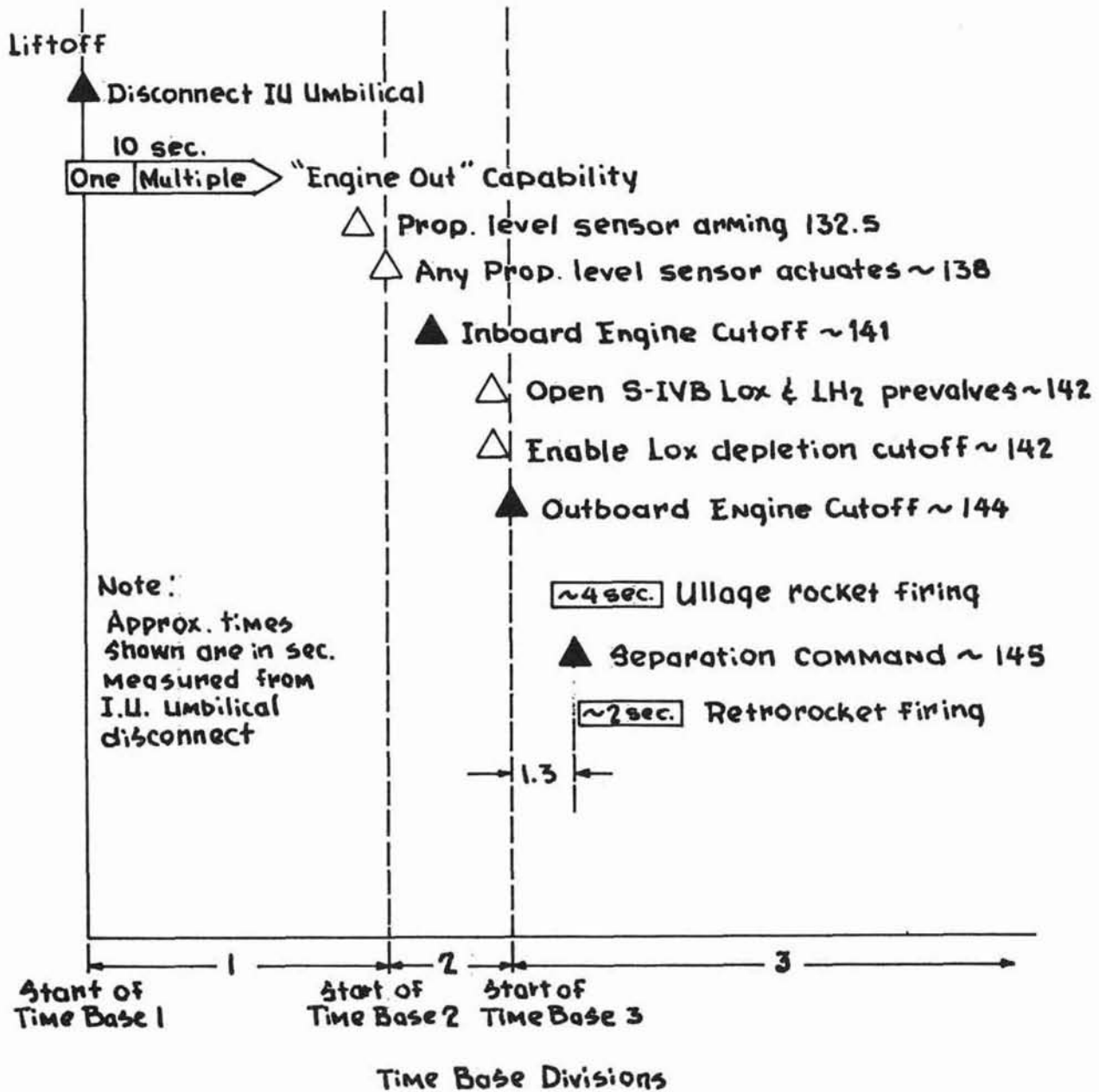


Figure 6

S-IB Stage
Flight Sequencing

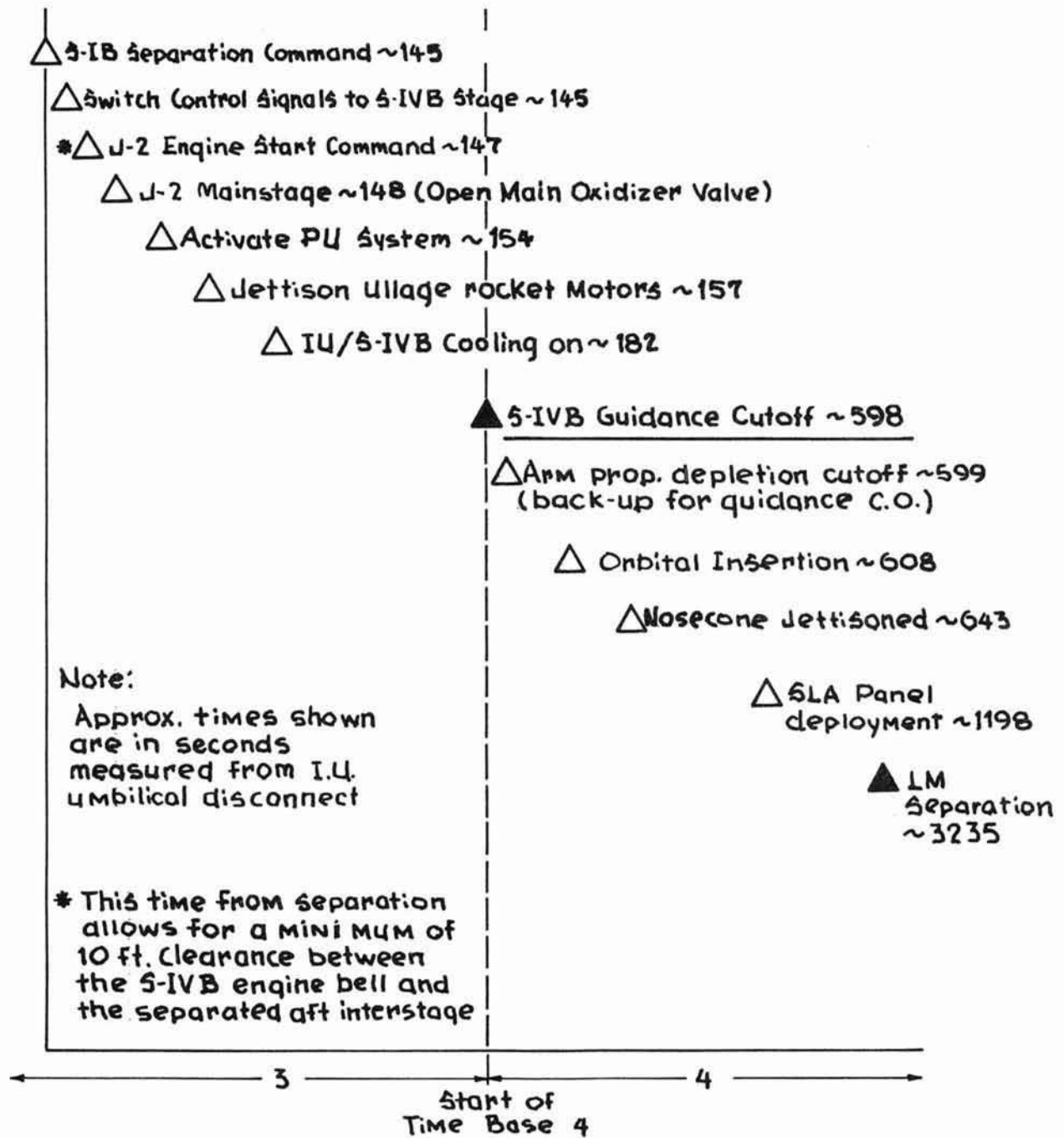


Figure 7

S-IVB Stage
 Flight Sequencing

LAUNCH VEHICLE SECURE RANGE SAFETY SYSTEMS

The secure range safety systems on the S-IB and S-IVB stages provide a communications link to transmit commands from ground stations to the vehicle during powered flight, and a positive means of terminating the flight of an erratic vehicle by initiating emergency engine cutoff and, if necessary, propellant dispersion.

Each powered stage contains two UHF radio receivers. Both command receivers on each of the two stages respond to the same command signal, each providing a backup system for the other.

The safing and arming device located on each stage is armed by a signal from the blockhouse before vehicle ignition. Following orbital insertion the S-IVB range safety system is "safed" by a command from Range Safety Control to preclude accidental destruct.

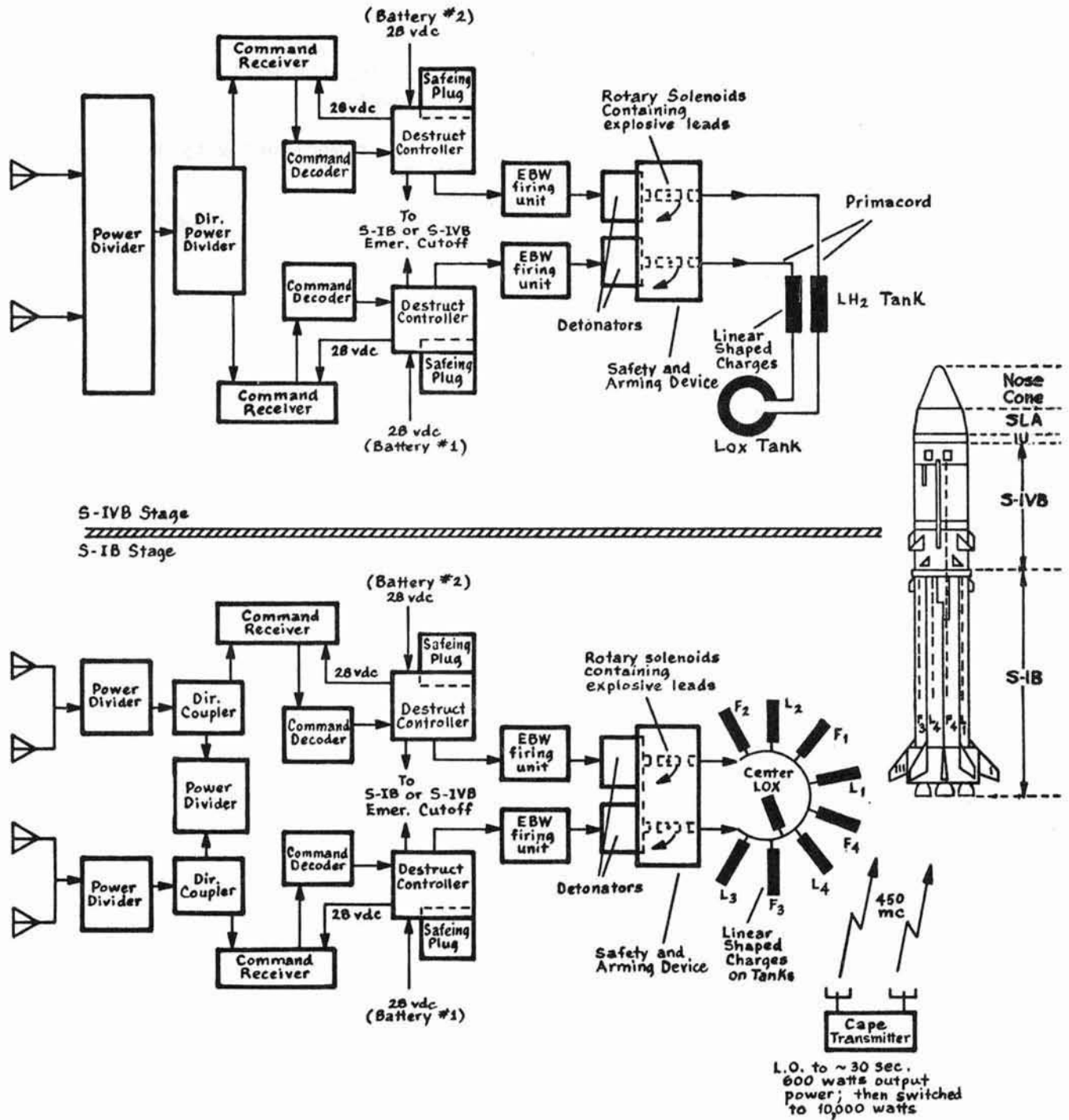


Figure 8

Secure Range Safety System

EMERGENCY DETECTION SYSTEM

Mission AS-204/LM-1 does not carry an Apollo Spacecraft and therefore does not have a complete EDS. Since the EDS will be flown "open loop" it cannot initiate an automatic abort.

All EDS abort parameters are telemetered for monitoring by the Launch Director.

Launch vehicle rate abort limits for telemetry monitoring:

| | |
|---------------|-------------------------|
| Pitch and yaw | 5.0 ± 0.6 deg/sec. |
| Roll | 20.0 ± 1.5 deg/sec. |

On AS-204/LM-1 the EDS
CANNOT activate an abort
(flown in "open loop" configuration)

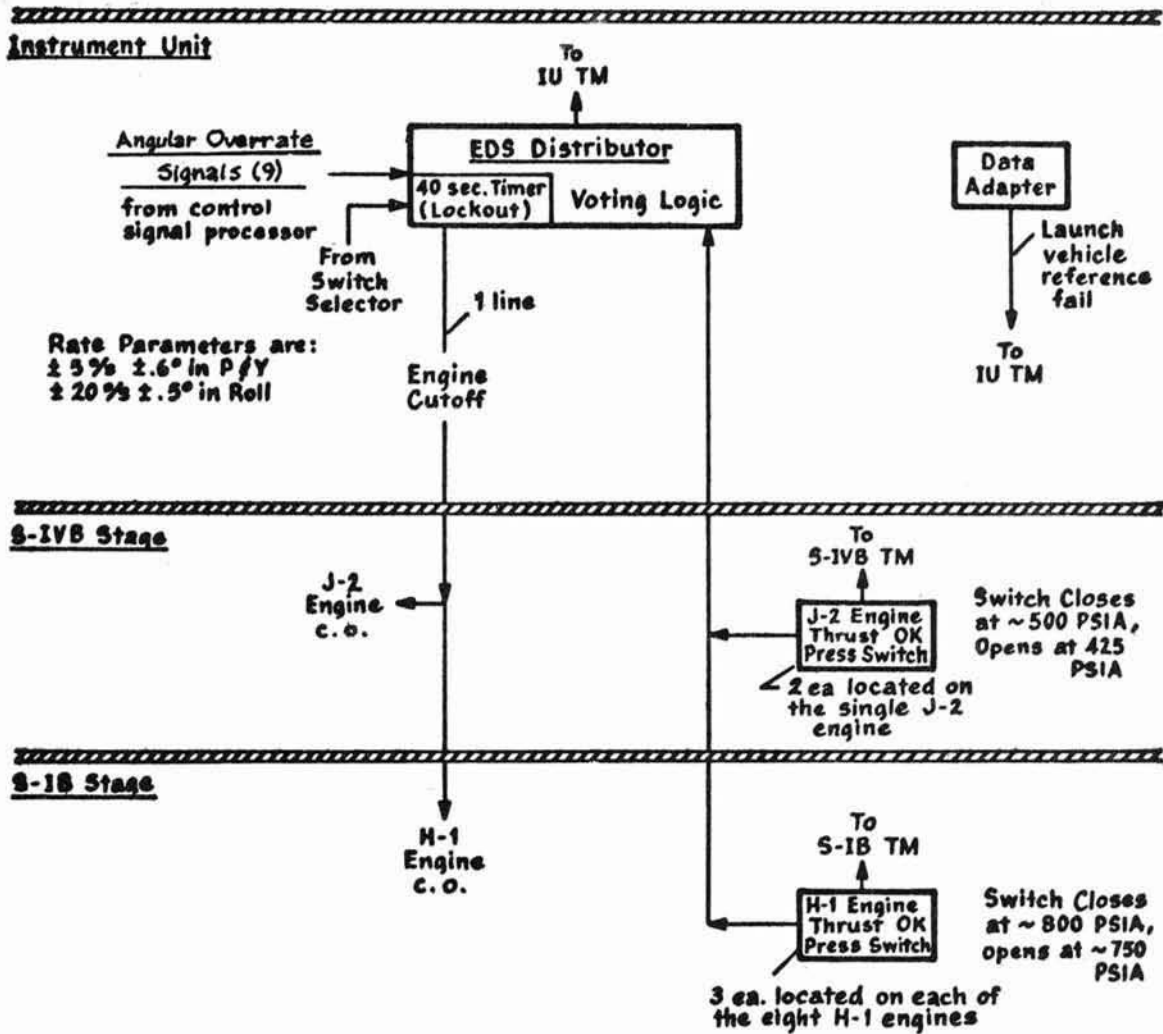
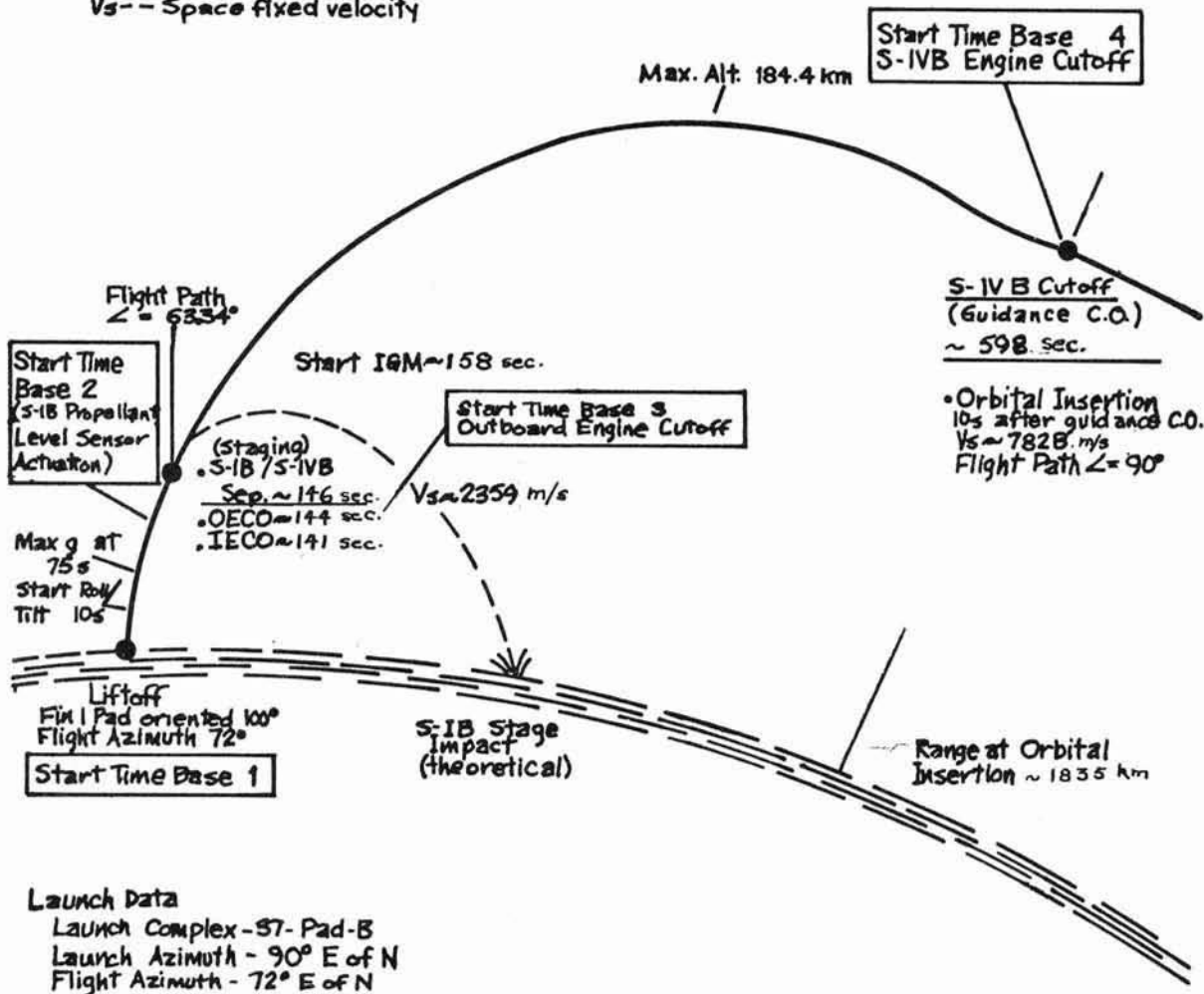


Figure 9

Emergency Detection System (EDS)

IECO - Inboard Engine Cutoff
 OECO - Outboard Engine Cutoff
 IGM - Iterative Guidance Mode
 Vs - Space fixed velocity



Launch Data

Launch Complex - 57 - Pad - B
 Launch Azimuth - 90° E of N
 Flight Azimuth - 72° E of N

Figure 10

Trajectory Information

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GUIDANCE AND CONTROL SUBSYSTEMS

Function and Description

Problems to be solved in order to insure mission success involve - navigation, guidance and control.

Figure 11 contains a block diagram of the Guidance and Control Subsystem.

Three accelerometers, mounted on the inner (inertial) gimbal of the stabilized platform, measure the three components of velocity resulting from vehicle propulsion (x, y, z). These acceleration measurements are fed to the Launch Vehicle Data Adapter (LVDA) which serves as an input/output device for the Launch Vehicle Digital Computer (LVDC).

The dual speed resolvers, located at the gimbal pivot points, are used to measure vehicle attitude with respect to the Inertial Platform. These angular outputs are converted into a digital count in the LVDA.

Any maneuver, required to achieve a desired end condition, is determined by the LVDC. The LVDA, acting as the input and output device for LVDC, transforms this data into a form which is compatible with other portions of the system.

The LVDC compares vehicle attitude correction commands with control sensor inputs to develop a control command to the stage engine actuators. The resulting command represents a computed difference between existing and desired attitude angles.

The required resulting action (thrust direction) is obtained by gimbaling the engines in the propelling stage, thus changing vehicle direction. In the S-IVB stage, an auxiliary propulsion system is used for roll control since the stage has only one engine. This control is effective during S-IVB powered flight. During coast flight, the auxiliary propulsion system provides complete control of the S-IVB/IU stage.

LVDA output is also routed to stage circuitry via the switch selectors for sequencing purposes.

Changing or introducing new data into the LVDC is made possible through the Instrument Unit command system from ground stations.

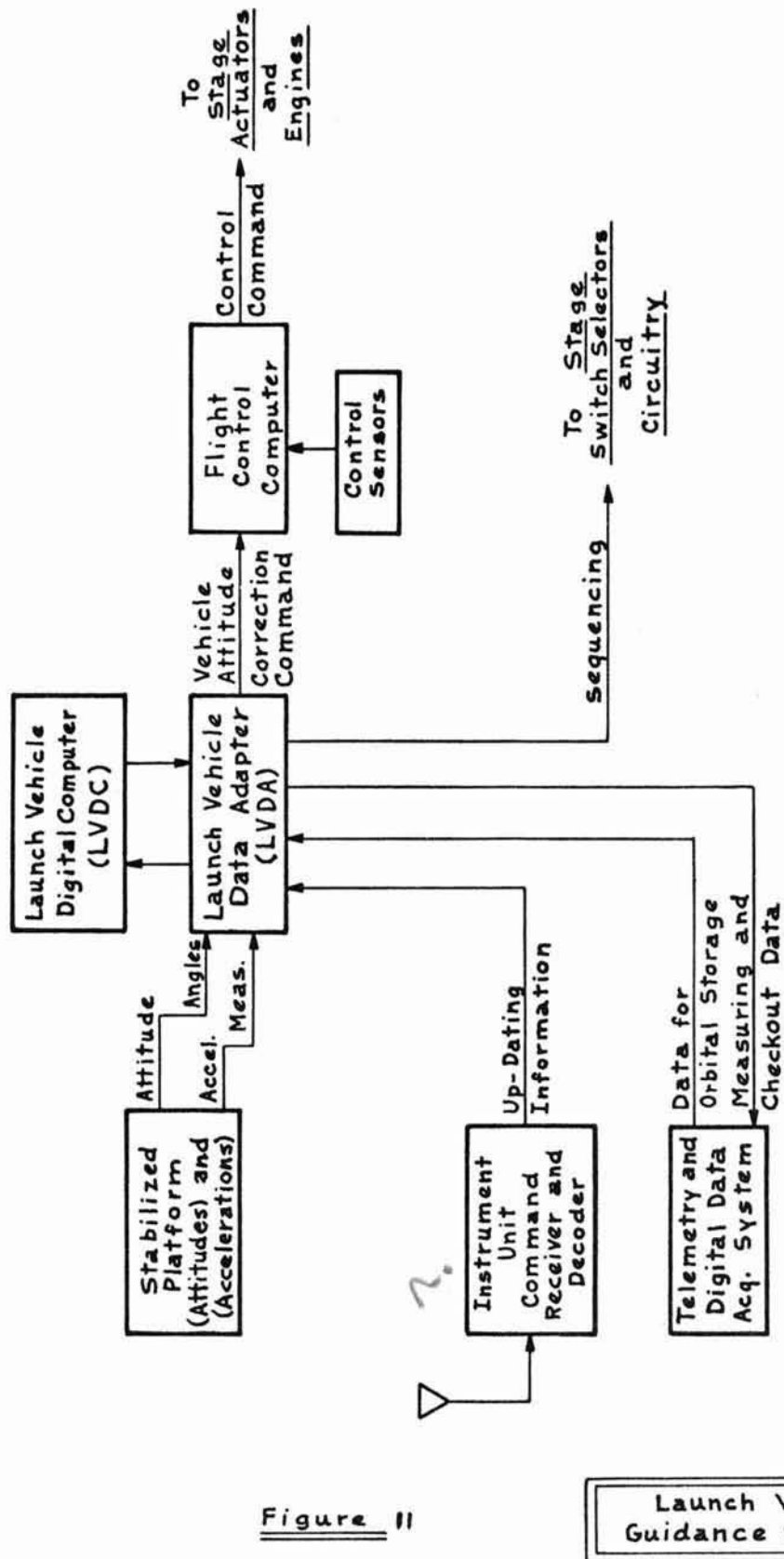


Figure 11

Launch Vehicle
Guidance Subsystem

LAUNCH VEHICLE GROUND SUPPORT PLAN (SA-204/LM-1)

Mission Description

The Apollo Mission, SA-204/LM-1 will be the first launch of the updated Saturn I Launch Vehicle with a fully configured Lunar Module.

Primary purpose of the Launch Vehicle is to insert the LM/S-IVB/IU into an elliptical earth orbit having an 85 nm perigee and a 120 nm apogee and to position the LM for unmanned tests of subsystem operations.

A ground projection of the first six revolutions is shown in Figure 15.

Basic Support

Basic mission support required from the global network are; Tracking, Telemetry Recording, Telemetry Real Time Display and Update.

Mission Support Planning

For support planning purposes, the mission can be divided into three phases:

1. The Launch Phase - Liftoff to S-IVB cutoff plus 1.5 minutes.
2. Pre-separation Phase - Begins at the end of Launch Phase and is terminated by the initiation of LM separation sequence.
3. Post-separation Phase - Starts with initiation of the Separation Phase and continues for the duration of the LM system life.

For mission planning purposes, LM System life is assumed to be 10 hours.

The mission's secondary objective is to determine the system life of the Launch Vehicle.

Launch Phase

The Apollo Saturn Vehicle, launched from Pad 37B, will have a launch azimuth of 90° and will roll to a flight azimuth of 72° east of true north.

Pre-separation Phase

Following S-IVB cutoff, approximately 598 seconds after liftoff, the S-IVB/IU and the LM are inserted into their earth parking orbit (85 by 120 nm). The vehicle remains in this phase for about 42 minutes which presents the first opportunity for separation. A second opportunity occurs over the United States on the first revolution.

Visibility limit circles for an elevation of 5 degrees are shown in Figure 15 for the primary ground stations for tracking, telemetry and updata.

Whenever the orbital ground projections are within the limit circle, the vehicle will be visible to the stations.

Post-separation Phase

During the second revolution, the S-IVB LOX and LH₂ Propellant Dump Experiment will be activated. This experiment is also described as Propellant Removal Test and S-IVB Stage Passivation.

Figure 12 describes the network coverage constraints for each of the phases described above.

| | Launch Phase | Separation Phase | Active Post-Separation Phase |
|---|---|--|--|
| T R A C K I G | Continuous Record From Liftoff to S-IVB Cutoff From 2 Independent Systems, and From S-IVB Cutoff for 1.5 Minutes From 1 Syst. | Continuous C-band Cover for at Least 2 Minutes Before Separation Until 2 Minutes After Separation. | C-band Beacon Tracking From 2 Stations per Rev.-180° Apart-For First 4 Revs. and 1 Station/Rev. For Duration of Systems Life. |
| T E L E M E T R Y | Continuous Record From Liftoff to S-IVB Cutoff by 2 Stations and From S-IVB Cutoff For 1.5 Min. by 1 Station. Continuous Record of S-IB Ballistic Flight From S-IB Cutoff For 2 Min. Continuous Real-Time Flight Control Data From Liftoff to S-IVB Cutoff + 1.5 Minutes. | Continuous Record and Real-Time Flt. Control Data For at Least 2 Min. Before Until 2 Min. After Separation. NOTE; Prior to Separation, Record and Real-Time Data is Provided For at Least 3 Minutes From 1 Station. | Record at Least 3 Minutes From at Least 4 Stations/Rev. Until 4 1/2 Hours Into Mission. Then 2 Sta./Rev. Until End of Estimated Systems Life; Then 1 Sta./Rev. For Duration of Syst. Life. Real-Time Flight Control Data For at Least 3 Min. From 1 Sta./Rev. Until 4 1/2 Hours Into Miss Mission. |
| U P D A T A | Updata Capability From Liftoff Plus 160 Seconds to S-IVB Cutoff +90 Seconds. | Continuous Updata Capability For at Least 2 Minutes Before Separation Until 2 Minutes After Separation. | Updata Capability For At Least 3 Minutes From 1 Station/Rev. Until 4 1/2 Hours Into Mission. |

Figure 12

Network Coverage Constraints

COMMUNICATIONS

Command (Data Transfer from Ground to Space Vehicle)

The purpose of the Saturn Instrument Unit Command System is to provide radio frequency digital data transmission between Manned Space Flight Network Stations and the on-board Digital Computer in the Launch Vehicle (LVDC).

Data received by the LVDC is used to update certain vehicle attitude parameters or to perform certain orbital operations in the S-IVB/IU.

Telemetry (Transmission of On-Board Parameters from Space Vehicle to Ground Stations)

Telemetry utilizes a system of sensing devices (transducers) which enables large quantities of physical data to be reduced into electrical intelligence. Various combinations, involving Frequency as well as Pulse Code and Pulse Amplitude Modulation, plus a frequency time-sharing system allows a great amount of data, in vehicle physical parameters, to be relayed to ground stations through limited transmitting paths.

While the vehicle is still on the launch pad, pre-flight telemetry checkout is accomplished by hardwire and umbilical cord transmission.

The 204/LM-1 carries a total of 18 telemetry systems distributed as follows:

| | |
|---------------|---|
| - S-IB Stage | 4 |
| - S-IVB Stage | 5 |
| - IU | 4 |
| - LM | 5 |

Tracking (Monitor or Measure Vehicle In-Flight Location by Communication)

Purpose:

- Evaluate Guidance and Control
- Perform Attitude Corrections
- Insure Range Safety

Vehicle 204/LM-1 carries transponders and beacons in the following locations:

| <u>Location</u> | <u>System</u> |
|-----------------|--|
| - S-IB | - ODOP Transponder |
| - IU | - Two C-Band Radar Beacons - Glotrac Transponder |
| - LM | - X-Band Rendezvous Radar - Two C-Band Radar Beacons - USB Transponder |

INSTRUMENT UNIT - DIGITAL COMMAND SYSTEM CAPABILITY

| <u>Function</u> | <u>Description</u> | <u>Periods of Acceptance</u> |
|----------------------------------|--|--|
| LM Abort | Causes LM abort switch selectors and maneuvers. | Enabled at $T_3 + 10$ sec. until end of mission. |
| Inhibit | Inhibits certain coast phase attitude maneuvers. | Enabled at $T_4 + 15$ sec. until end of mission. |
| Update | Changes the time of initiation of the certain attitude maneuvers. | Enabled at $T_4 + 15$ sec. until end of mission. |
| Time Base Update | Time base time is advanced or retarded at the next telemetry loss. | Enabled at $T_4 + 15$ sec. until end of mission. |
| Navigation Update | Navigation quantities are reset at the time specified. | Enabled at $T_4 + 15$ sec. until end of mission. |
| Generalized Switch Selector | Specified switch selector function is issued at the first opportunity. | Enabled at $T_4 + 15$ sec. until end of mission. |
| Sector Dump | Contents of specified memory-sector are telemetered. | Enabled at $T_4 + 15$ sec. until end of mission. |
| Telemeter Single Memory Location | Contents of specified memory-sector are telemetered. | Enabled at $T_4 + 15$ sec. until end of mission. |
| Terminate | Stop DCS routine and reset for new command. | Enabled at $T_4 + 15$ sec. until end of mission. |

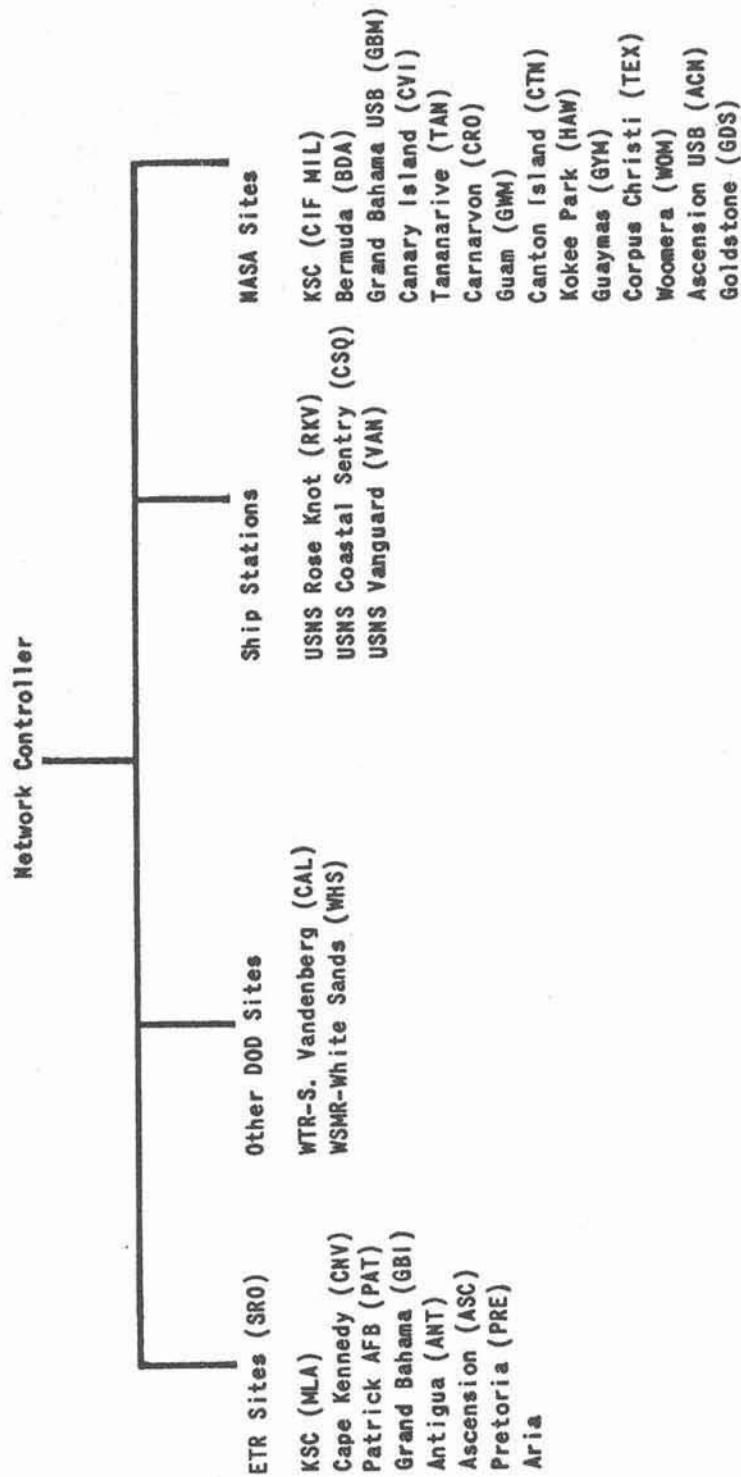
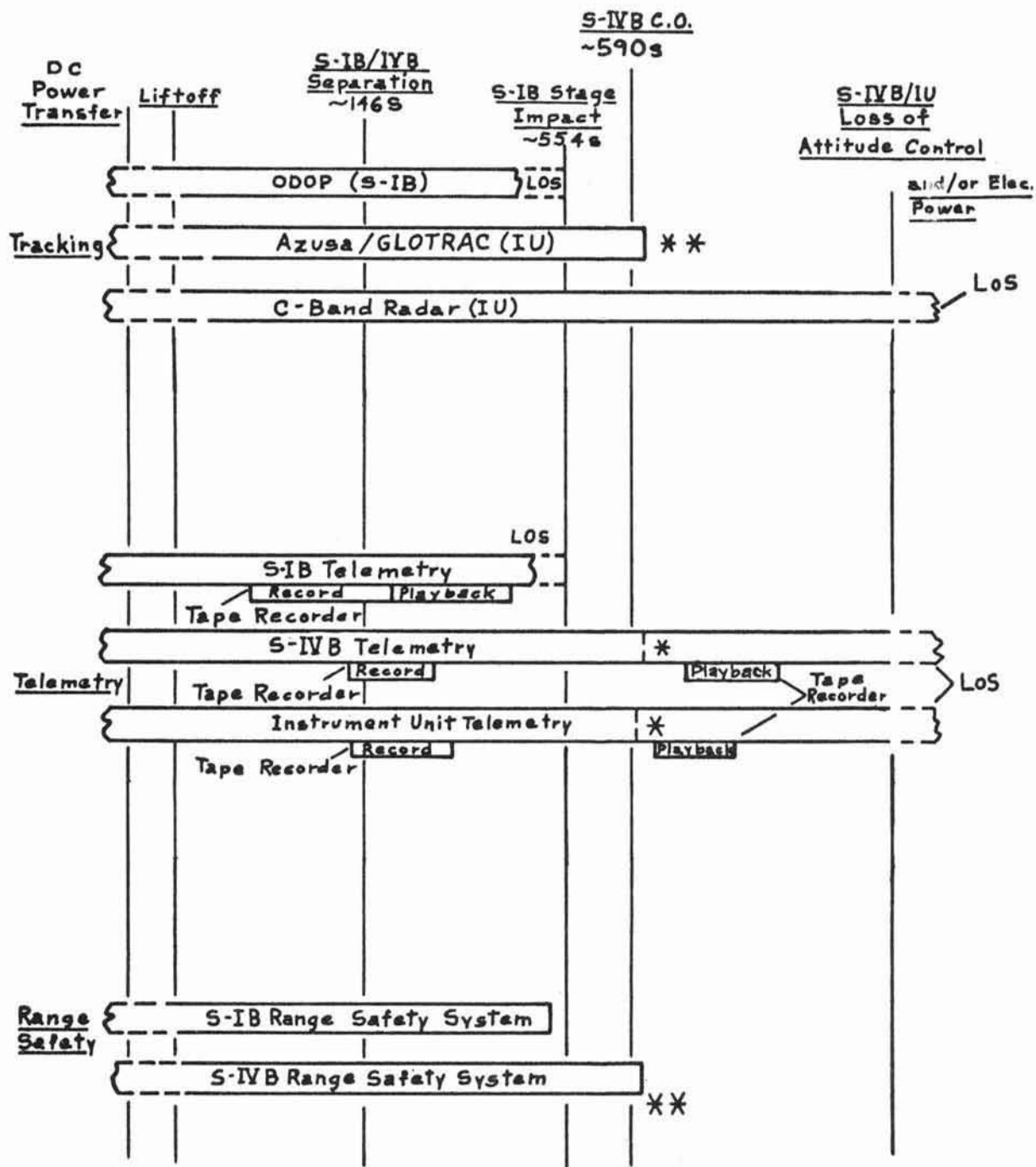


Figure 13

TRACKING NETWORK



LOS = Loss of Signal

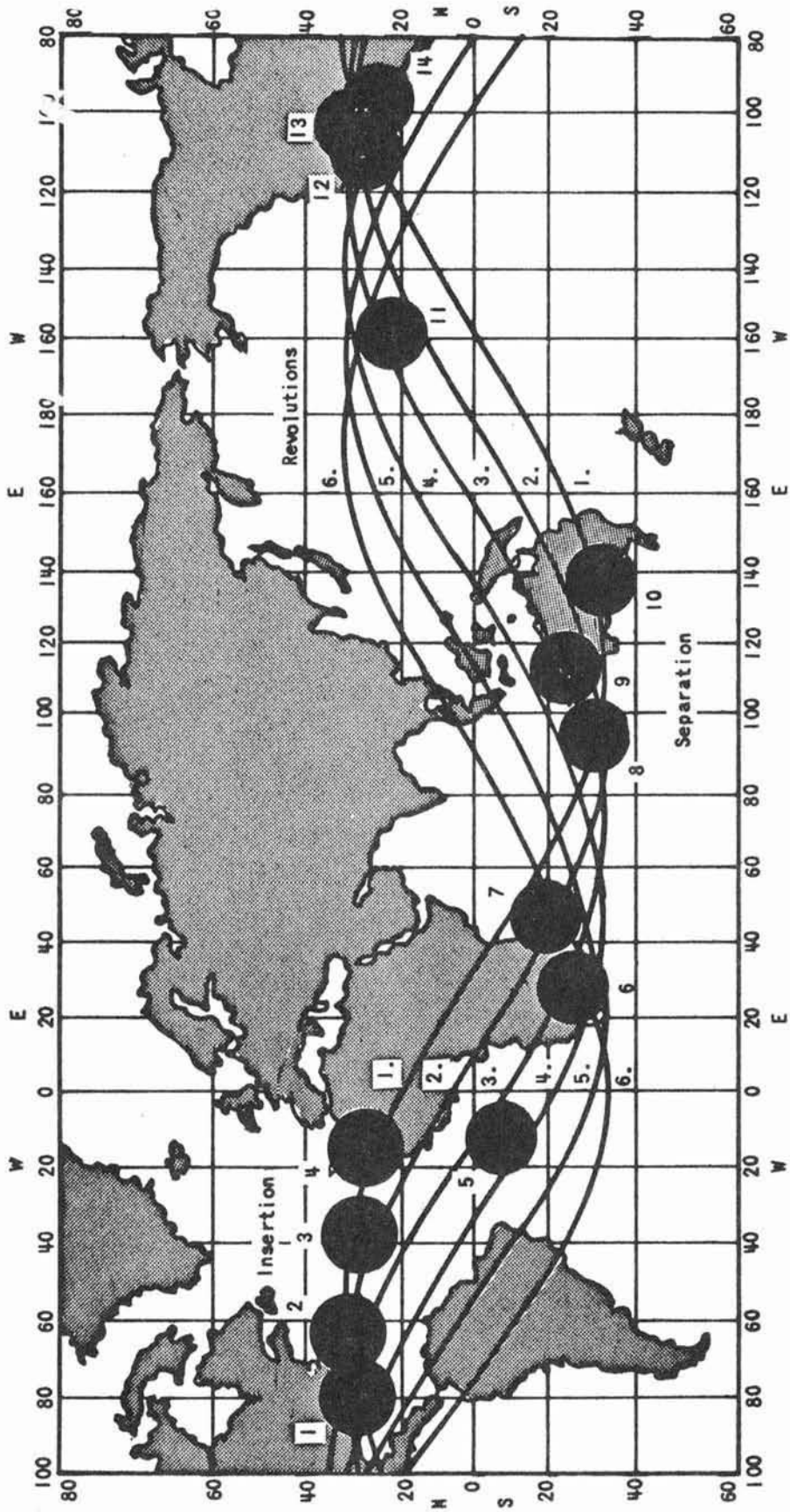
* = IU SSB off at ~600s, S-IVB SSB off at ~610s.

During orbit the S-IVB tape recorder records between stations and plays back over selected stations.

** Commanded off after S-IV engine cutoff.

Figure 14

Tracking, Telemetry, and
Range Safety Coverage



- NOTE:
 Acquisition
 Circles are for
 50 Coverage.
- | | | | | |
|-------------------|------------------|---------------|-------------|--------------------|
| 1. Cape Kennedy | 4. Canary Island | 7. Tananarive | 10. Woomera | 13. White Sands |
| 2. Bermuda | 5. Ascension | 8. CSQ Ship | 11. Hawaii | 14. Corpus Christi |
| 3. Insertion Ship | 6. Pretoria | 9. Carnarvon | 12. Guaymas | |

Figure 15

ORBITAL GROUND PROTECTION

SPACE VEHICLE WEIGHT VS. FLIGHT TIME

Propellant consumption during S-IB Stage flight (approximately 144 seconds) is approximately 883,200 pounds and during S-IVB Stage flight (approximately 435 seconds) is 226,400 pounds.

In case one engine of the S-IB Stage malfunctions and is cutoff during flight, the remaining engines will consume the propellant intended for the "dead" engine. Burning time of the stage would increase, and the overall vehicle loss would be minimized.

Vehicle Weight Data (Approximate)

Pounds

| | |
|-----------------------------|-----------|
| Total at S-IB ignition | 1,299,000 |
| Total at liftoff | 1,285,000 |
| Total at S-IB O.E.C.O. | 400,000 |
| Total at S-IVB ignition | 296,100 |
| Total of S-IVB cutoff | 69,800 |
| Total at nose cone jettison | 68,100 |
| Total at LEM separation | 36,800 |

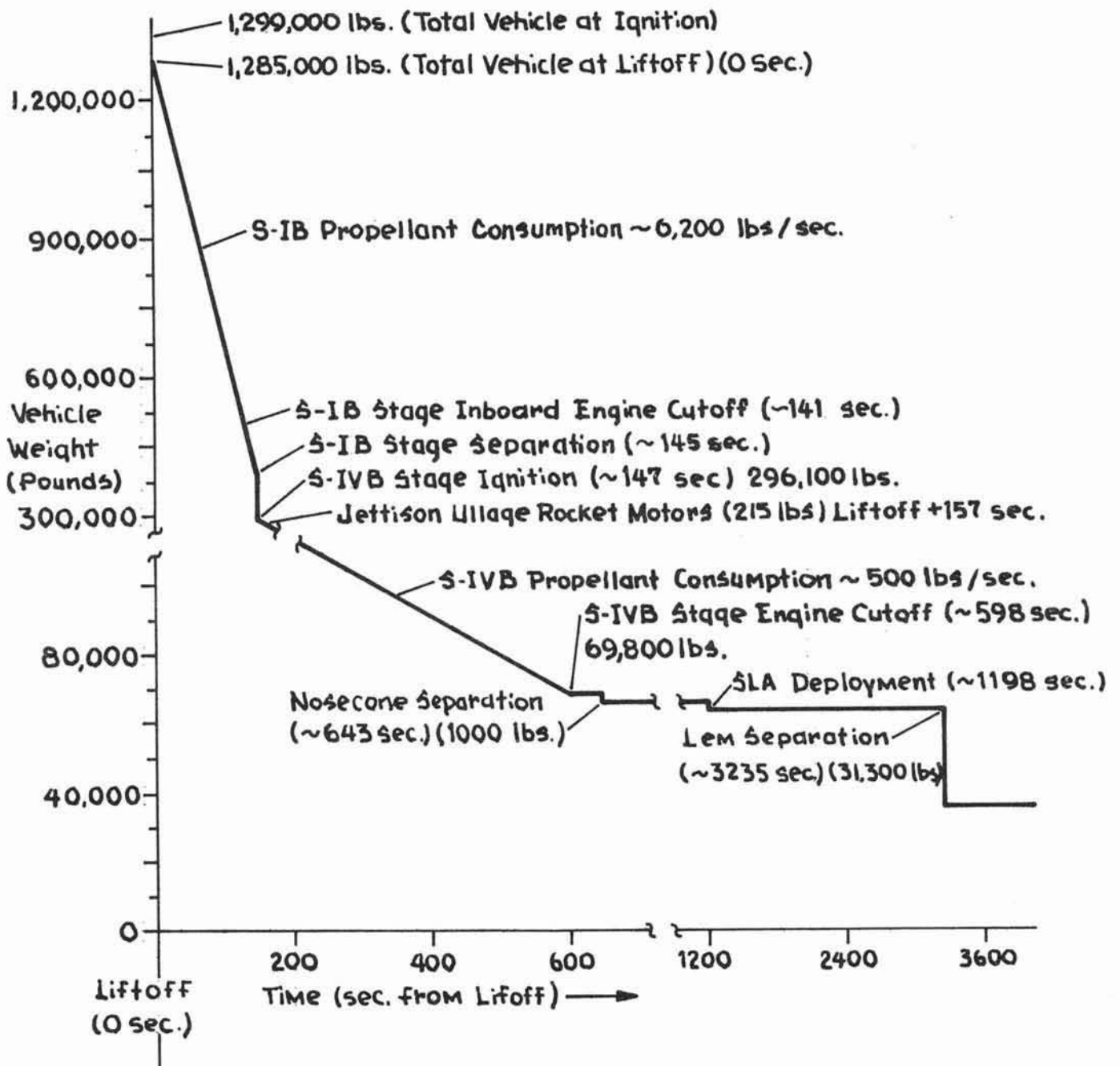


Figure 16

SPACE VEHICLE WEIGHT
 VS FLIGHT TIME

S-IB STAGE STRUCTURE

The S-IB Stage consists of four 70-inch diameter fuel containers mounted alternately with four 70-inch diameter LOX containers around a 105-inch diameter LOX container. The containers are supported at the base by a thrust structure assembly to which are affixed eight H-1 engines. The spider beam assembly provides the support structure at the forward end of the containers and serves as an adapter for the S-IVB interstage. Eight fins are mounted at the base of the S-IB stage to improve aerodynamic stability, and provide preflight support, and hold-down of the vehicle.

PROPULSION SYSTEM

The first stage of the launch vehicle is powered by a cluster of eight Rocketdyne H-1 engines developing a total sea level thrust of 1,600,000 pounds. Four engines are mounted outboard and four inboard; the four outboard engines are gimballed for vehicle control. The propellants are LOX and RP-1.

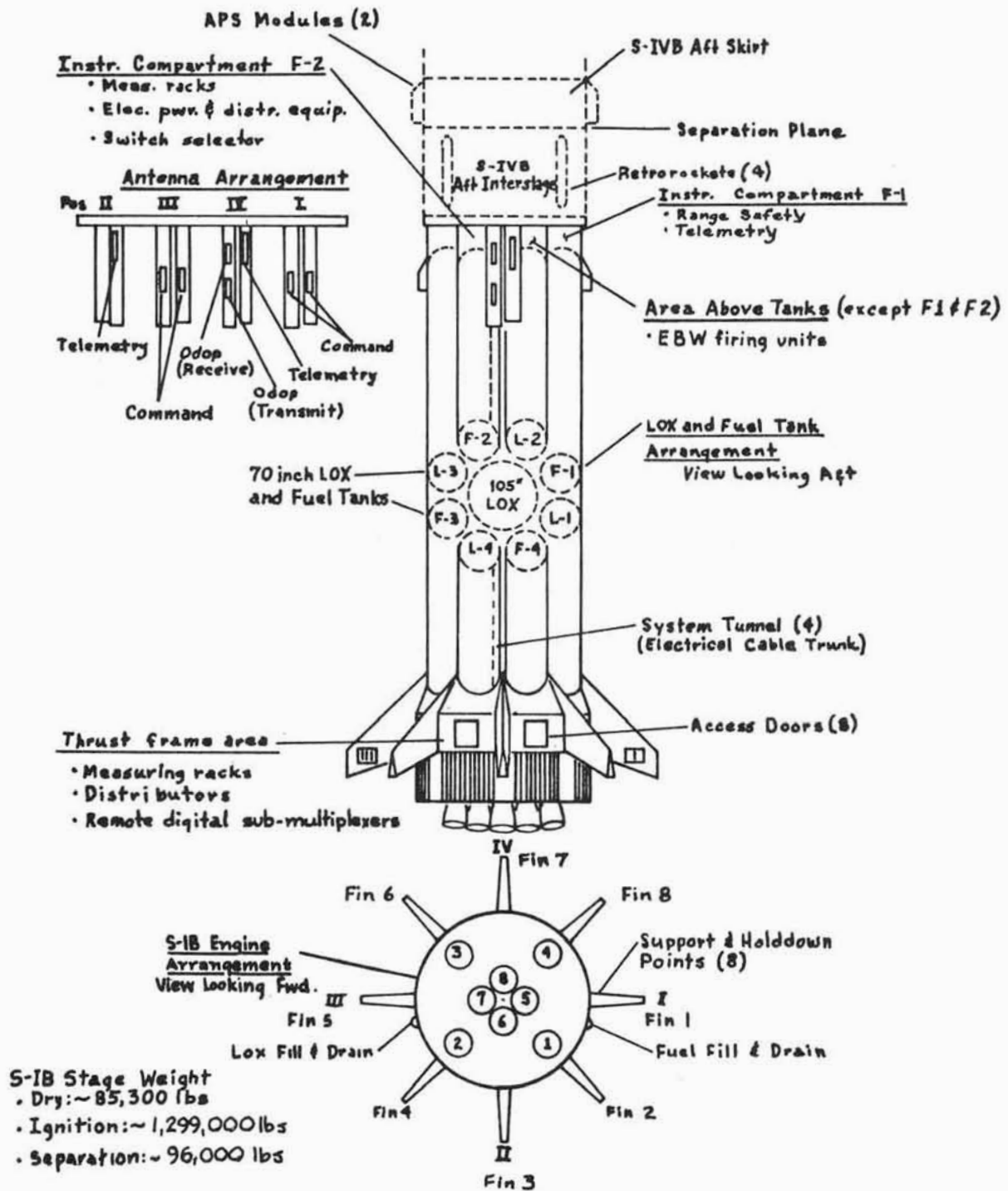


Figure 17

S-IB Stage Configuration

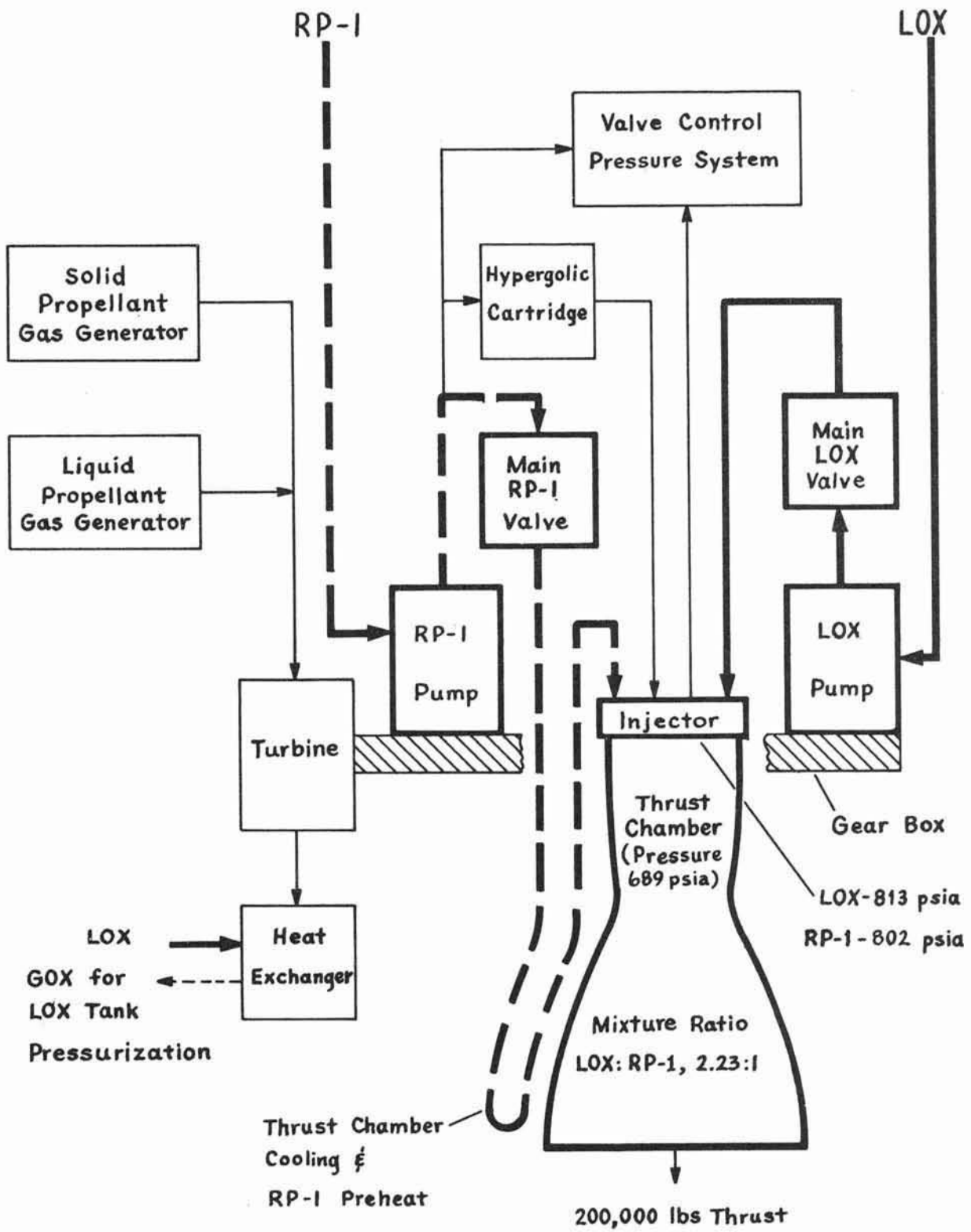
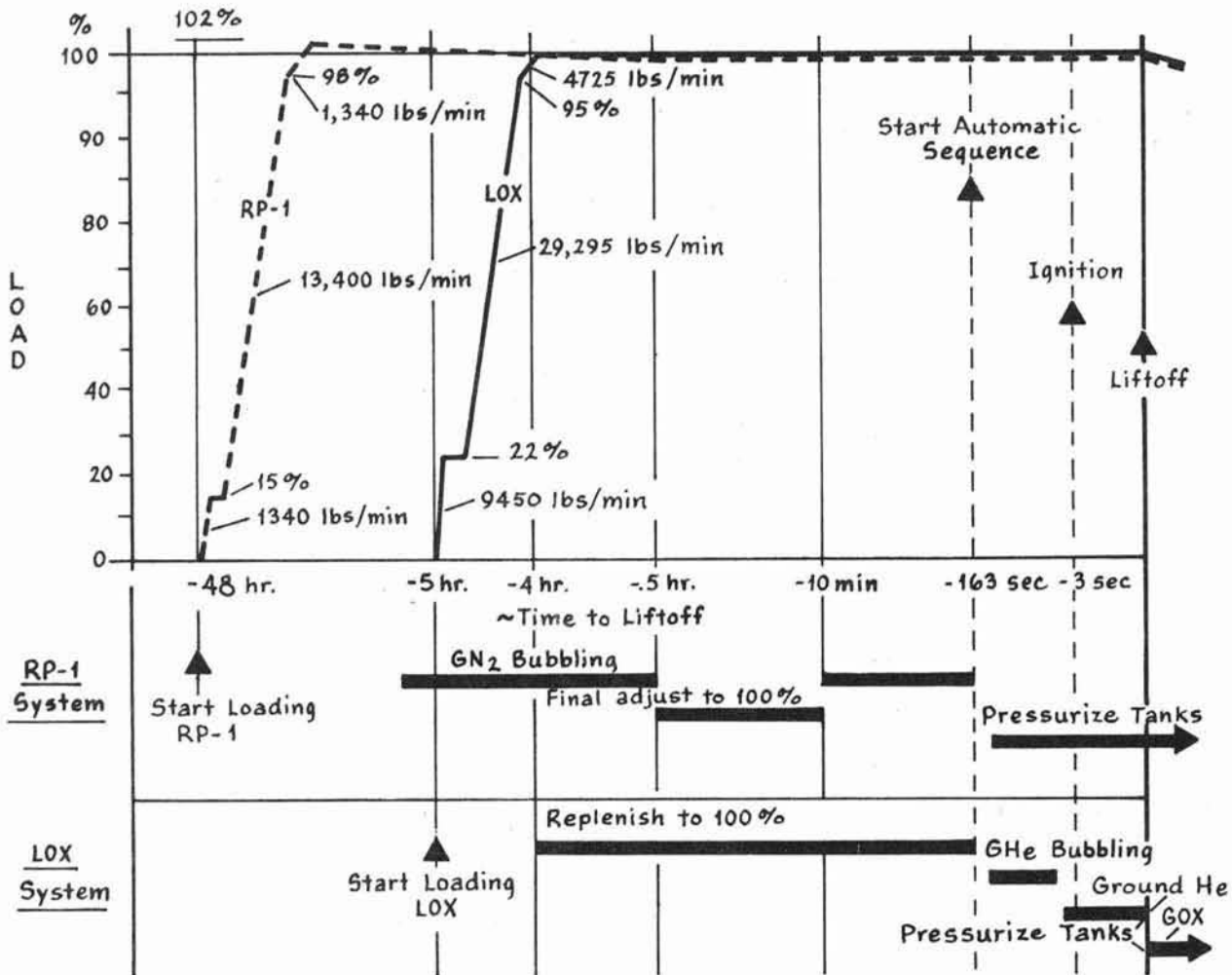


Figure 19

H-1 Engine System

S-IB STAGE PROPELLANT SYSTEM

The S-IB Stage propellant system is composed of five LOX tanks, four RP-1 tanks, propellant lines, control valves, vents, and pressurization subsystems. The sumps of each group of tanks are interconnected to provide uniform propellant levels and pressures. Loading of LOX and RP-1 tanks is controlled by ground computers. After the RP-1 has been loaded and just before the start of LOX loading, ground source GN₂ is bubbled through the RP-1 suction lines to prevent temperature stratification. At the start of the automatic sequence the RP-1 tanks are pressurized with ground source GN₂. During S-IB burn, fuel tank pressurization is maintained by GHe from two 19.3 cubic foot spheres located above two of the fuel tanks. Ground source helium is bubbled through the LOX lines and tanks at the start of the automatic sequence to prevent temperature stratification in the engine LOX suction lines. Prior to engine ignition the bubbling is discontinued and the LOX tanks are pressurized with helium from a ground source. After liftoff, the LOX tank pressurization is maintained with GOX converted from LOX in the heat exchanger.



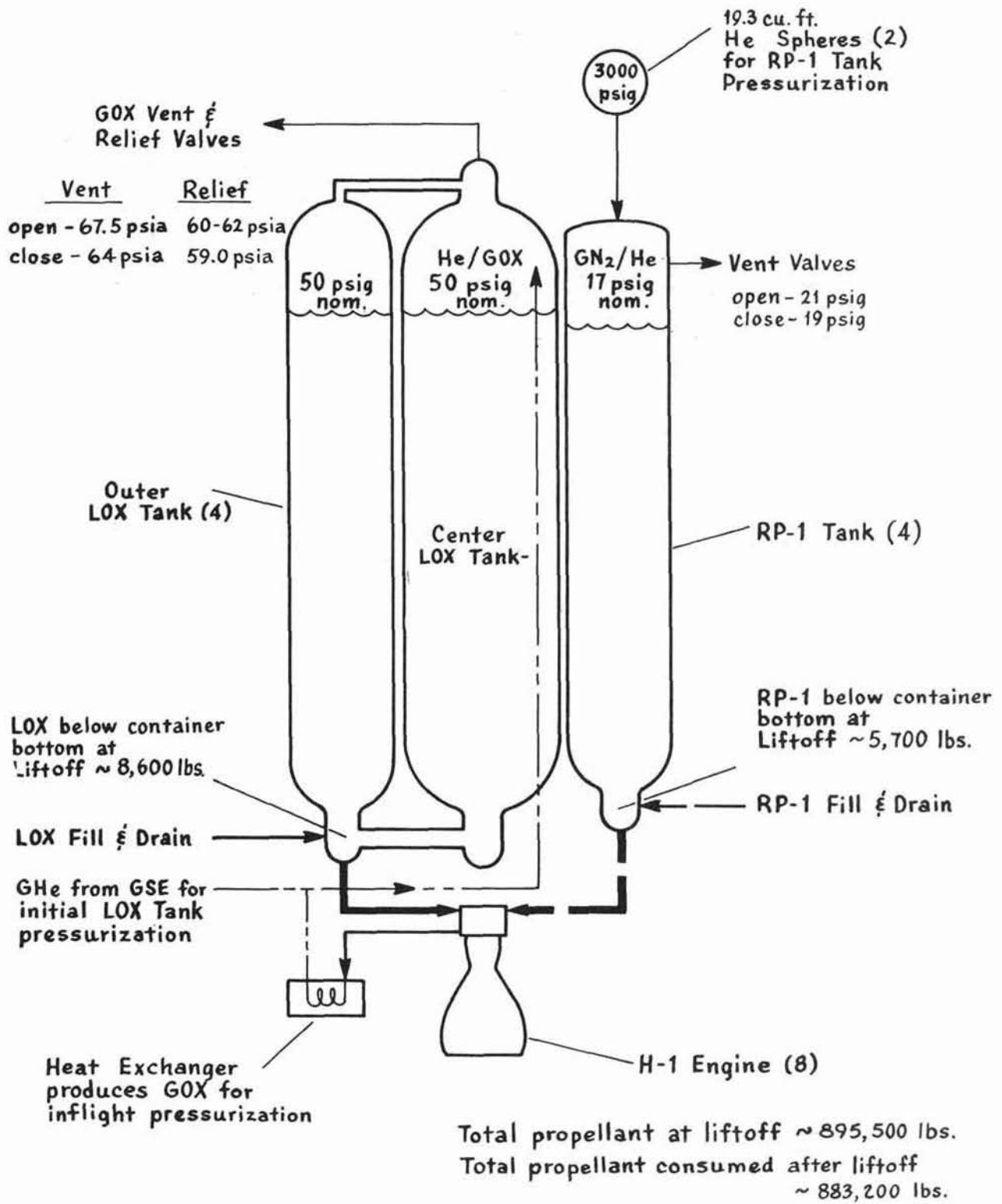


Figure 20

S-IB Stage Propellant System

S-IB STAGE THRUST VECTOR CONTROL SYSTEM

Each of the four outboard H-1 engines is gimbal mounted on the stage thrust structure to provide engine thrust vectoring for vehicle attitude control and steering. Two hydraulic actuators are utilized to gimbal each engine in response to signals from the Flight Control Computer located in the Instrument Unit.

The actuators are part of an independent hydraulic system on each gimballed engine. Hydraulic fluid flows to the actuators from the high pressure accumulator and returns to the low pressure reservoir. The electric motor driven auxiliary pump operates only during prelaunch check-out of the thrust vector control system.

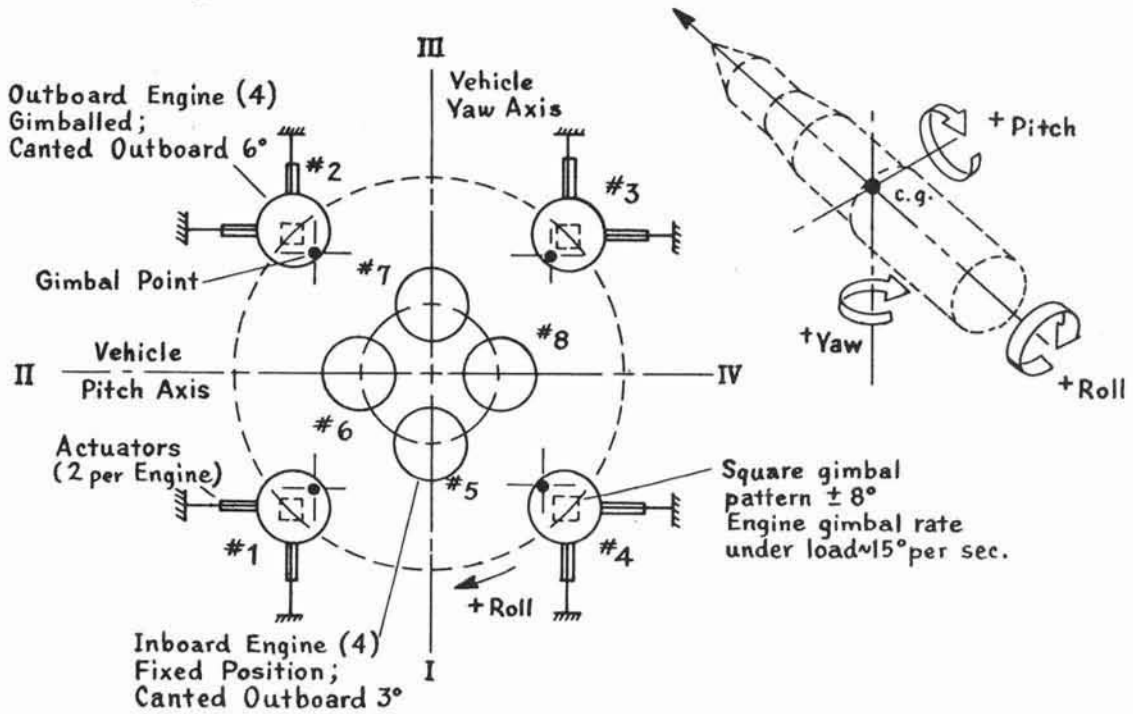
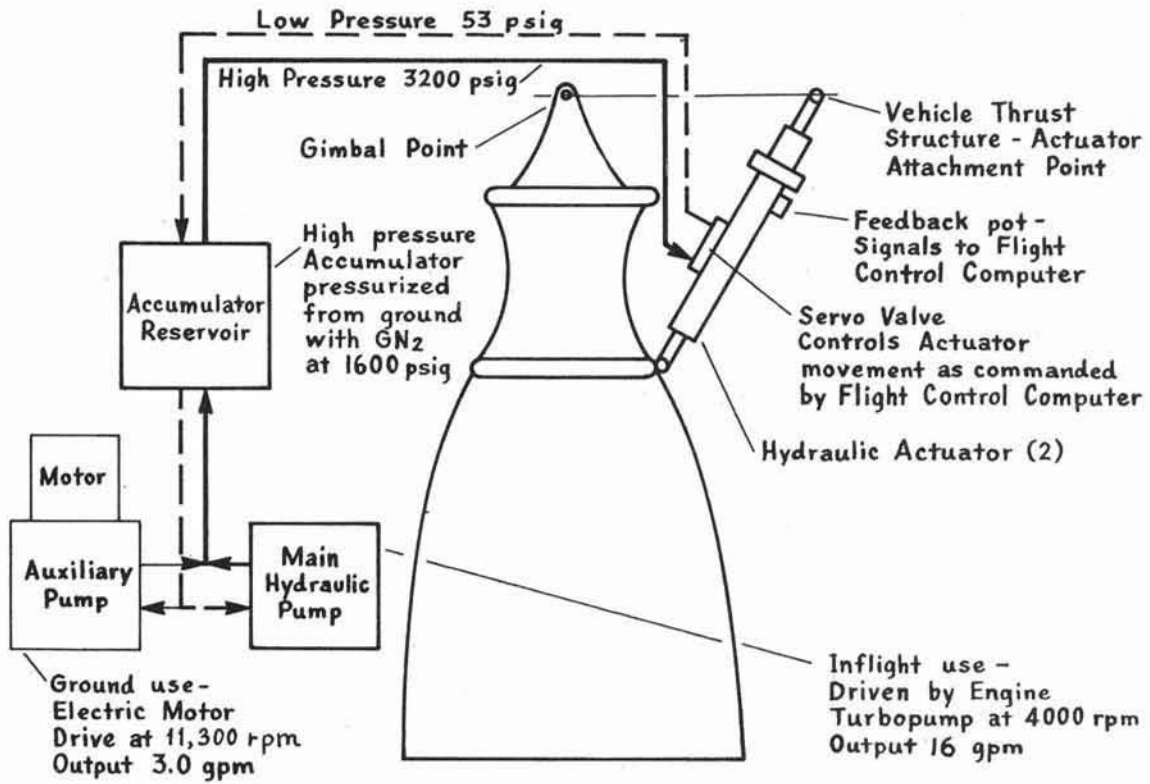


Figure 21

S-IB Stage Thrust Vector Control System

| Summary of Measurements | |
|---------------------------|----------|
| Inflight | 5-1B-204 |
| 1 Acceleration | 3 |
| 2 Acoustics | 1 |
| 3 Temperature | 90 |
| 4 Pressure | 101 |
| 5 Jib | 62 |
| 6 RFET/M | 2 |
| 7 Signals | 99 |
| 8 Level | 18 |
| 9 Voltage, Current, Freq. | 26 |
| 10 Angular Velocity | 3 |
| 11 Strain | 26 |
| 12 Speed | 8 |
| LCC (Blockhouse) Total | 439 |
| | 165 |

Note: There were ~503 inflight and ~167 LCC measurement on 5-1B-203

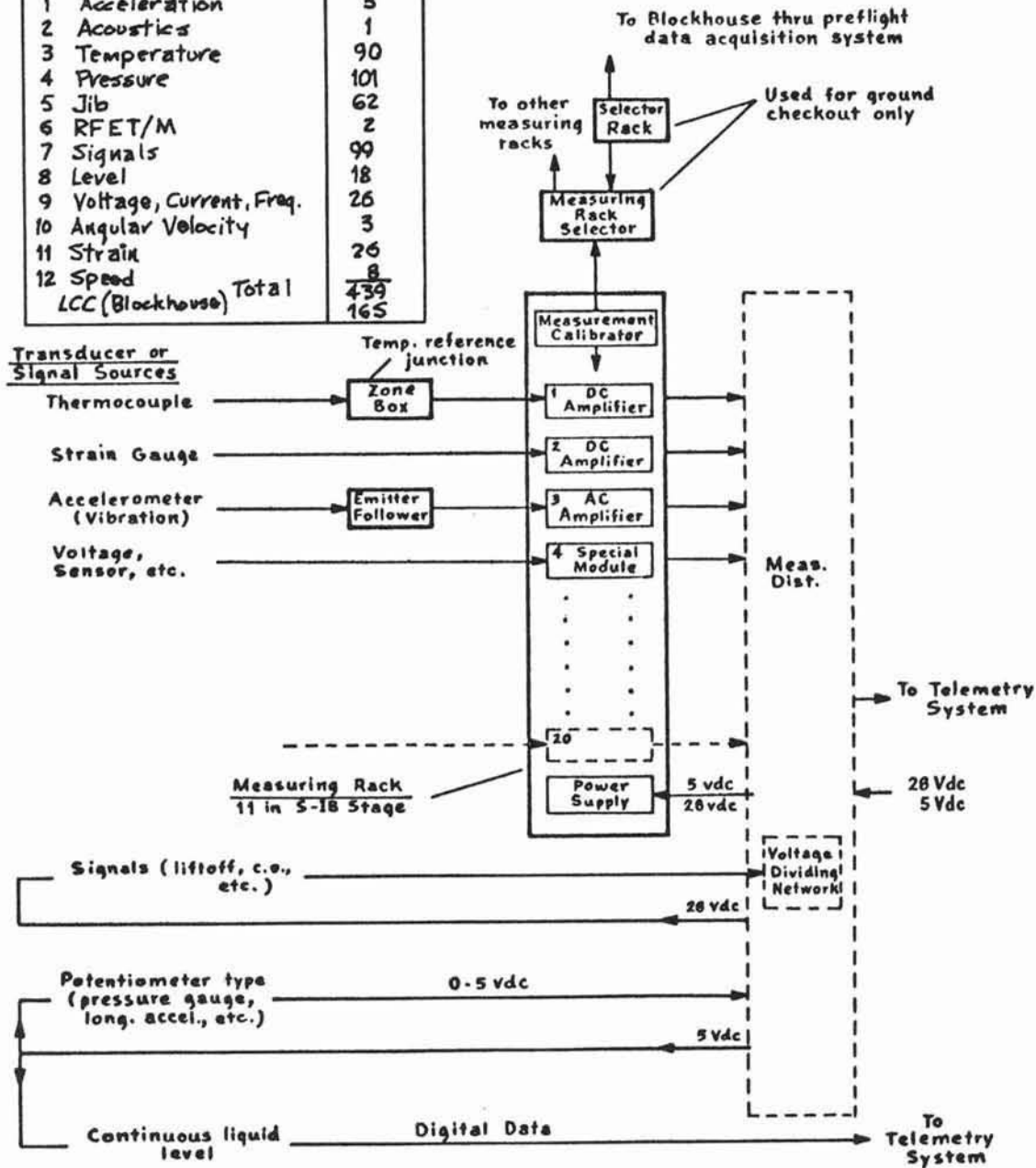


Figure 22

5-1B Stage Measuring System

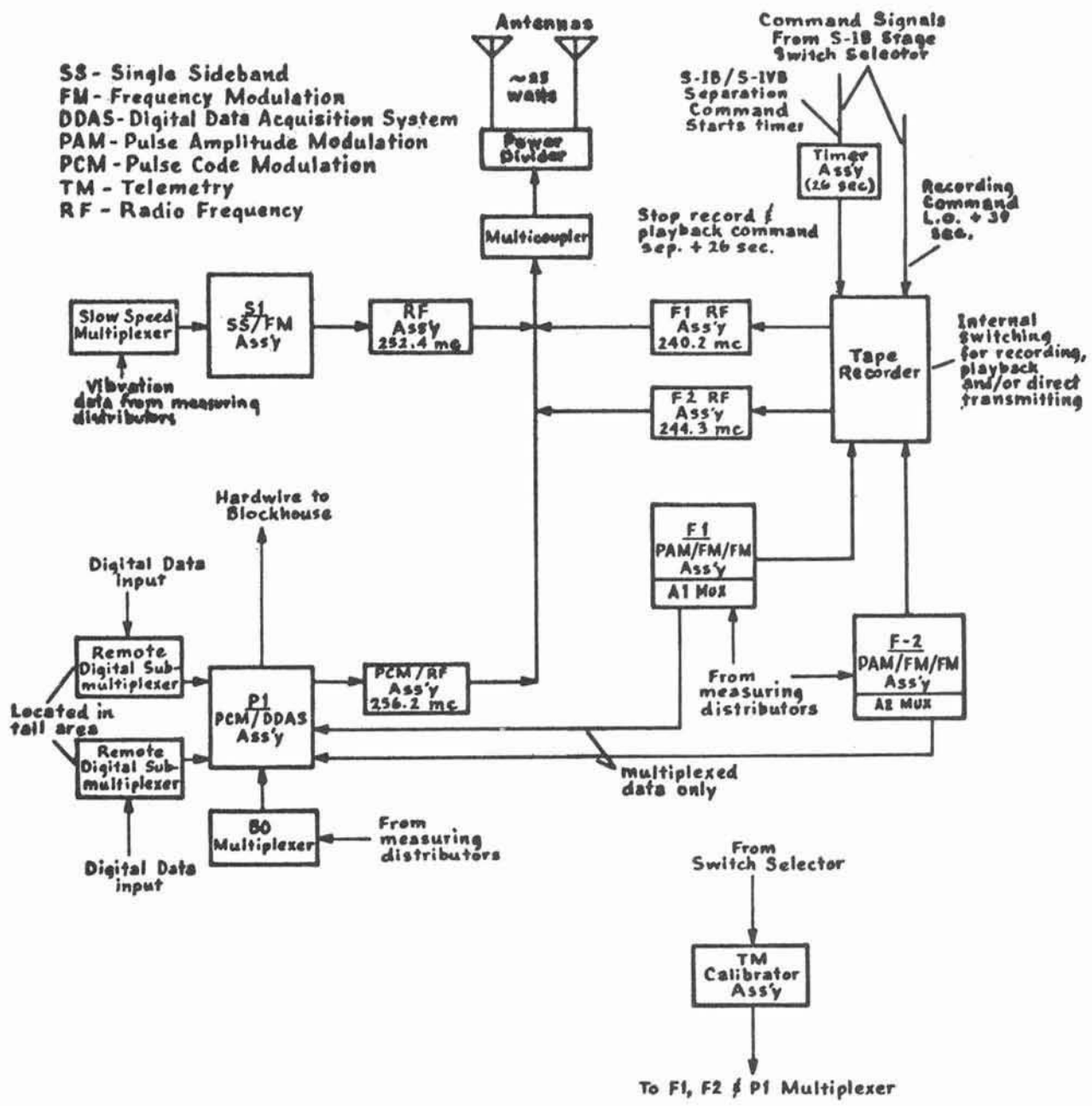


Figure 23

S-1B Stage Telemetry System

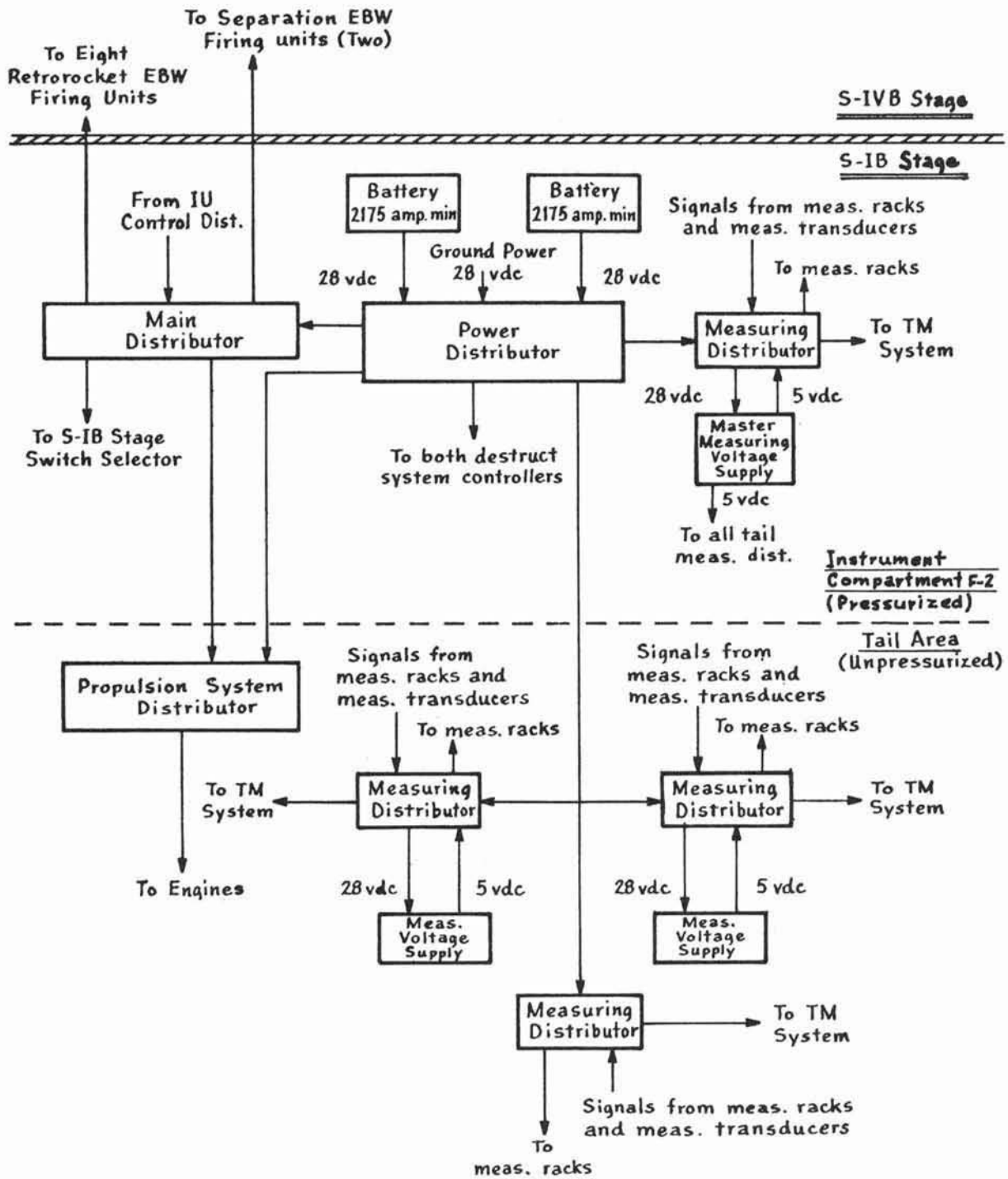


Figure 24

S-IB Stage Electrical Power and Distribution System

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S-IVB STAGE STRUCTURE

The S-IVB Stage consists basically of an aft interstage, an aft skirt, a thrust structure, a divided propellant container and a forward skirt.

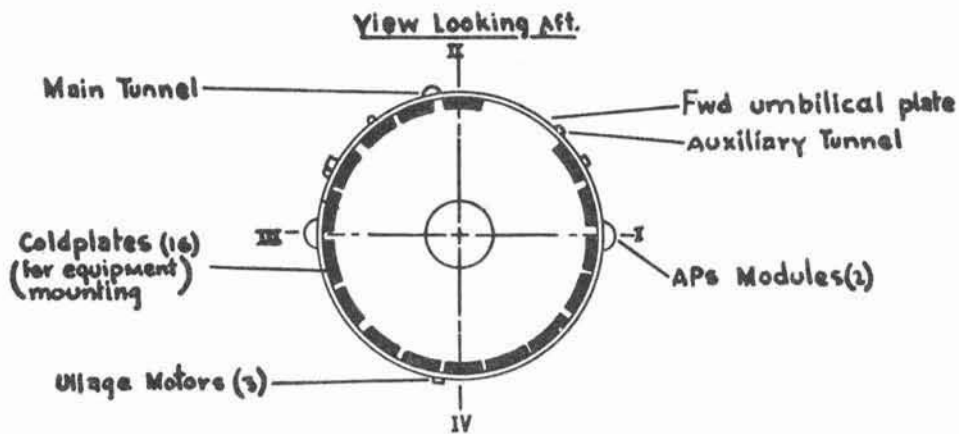
Aft Interstage The aft interstage, also referred to as the S-IB/S-IVB interstage, is a semimonocoque structure which supports the S-IVB Stage, the Instrument Unit and the Apollo Spacecraft payload prior to the S-IB/S-IVB separation. The aft interstage provides mounting facilities for retro-motors. Four Thiokol TE-29-IB solid propellant retro-motors equally spaced circumferentially provide thrust to impart a negative acceleration to the S-IB Stage and the aft interstage after the explosive skin cutting separation at the aft interstage/aft skirt interface.

Aft Skirt The aft skirt is a semimonocoque structure which attaches to the end of the cylindrical portion of the propellant container. The aft skirt houses electrical and electronic components as noted in figure 25. Three Thiokol TX-280 solid propellant motors equally spaced circumferentially provide a positive acceleration to the S-IVB Stage to settle propellants for J-2 engine start. The aft skirt also provides mounting hardware for two attitude control modules diametrically opposed. Each module contains three TAPCO 150-pound thrust (vacuum) hypergolic (MMH and N_2O_4) rocket engines.

Thrust Structure The thrust structure is a truncated cone with longitudinal stiffeners. The forward end (large diameter) of the cone attaches tangentially to the aft bulkhead of the propellant container. The thrust structure provides attachment points for the engine gimbal mount and the hydraulic actuators. A single J-2 rocket engine of 200,000 pound nominal thrust (vacuum) is installed on the centerline of the S-IVB Stage.

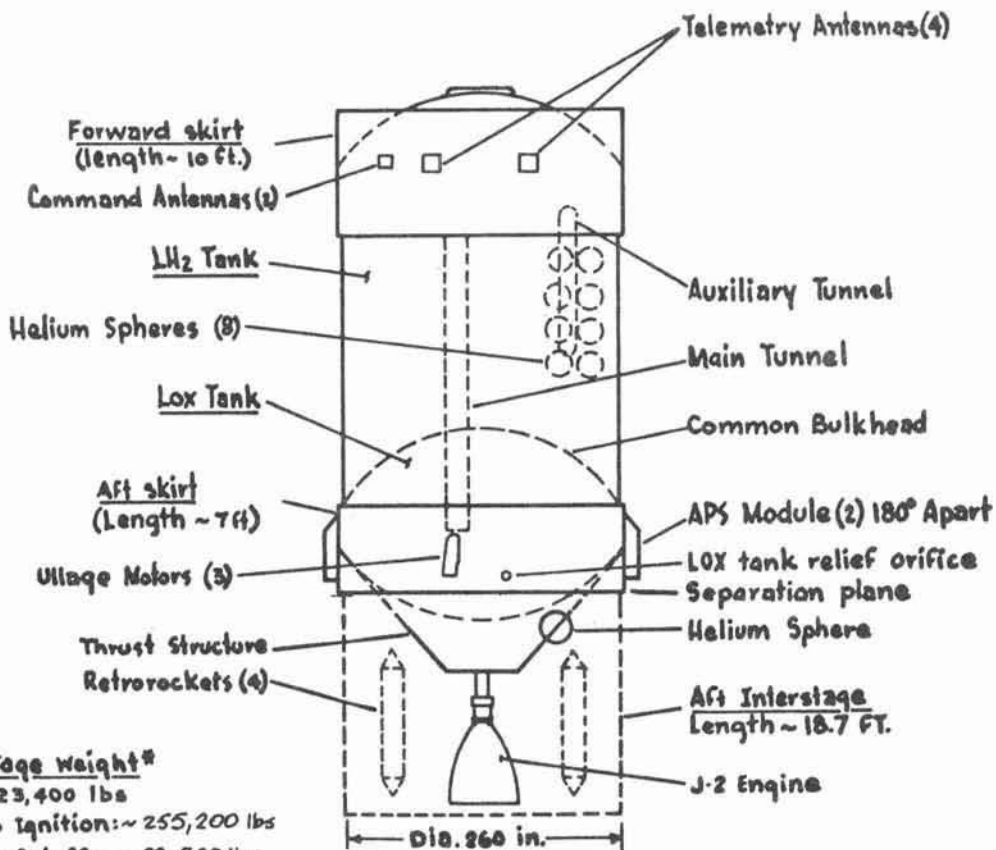
Propellant Container The propellant container is an internally insulated cylinder with hemispherical bulkheads at each end. An internal hemispherical bulkhead with the concave side facing aft divides the propellant container into an aft section for LOX and a forward section for liquid hydrogen. Eight cold helium spheres located in the hydrogen tank provide LOX tank pressurization. An ambient spherical helium bottle mounted on the engine thrust structure provides pneumatic control pressurization throughout the vehicle pressure system. The ambient helium bottle on AS-204 has been increased from .5 cu. ft. to 4.5 cu. ft. to provide pressurization for propellant venting exercises during orbit.

Forward Skirt The forward skirt is a semimonocoque cylindrical structure which attaches to the forward end of the cylindrical portion of the propellant container and supports the Instrument Unit and the payload. The forward skirt houses electrical and electronic components (most mounted on coldplates) and provides external mounting for telemetry and command antennas.



Stage Length: ~ 59 ft.

Including 8 in. protrusion
of LH₂ tank beyond S-IVB/IV
mating surface



S-IVB Stage Weight*
 • Dry: ~ 23,400 lbs
 • At S-IVB Ignition: ~ 255,200 lbs
 • At S-IVB Cutoff: ~ 29,500 lbs
 * Excludes wt. of
 aft interstage

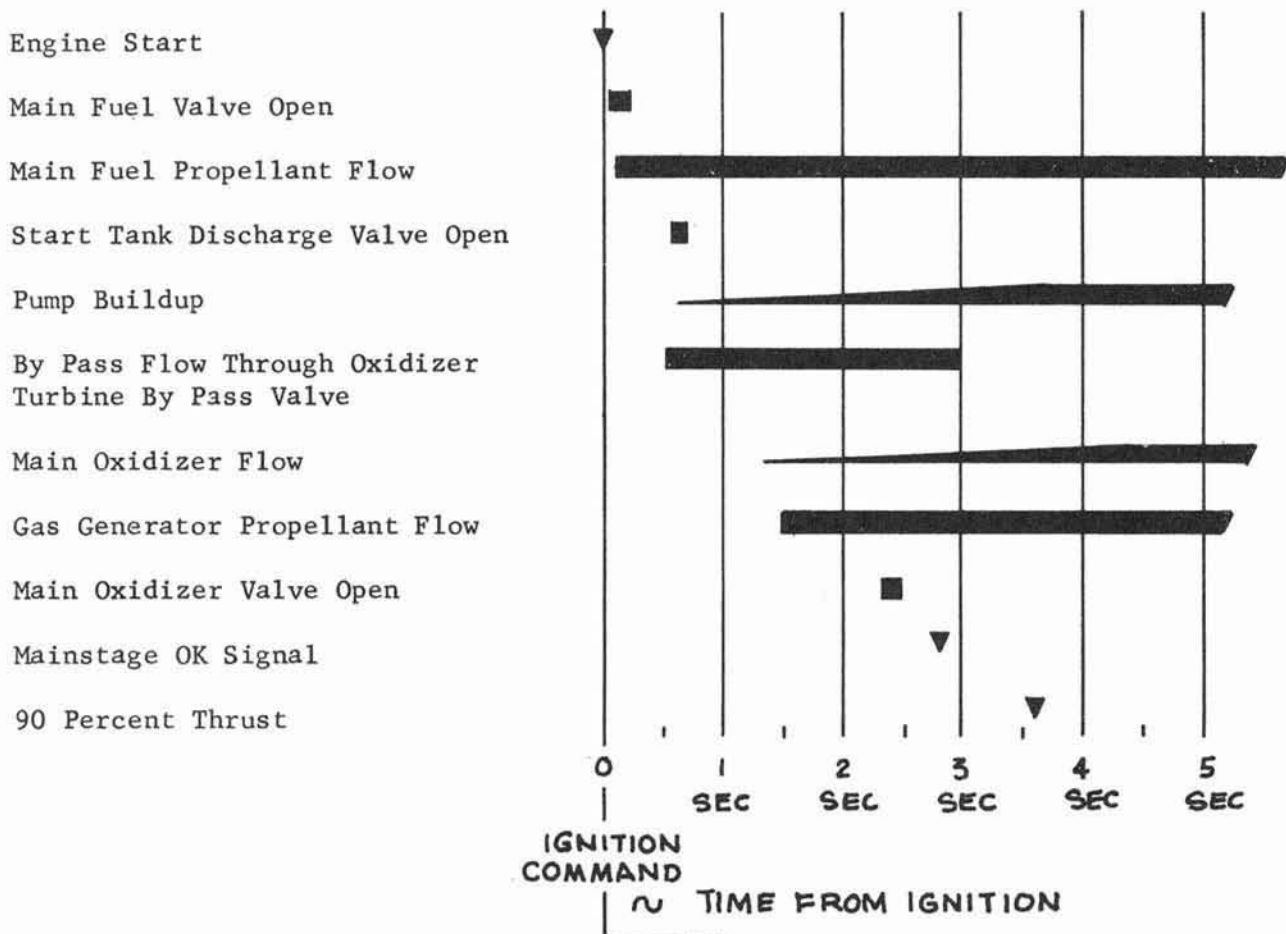
Figure 25

S-IVB Stage Configuration

J-2 ENGINE OPERATION S-IVB

The operating cycle of the J-2 Engine consists of prestart, start, steady-state operation and cutoff sequences. During prestart, LOX and LH₂ flow through the engine to temperature-condition the engine components, and to assure the presence of propellant in the turbopumps for starting. Following a timed cooldown period, the start signal is received by the sequence controller which energizes various control solenoid valves to open the propellant valves in the proper sequence. The sequence controller also energizes spark plugs in the gas generator and thrust chamber to ignite the propellant. In addition, the sequence controller releases GH₂ from the start tank. The GH₂ provides the initial drive for the turbopumps that deliver propellant to the gas generator and the engine. The propellant ignites, gas generator output accelerates the turbopumps, and engine thrust increases to main stage operation. At this time, the spark plugs are de-energized and the engine is in steady-state operation.

Steady-state operation is maintained until a cutoff signal is received by the sequence controller. The sequence controller de-energizes the solenoid valves which in turn close the engine propellant valves in the proper sequence. As a result, engine thrust decays and the cutoff sequence is complete.



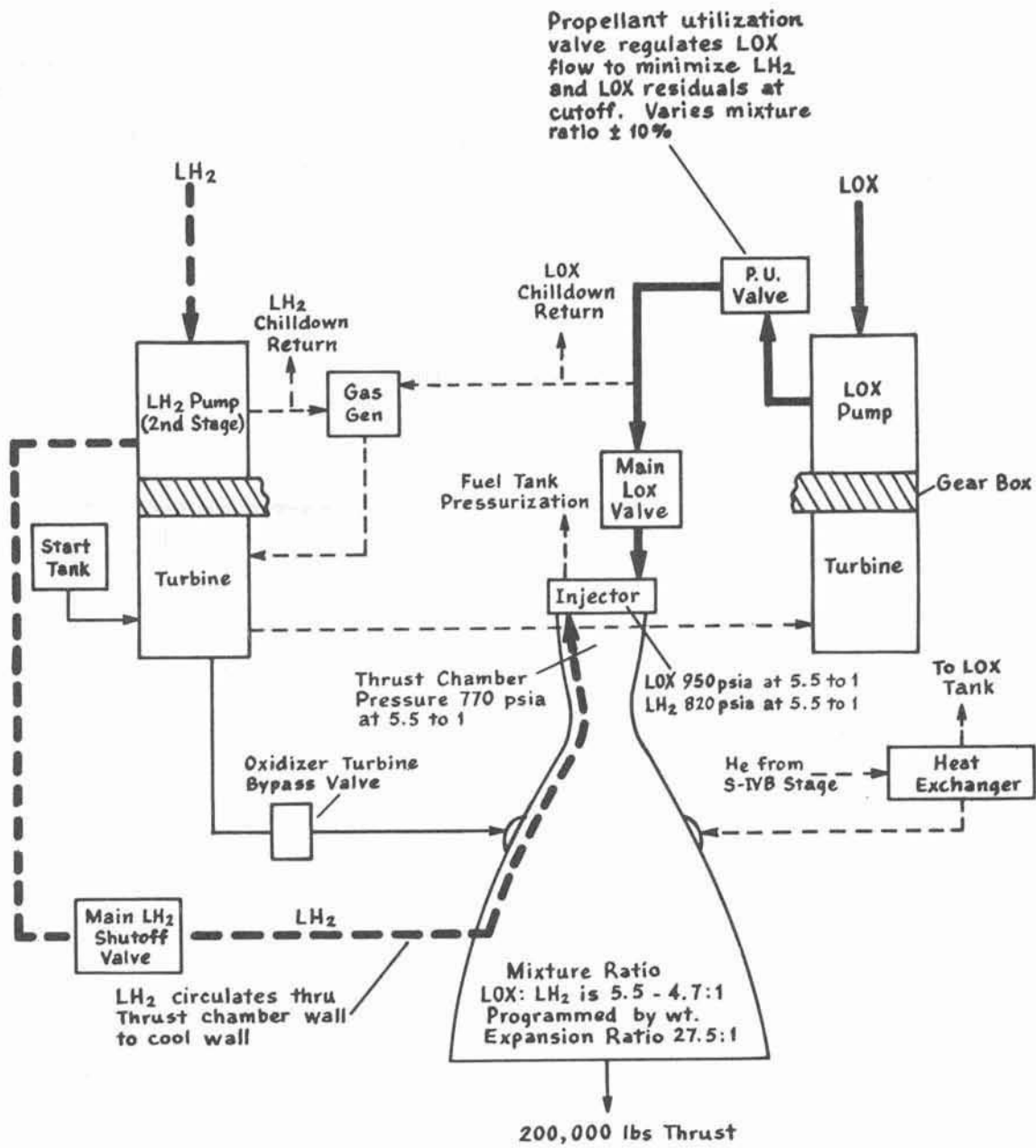


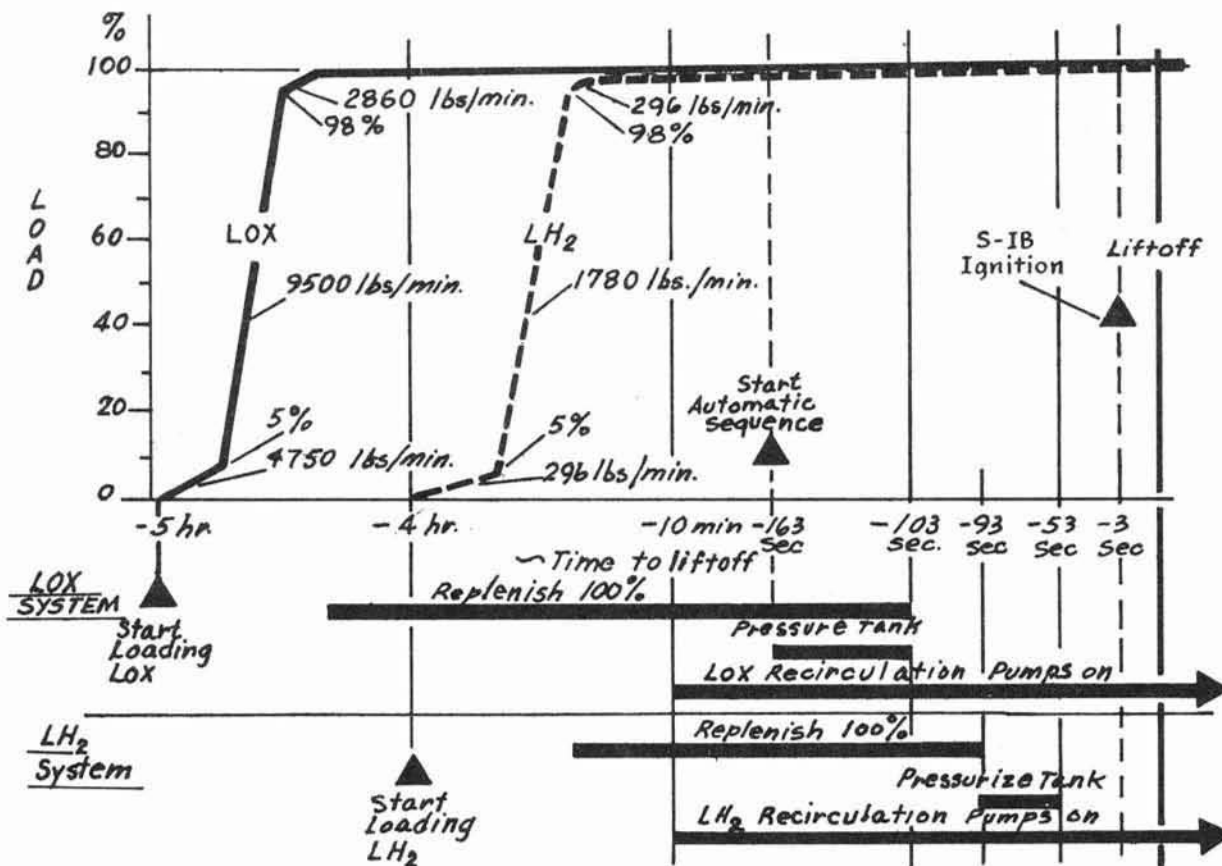
Figure 26

J-2 Engine System

S-IVB STAGE PROPELLANT SYSTEM

The S-IVB propellant system is composed of integral LOX/LH₂ tanks, propellant lines, control valves, vents, and pressurization subsystems. Loading of the propellant tanks and flow of propellants is controlled by the propellant utilization system. Both propellant tanks are initially pressurized by ground source cold helium. LOX tank pressurization during S-IVB Stage burn is maintained by helium supplied from spheres in the LH₂ tank, which is expanded by passing through the helium heater, to maintain positive pressure across the common tank bulkhead and to satisfy engine net positive suction head. The LH₂ pressurization strengthens the stage in addition to satisfying net positive suction head requirements. After engine ignition the pressure is maintained by GH₂ tapped from the engine supply.

S-IVB PROPELLANT LOAD AND OPERATIONAL SEQUENCE



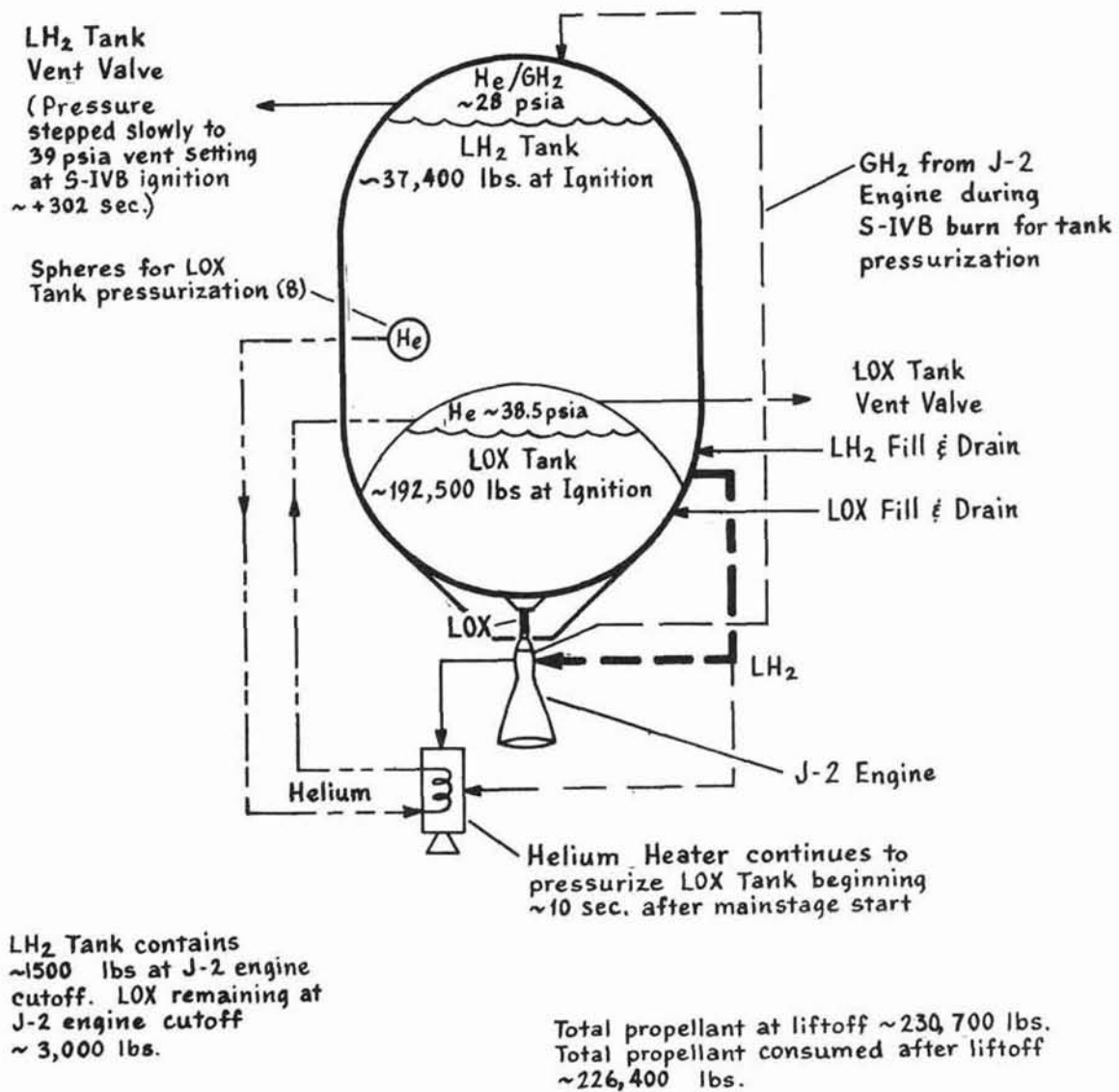


Figure 27

S-IVB Stage Propellant System

