LTP-770-154-900

Introduction to the Lunar Module

Programmed Text

V A L I D A T I O N C O P Y

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CONTENTS

INSTRUCTIONS

Before you start this programmed text, it is advisable that you take the Introduction to the Lunar Module (LM) pretest. You may already possess the knowledge that will be presented and this method of pretesting will allow you to advance in accordance with your background and knowledge. Successful completion of this pretest will give you credit for this text.

This program is self-teaching and will allow you to progress at your own speed. Information is presented on each page. You will normally be required to answer or respond to the information that you have just read. Your response may be in the form of matching statements to equipment lists, completing sentences, filling in block diagrams, or completing diagrams. Your response will require you to not only use the information you will read in the frame, but will also allow you to participate in teaching yourself by reaching conclusions on the subject. Your answer or conclusion will be reinforced on the next page, where you will find find the correct answer.

Read a frame, or information page; complete the exercise; then check your answer. If you missed the answer, reread the material given to ascertain your error. Retest yourself and then continue with the programmed text. You will be periodically tested to allow you to determine how well you are progressing. An end-of-text examination will be administered by the Flight Control Qualification Section (FCQS).

OBJECTIVES

At the completion of this programmed instruction text, the student will be able to:

1. Identify the Lunar Module axes and eleven external structural components, when given a picture of the LM with unlabeled axes and a list of eleven components.

2. State the location of the Commander and Lunar Module Pilot in the cabin while at the normal crew stations.

3. Complete a block diagram of the Electrical Power Subsystem, when given a list of EPS components.

4. Identify correct statements from a given list pertaining to the Environmental Control Subsystem.

5. Complete a table of statements on the Propulsion and Reaction Control Subsystem by filling in the proper section; Ascent Engine, Descent Engine, or Reaction Control Jet.

6. Match a list of statements about the Guidance, Navigation, and Control Subsystem to the applicable section; Abort Guidance, Primary Guidance and Navigation, Control Electronics, or Radar.

7. Select correct statements from a given list about the Explosive Devices used on the LM.

8. Identify eight statements about the Instrumentation Subsystem as to Telemetry, Caution and Warning, or Conditioning.

9. Draw the possible Communication links between the LM and Earth or the Command Service Module, when given a drawing with the LM, Earth, and Command Service Module indicated.

10. Label a list of Communication capabilities as an S-Band link, or VHF link.

11. Match a list of statements pertaining to the Lunar Module to the appropriate LM subsystem.

INTRODUCTION

The Lunar Module (LM) is the spacecraft that will land two Apollo astronauts on the lunar surface and return them to the orbiting Command and Service Module (CSM). To provide the necessary equipment stowage and engine systems for the lunar landing and lift-off, the LM is configured in two stages. The Descent, or lower stage contains the Descent Engine and its fuel and oxidizer system; water and oxygen supplies for the Descent phase of the LM mission; Landing Radar; Apollo Lunar Surface Experiment Package (ALSEP), and the Landing Gear.

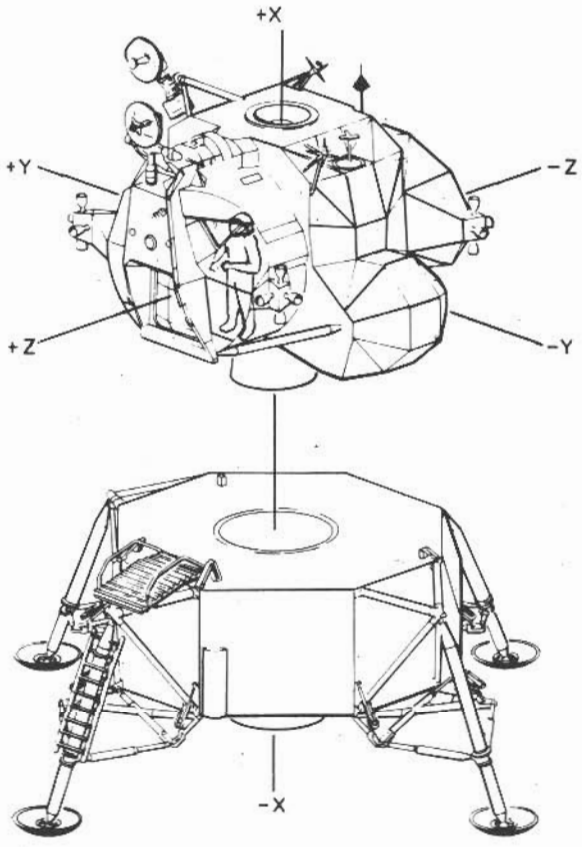
The Ascent Stage of the LM houses the pressurized crew compartment; the Ascent Engine, utilized for lift-off from the lunar surface; rf antennas used for communications links with the Earth and CSM, and a radar link between the LM and CSM, and the necessary electronic and life support equipment for the lunar mission.

For the discussion in this programmed text, the LM will be divided into the following areas:

1. LM External Structural Identification
2. Electrical Power
3. Environmental Control
4. Propulsion and Reaction Control
5. Guidance, Navigation, and Control
6. Explosive Devices
7. Instrumentation
8. Communications

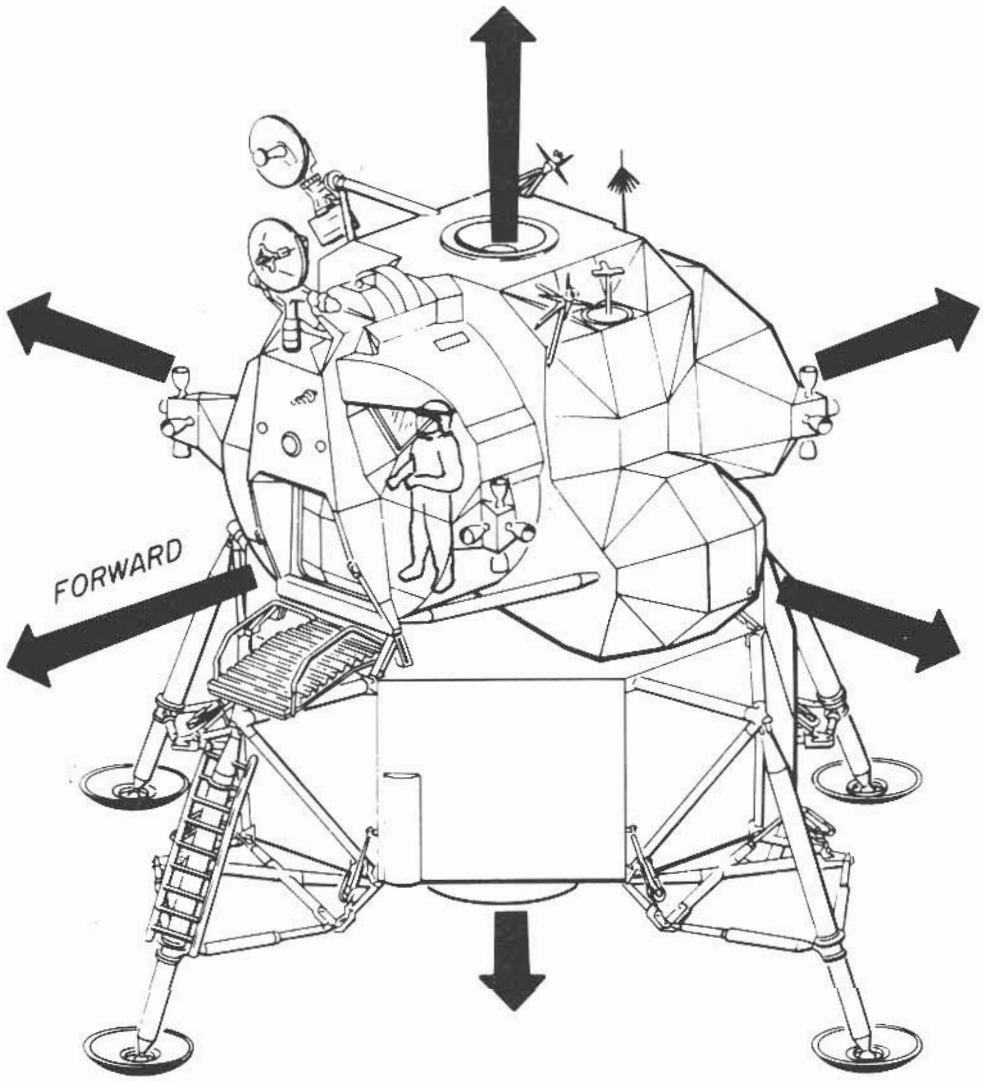
LUNAR MODULE (LM) EXTERNAL STRUCTURAL IDENTIFICATION

The Lunar Module (LM) contains two stages; Ascent and Descent. The following drawing shows the LM and its three axes which form a right-handed orthogonal triad. The forward axis is +Z and goes through the Ingress/Egress hatch. The vertical axis is +X and goes through the docking tunnel. The lateral axis, completing the triad, is Y.

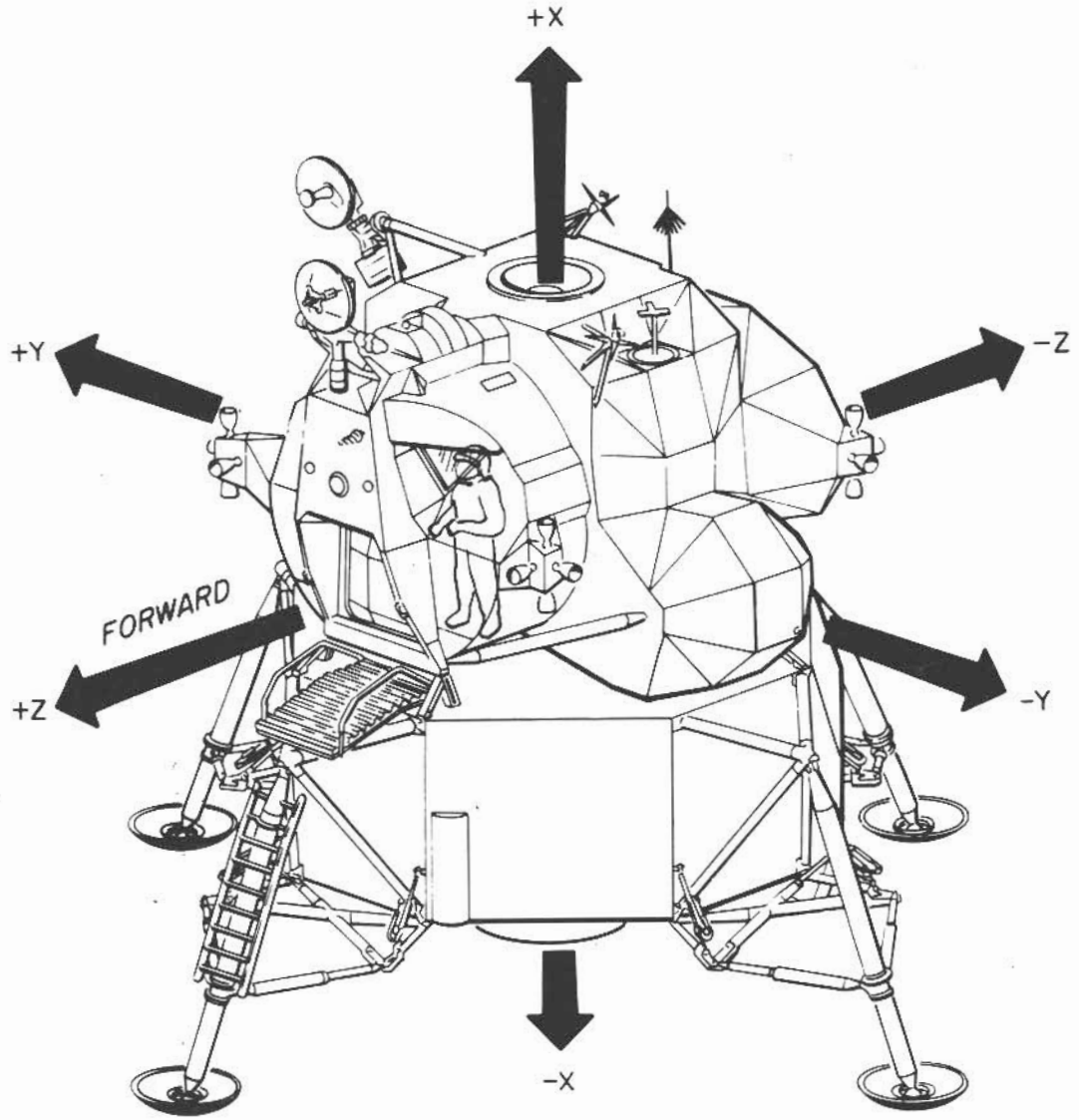


Positive directions of the LM axes are defined as +Z forward, +Y to the right, +X upward. All directions are referenced to a crew member standing in the cockpit looking forward.

On the following LM drawing, label the LM positive and negative X, Y, and Z axes.



Answer:



The docking tunnel is along the _____axis. The _____ axis goes through the ingress/egress hatch.

Answer: X axis; Z axis

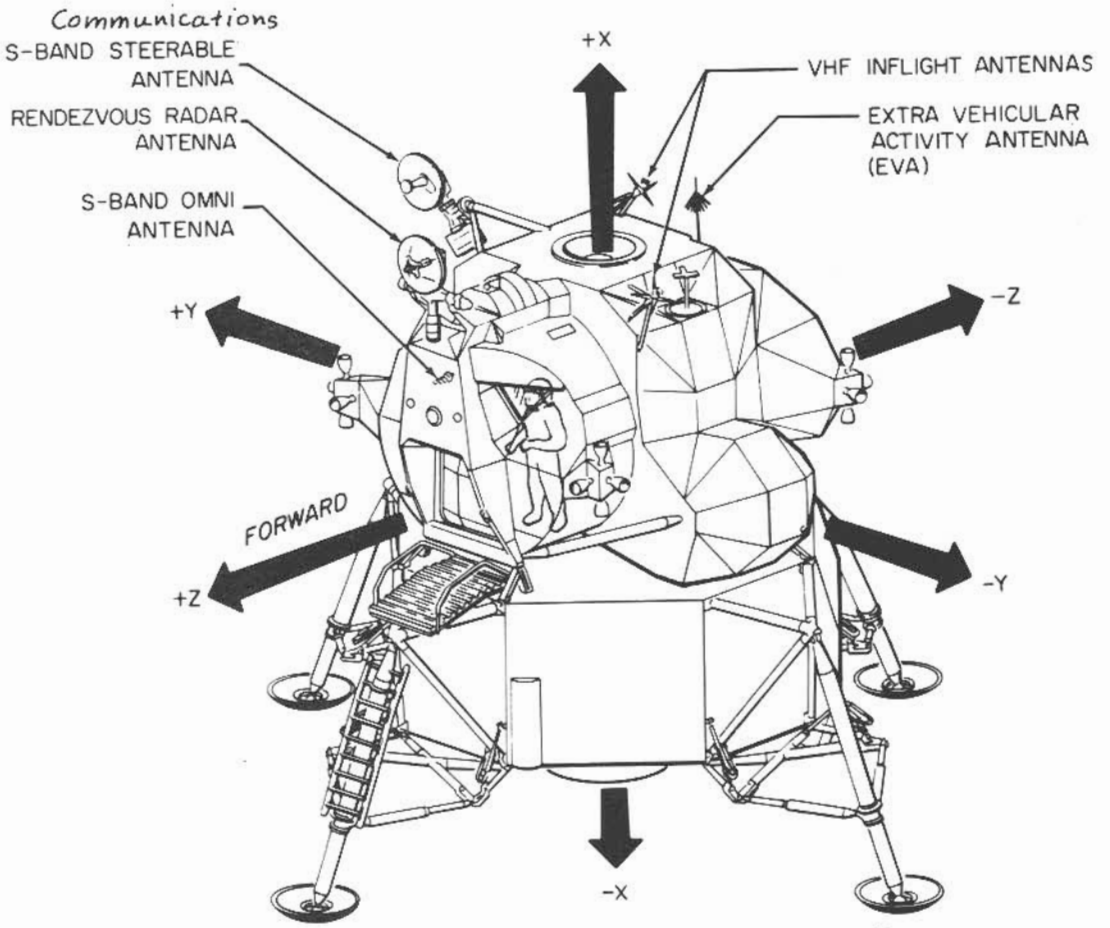
There are two astronauts to fly the LM. The Commander and the LM Pilot stand side-by-side, looking forward along +Z. The Commander is on the LM -Y side, and the LM Pilot is on the LM +Y side. The +X axis is at their head.

Circle the correct answer:

Looking forward, the Commander is on the (left/right) side; the LM Pilot is on the (left/right) side.

Answer: Commander, left side; LM Pilot, right side.

There are several antennas mounted on the outer structure of the LM Ascent Stage. The Rendezvous Radar Antenna and the Communications S-Band Steerable Antenna stand out due to their respective size and position.



On the following diagram, label the unlabeled axes and write in the names of the given components next to their location on the LM:

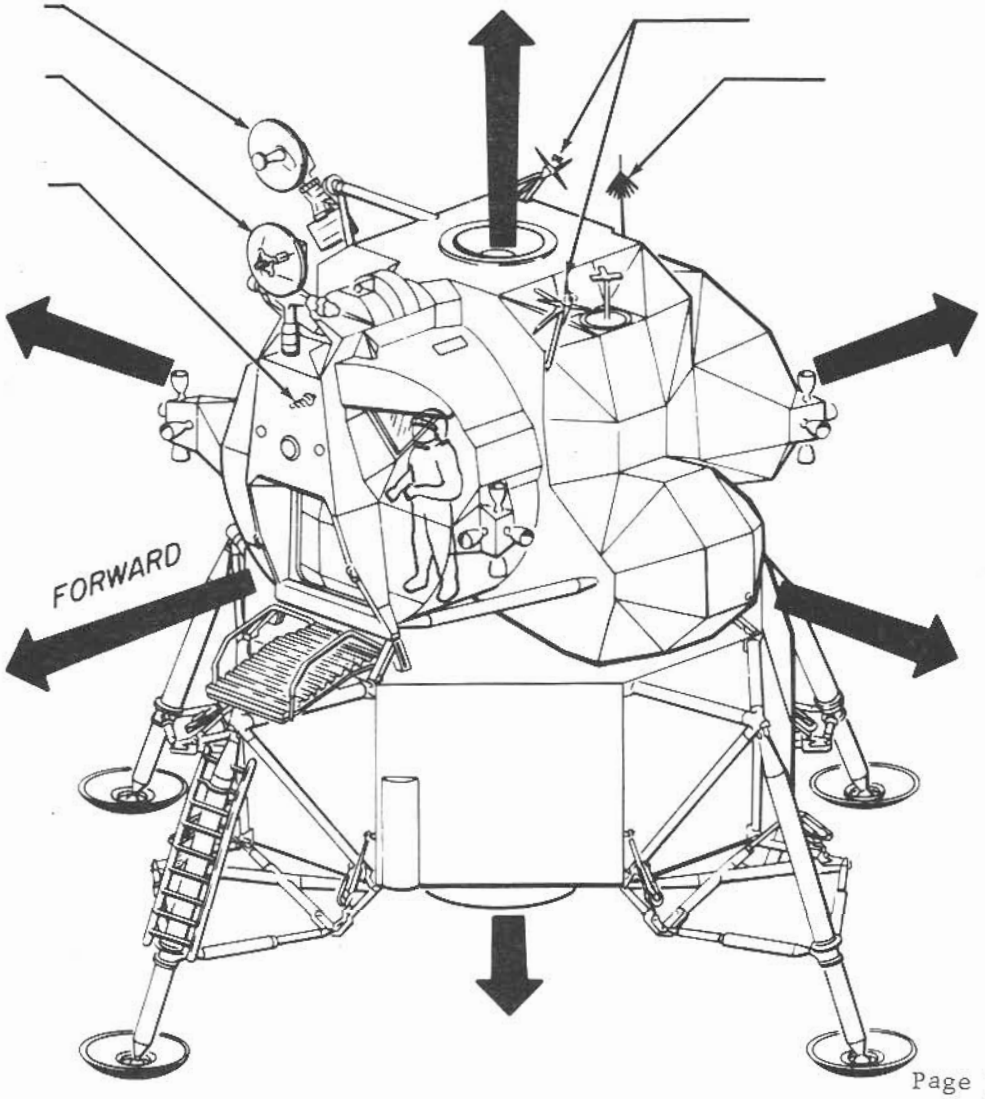
S-Band Steerable Antenna

Rendezvous Radar Antenna

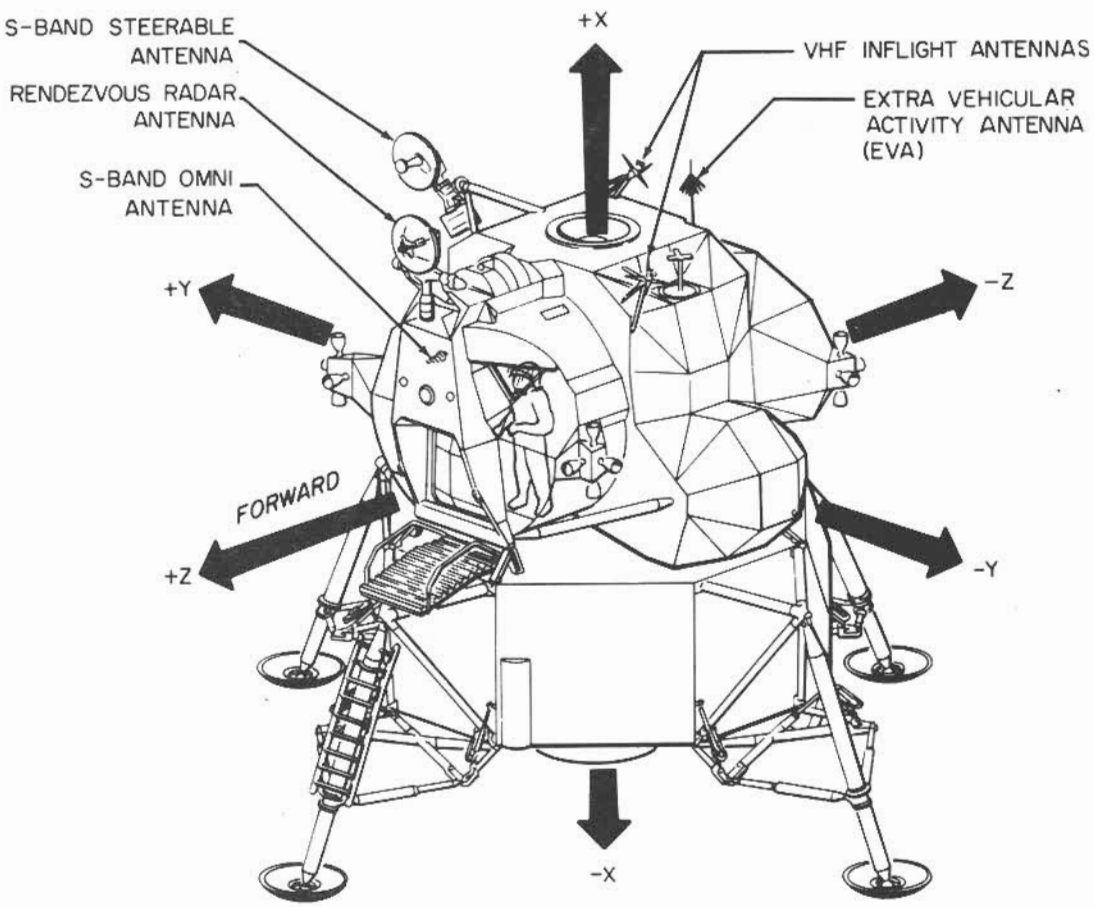
VHF Inflight Antennas

S-Band Omni Antenna

EVA Antenna



Answer: Your diagram should be labeled like the one below:



In addition to antennas, there are several other important externally mounted components to become familiar with, and which should be easily identifiable.

On the given diagram, identify the items listed below by writing the letter of each item in the space provided next to the location on the LM structure.

a. Docking Target

b. Landing Gear

c. Ingress/Egress Hatch

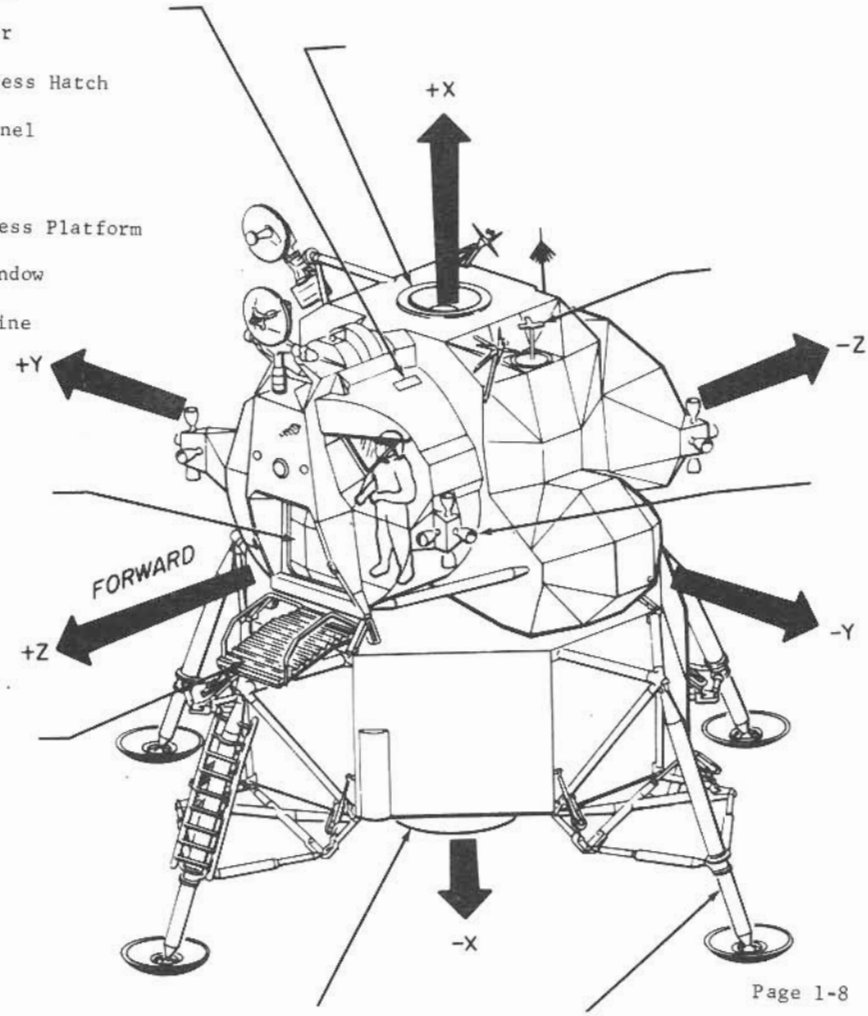
d. Docking Tunnel

e. RCS Jet

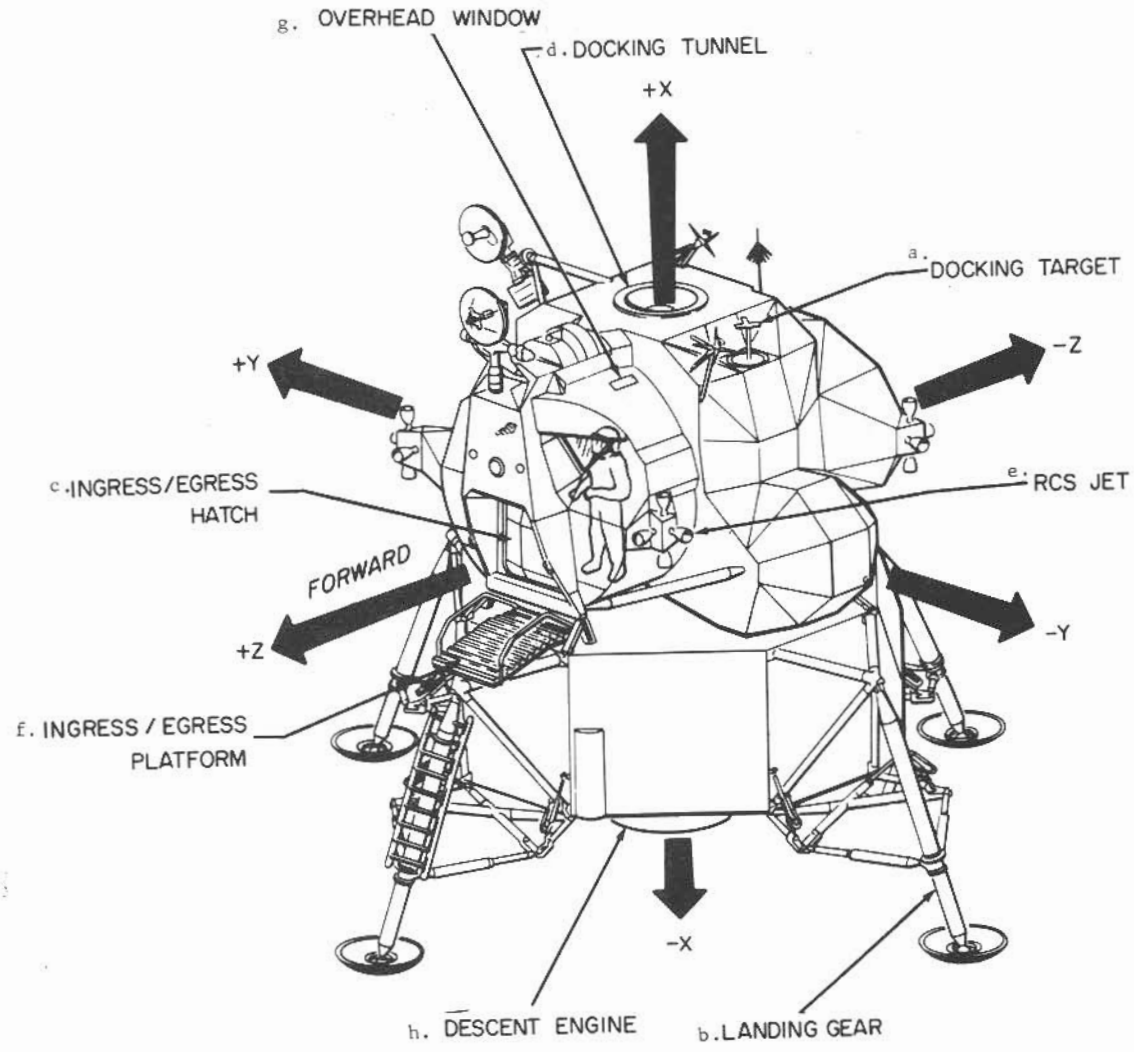
f. Ingress/Egress Platform

g. Overhead Window

h. Descent Engine



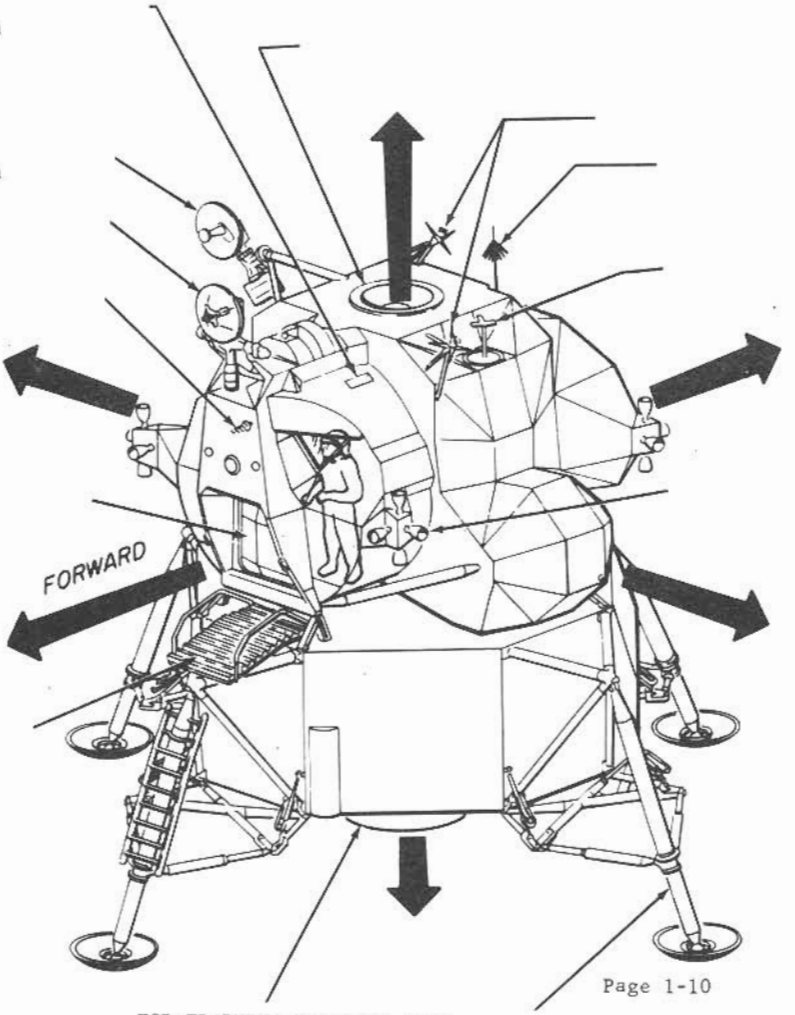
Answer: Your correctly labeled diagram should look like the one below.



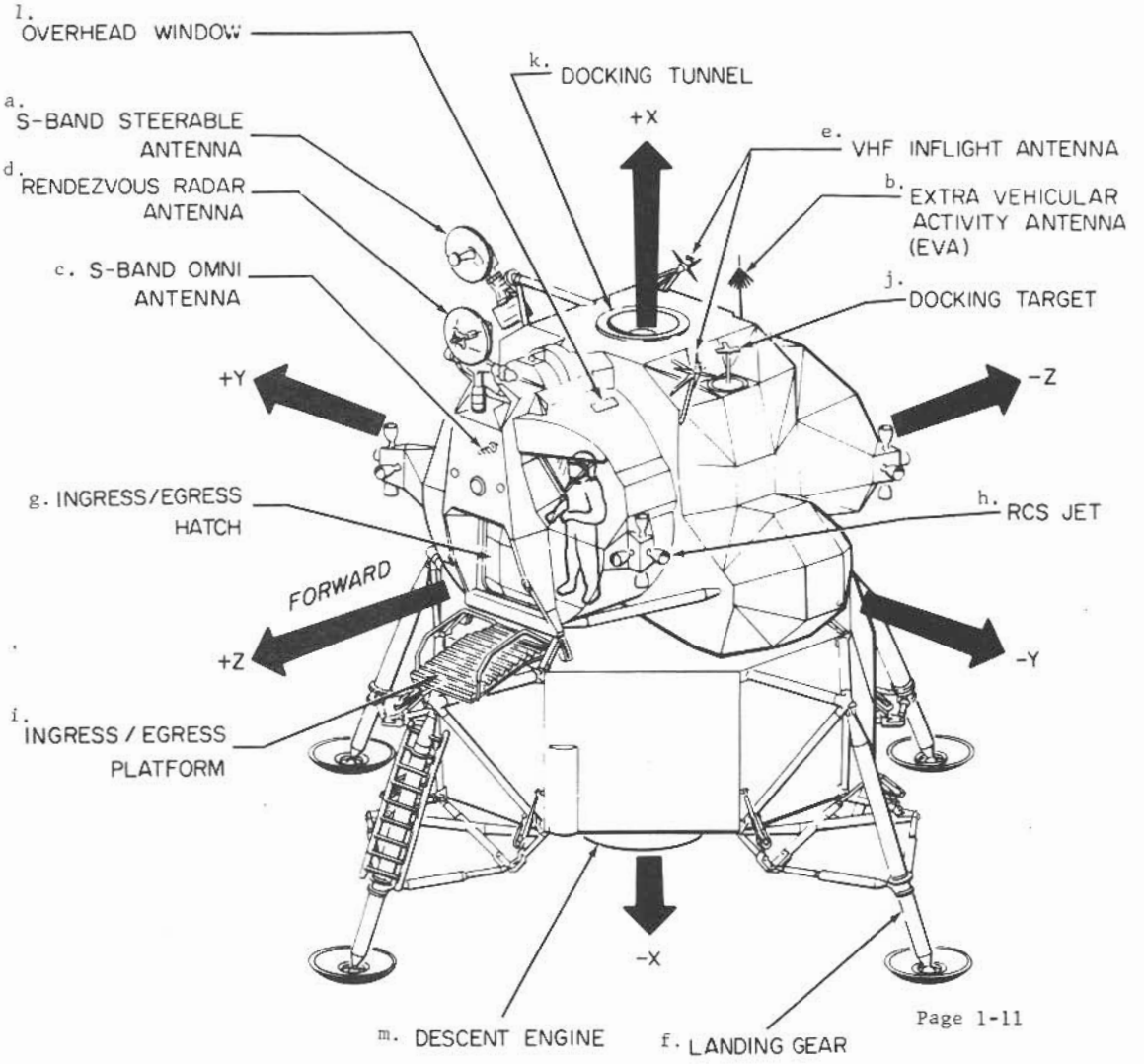
Now that you are familiar with the LM physical appearance and the LM axes, you should be able to identify by name the externally mounted LM components and the LM axes.

On the unlabeled LM diagram below, label the axes and write the letter by each component next to the arrow pointing to it. Given below is the list of components to be identified.

a. S-Band Steerable Antenna
b. EVA Antenna
c. S-Band Omni Antenna
d. Rendezvous Radar Antenna
e. VHF Inflight Antennas
f. Landing Gear
g. Ingress/Egress Hatch
h. RCS Jet
i. Ingress/Egress Platform
j. Docking Target
k. Docking Tunnel
l. Overhead Window
m. Descent Engine



Answer: Your completely labeled LM diagram should look like the labeled LM diagram below. If it does, you have satisfactorily completed the first objective of this text.



ELECTRICAL POWER SUBSYSTEM

The Electrical Power Subsystem consists of four busses, (Commander's DC, LM Pilot's DC, AC Bus "A", and AC Bus "B"), to supply power for all electrical functions of the LM Mission.

The four busses in the Electrical Power Subsystem are: (Circle the proper answer.)

a. One DC bus and three AC busses.

b. One DC bus and one AC bus.

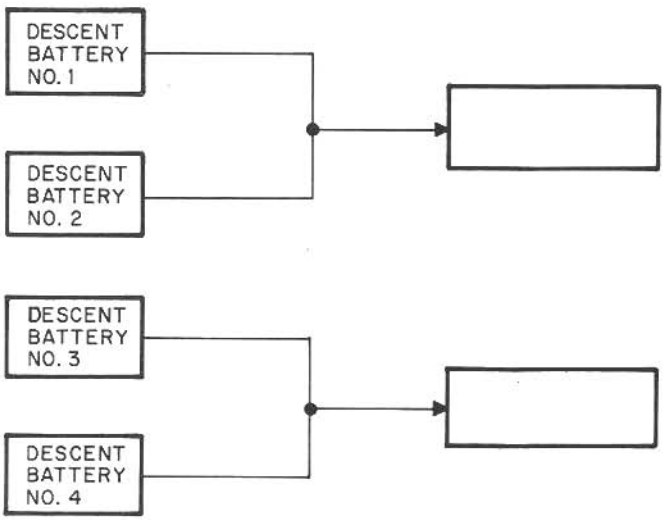
c. Two DC busses and two AC busses.

d. Three DC busses and one AC bus.

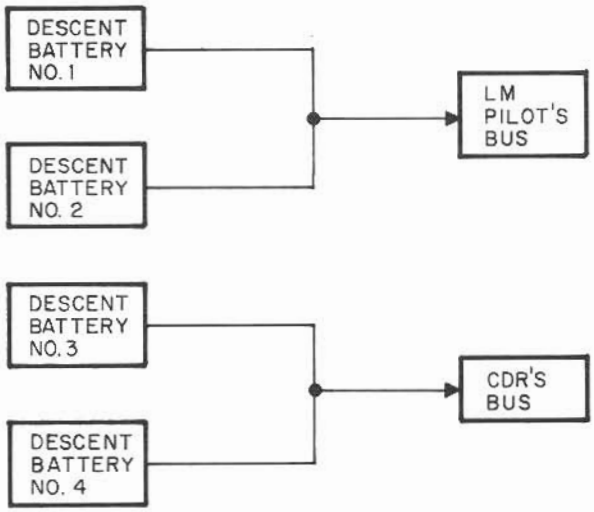
Answer: c., Two DC busses and two AC busses.

Initially, the Commander's and LM Pilot's DC busses are supplied power from batteries located in the descent stage of the vehicle. Descent batteries No. 1 and No. 2 are connected to the LM Pilot's bus, and descent batteries No. 3 and No. 4 are connected to the Commander's bus.

Label the proper DC busses in the diagram below:



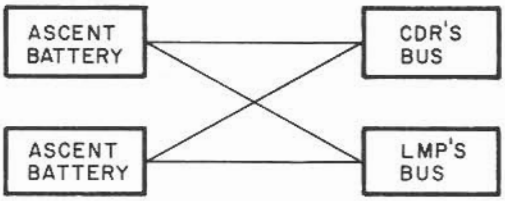
ANSWER:



Later in the mission, the LM will be staged, separating the descent and ascent stages. To maintain power on the two DC busses, two batteries located in the ascent stage are connected to the busses. In normal operation, each bus is connected to one battery, but in the event of abnormal operation, the battery may also be connected to the other bus.

On the drawing below, draw lines between the battery/ batteries to the busses to indicate all possible connections (normal and abnormal).

Answer:



Any time the descent engine is operating, all the descent and ascent batteries are turned ON to assure proper bus voltage.

Circle the total number of batteries that are turned ON for descent engine operation:

A. 4

B. 2

C. 6

D. 5

Answer: (6) c. (4 descent batteries and 2 ascent batteries)

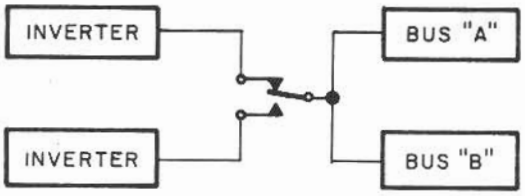
During the translunar coast period, all LM batteries are turned OFF, and the Command Service Module supplies DC power to the LM for critical electronic component heater power.

Place a T or F in the allotted space to indicate whether the following statement is true or false:

_____ During the translunar coast period, the LM batteries are paralleled with CSM DC power to assure required heater operation.

Answer: False

Two inverters are used to supply AC power for the LM. AC Bus A and Bus B are on the Commander's circuit breaker panel. Either inverter can be connected to both busses, but only one at a time is operable.



Label the following statements True or False:

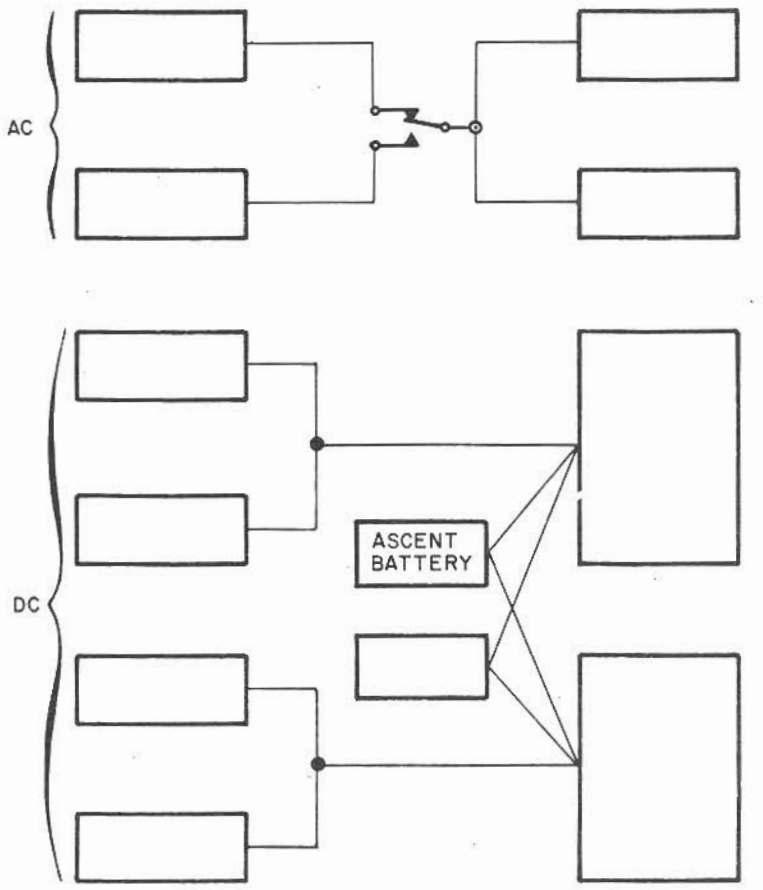
_____ The LM AC inverters replace the six batteries for equipment operation.

_____ Each inverter supplies its own equipment.

Answer: False

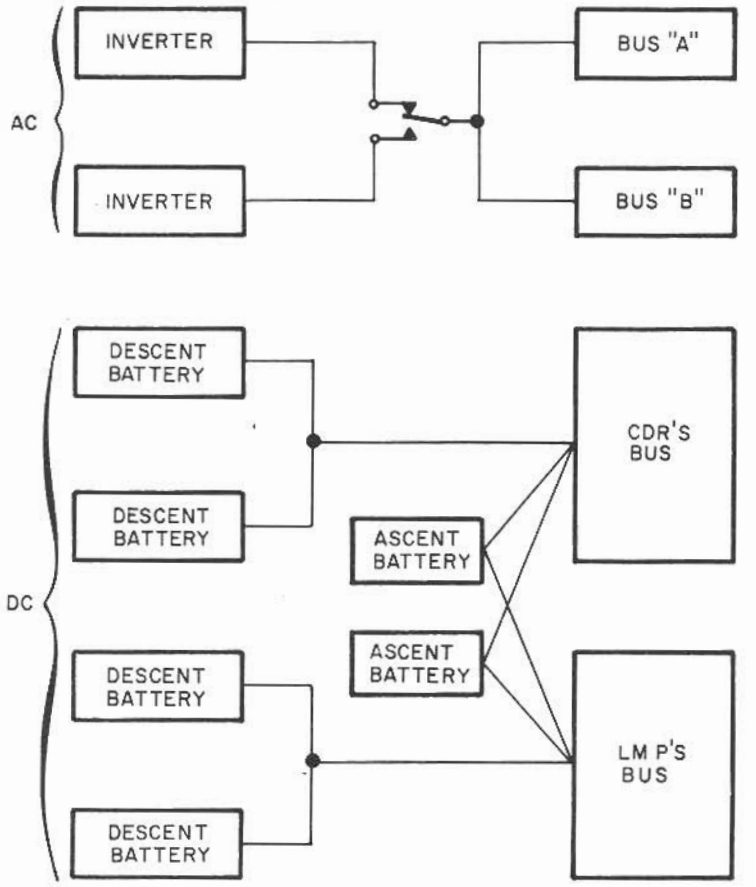
False

On the block diagram below, label the blocks from components in the given list. (NOTE: Some components may be used more than once; some are incorrect and will not be used.)



1. COMMANDER'S BUS
2. FUEL CELL
3. VOLTAGE REGULATOR
4. DESCENT BATTERY
5. BUS "B"
6. RELAY
7. INVERTER
8. BUS "A"
9. LM PILOT'S BUS
10. ASCENT BATTERY

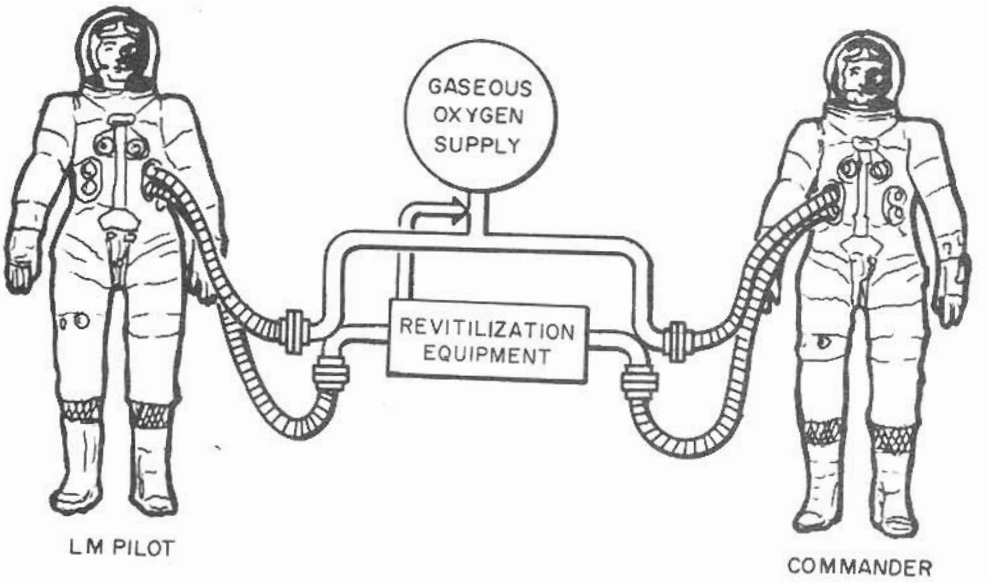
Answer: Your completed diagram should look like this:



Environmental Control Subsystem

The Lunar Module Environmental Control Subsystem provides an oxygen atmosphere for crew life support as well as the cooling required for the atmosphere and the LM electronic equipment.

The drawing below illustrates a suited, closed loop, oxygen supply for the LM astronauts. This source can supply either astronaut individually or both simultaneously.

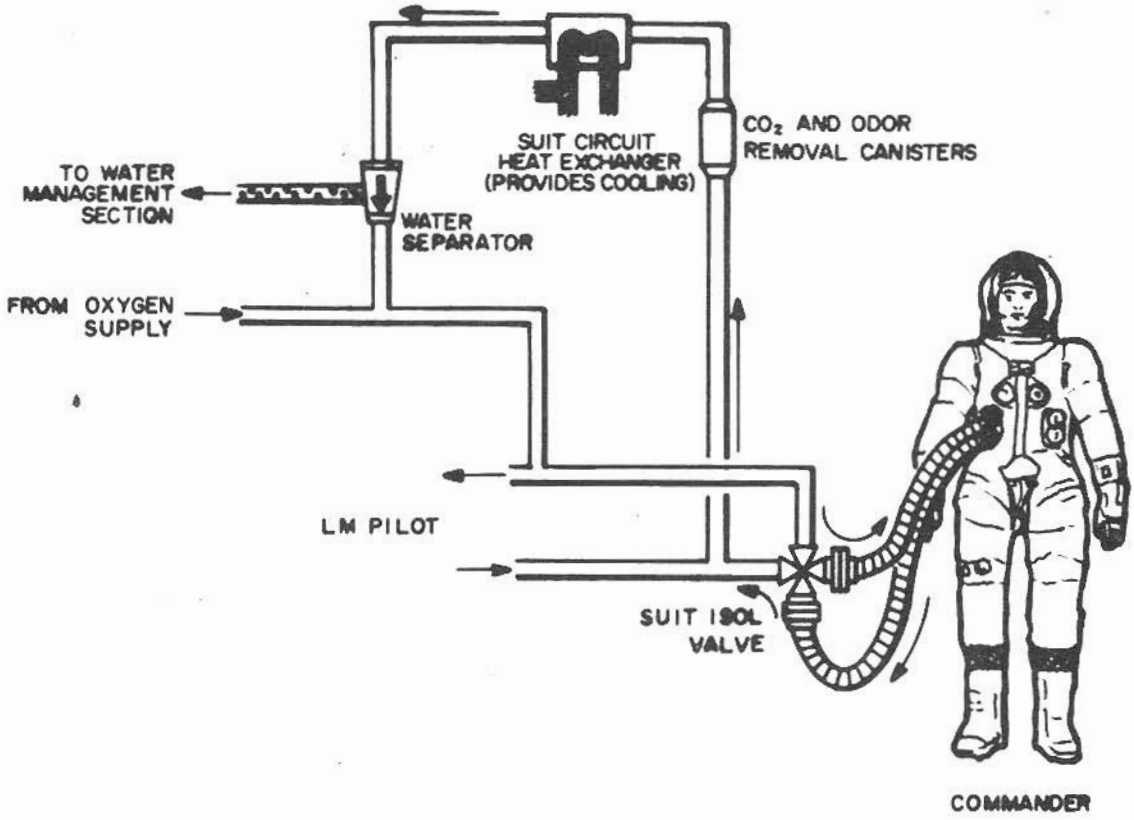


Circle the correct answer.

The closed loop oxygen supply shown indicates that the astronauts are dependent, independent of the cabin atmosphere.

Answer: The astronauts are independent of the cabin atmosphere.

The astronauts' oxygen is revitalized for reuse. The diagram below shows the oxygen flow from the Commander's suit through the revitalization loop back to the oxygen supply line.



Odor is one waste product removed by the revitalization loop. Utilizing the diagram, list three additional waste products removed by the revitalization loop.

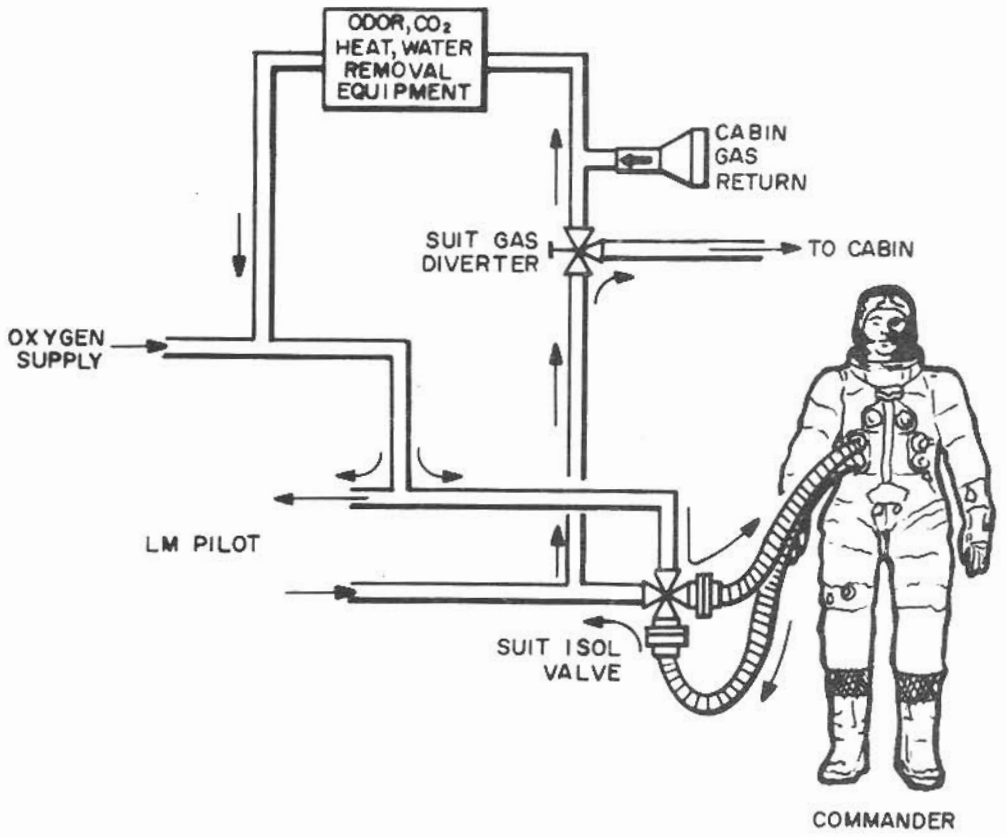
1. _____

2. _____

3. _____

Answer: 1. CO_2
2. Heat
3. Water

When the cabin is pressurized and the astronauts in an open loop configuration (helmets off) oxygen is returned from the cabin into the suit circuit. Here, it is revitalized and returned back into the cabin. The oxygen supply tanks maintain proper pressure.



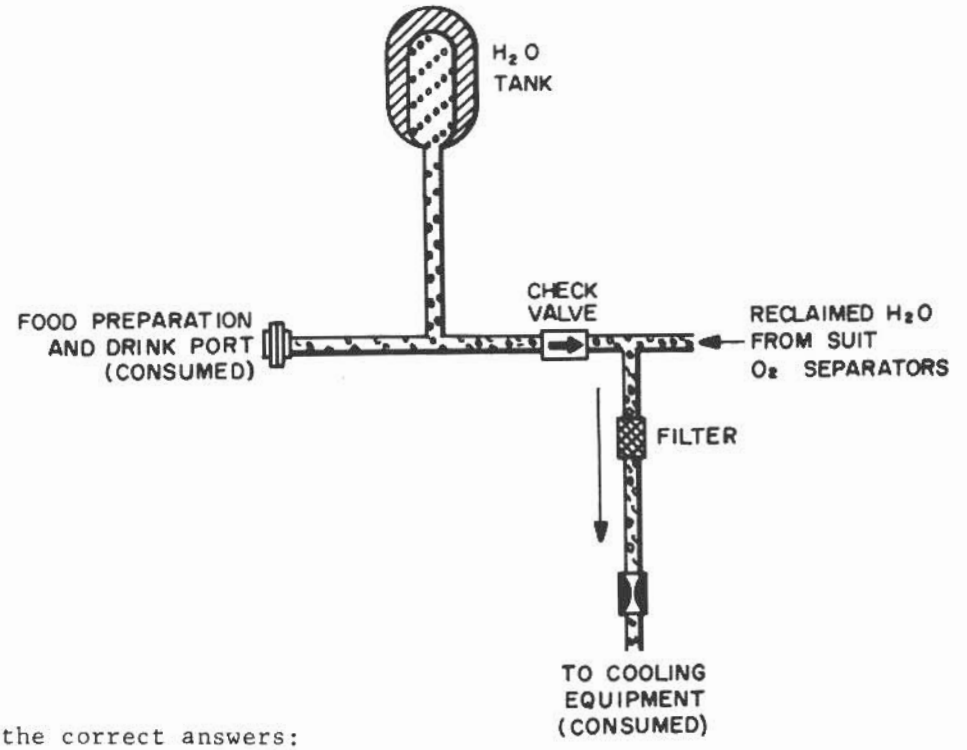
Circle the correct answer:

1. Cabin oxygen is replenished, completely replaced by the Oxygen Supply.
2. Cabin and suit oxygen are supplied from the same, a different source.

Answer: 1. replenished

2. the same

Oxygen is only one of two consumables in the Environmental Control Subsystem; the second is water. Water from the LM supply tanks is used for food preparation, drinking, and evaporative cooling.



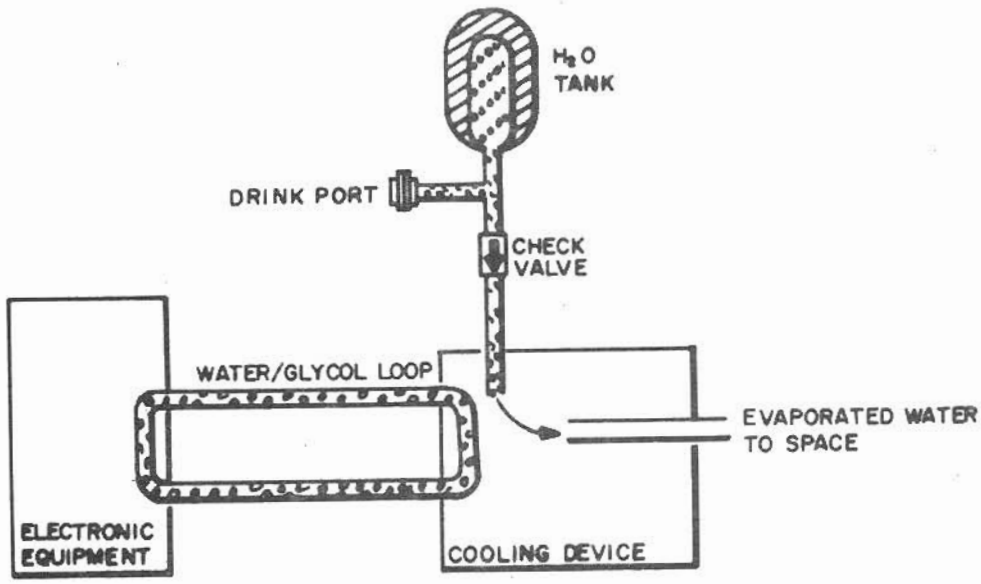
Circle the correct answers:

1. The drawing illustrates that water from the cooling equipment is, is not reclaimed.
2. The device that prevents astronaut consumption of the contaminated water from the suit circuit H_2O separators is the filter, check valve.

Answer: 1. is not reclaimed

2. check valve

Electronic equipment cooling is accomplished by mounting the equipment on a cold rail system with a water/glycol solution flowing through the cold rails. Heat is removed from the electronic equipment by the water/glycol and transferred along the coolant lines to a cooling device. The cooling device removes the heat from the water/glycol by evaporating water from the LM H_2O tanks.



Circle the correct answers:

1. The consumable used in the evaporator process is water, water/glycol.
2. The evaporator increases, decreases the temperature of the water/glycol.

Answer: 1. water

2. decreases

The water/glycol line is a closed loop system and is separate from the LM H_2O supply. The coolant is circulated from the electronic equipment through the evaporator to maintain a constant operating temperature for the equipment.

Circle the correct answer:

The water/glycol <u>is</u>, <u>is not</u> replenished from the main water tanks.

Answer: is not

Stop now and review to yourself the functions of the Environmental Control Subsystem. Then, label the following statements True or False:

_____ 1. Temperature control of critical electronic equipment is accomplished by yielding its heat to the cabin atmosphere.

_____ 2. Two consumables used by the LM Environmental Control Subsystem are water and oxygen.

_____ 3. Atmosphere recirculation and revitalization are functions of the LM Environmental Control Subsystem.

_____ 4. The water separator removes water from the water/glycol solution to be used as drinking water.

_____ 5. A recirculating water/glycol coolant loop is used to transport heat from its source to the evaporator.

Answer: False 1.

True 2.

True 3.

False 4.

True 5.

PROPULSION AND REACTION CONTROL SUBSYSTEMS

The Lunar Module uses separate Descent and Ascent propulsion systems. The Descent propulsion system is wholly contained in the descent stage and provides the thrust to control the rate of descent of the Lunar Module to the lunar surface.

To provide this thrust control, you would expect the descent engine to be: (check one below)

_____a. Throttleable

_____b. Non-throttleable

Answer. ✓ a. Throttleable

Throttling the descent engine allows a controlled, soft landing. A second area of control required during the descent to the lunar surface is compensation for attitude error. As the descent engine fuel and oxidizer are consumed, the LM center of gravity shifts, resulting in a new descent engine thrust vector requirement for maintaining attitude errors at zero.

In order to maintain the thrust vector through the LM Center of Gravity, the descent engine is:

_____a. Gimbaled

_____b. Throttleable

_____c. Canted

Answer. ✓ a. Gimbaled

Now you have determined two characteristics of the descent engine; (1) it is throttleable, and (2) it is gimbaled. These characteristics are a function of control. A third characteristic evolves from a requirement for orbital transfer of the LM from a 60-nautical mile circular orbit to an elliptical coasting descent transfer orbit.

The separate functions of orbital transfer and lunar descent require that the Descent engine be: (check one below)

_____ a. Continuously fired

_____ b. Restartable

Answer. ✓ b. Restartable

The Ascent Propulsion Subsystem is wholly contained in the ascent stage and uses the fixed angular position of the Ascent Engine to compensate for an existing off-set in the Ascent stage center of gravity. This fixed position engine provides a constant fixed thrust to provide a powered ascent from the lunar surface and insertion into a lunar orbit.

Circle the words required to complete the sentences:

1. The ascent engine is a fixed position engine which is (canted/gimbaled) to compensate for an off-set in the center of gravity.
2. The ascent engine provides constant thrust and is (throttleable/non-throttleable).

Answer. 1. Canted

2. Non-throttleable

A second function of the Ascent engine is to provide the thrust for orbit adjustments that may be necessary for successful rendezvous with the CSM.

Circle the correct answer:

To accomplish the functions of the Ascent engine it is (restartable, not restartable).

Answer. Restartable

Prior to discussing the Reaction Control Subsystem (RCS) jets, it is advisable to define two terms:

1. Attitude maneuver
2. Translation maneuver

Attitude maneuvers are rotations made around an axis (X, Y, or Z); Translation maneuvers are movements made along an axis (X, Y, or Z), changing the velocity or direction of motion.

The list below is made up of examples of LM attitude and translation maneuvers. Mark an A by the attitude examples, and a T by the translation examples.

_____a. Orbit change.

_____b. Increasing forward velocity.

_____c. Turning the LM to sight on a star.

_____d. Revolving to reduce heat absorption.

Answer. T a.

T b.

A c.

A d.

To accomplish attitude or translation changes, the RCS jets are pulsed on and off, rather than throttled. Pulsing allows short duration, constant thrust commands, which conserves fuel.

What common characteristic is displayed by the RCS jets and the Ascent and Descent engines? (check one)

_____ a. Throttleable

_____ b. Canted

_____ c. Gimbaled

_____ d. Restartable

Answer. ✓ d. Restartable

Utilizing the information that you have developed, it is now possible to make assumptions as to the relative thrust of the Propulsion engines and the RCS jets.

Consider the basic functions of the Ascent engine, Descent engine, and one RCS jet. List them in a descending order as to relative thrust.

_____ 1. Greatest thrust

_____ 2. Medium thrust

_____ 3. Least thrust

Answer. Descent 1.

Ascent 2.

RCS 3.

The Descent engine produces approximately 10,000 pounds of thrust to land the combined Ascent and Descent stages. The Ascent engine produces 3500 pounds of thrust to lift the Ascent stage off the lunar surface and establish a lunar orbit. Each RCS jet produces 100 pounds of thrust to perform attitude and translation maneuvers.

Control of the Propulsion engines and RCS jets is provided by the Control Electronics Section (CES) of the Guidance, Navigation, and Control Subsystem.

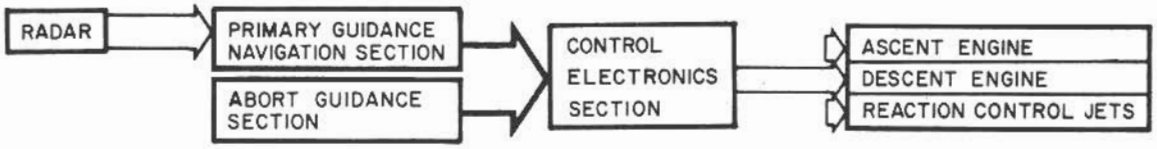
Before moving on the the next subsystem, you should verify to yourself that you understand the functions of the Propulsion and Reaction Control Subsystems. Below is a list of statements of functions or descriptions that apply to any one or all of the engines that you have been studying. Place an (X) in the applicable column(s) for each statement:

Ascent	Descent	RCS	
_____	_____	_____	1. 100 pounds of thrust
_____	_____	_____	2. Canted
_____	_____	_____	3. 3500 pounds of thrust
_____	_____	_____	4. Used for orbital transfer or insertion
_____	_____	_____	5. Gimbaled
_____	_____	_____	6. Throttleable
_____	_____	_____	7. Restartable
_____	_____	_____	8. 10,000 pounds of thrust
_____	_____	_____	9. Attitude maneuvers

	Ascent	Descent	RCS	
Answer.			X	1. 100 pounds of thrust
	X			2. Canted
	X			3. 3500 pounds of thrust
	X	X	X	4. Used for orbital transfer or insertion
		X		5. Gimbaled
		X		6. Throttleable
	X	X	X	7. Restartable
		X		8. 10,000 pounds of thrust
			X	9. Attitude maneuvers

GUIDANCE, NAVIGATION, AND CONTROL SUBSYSTEM

The flight of the LM is controlled by the Guidance, Navigation, and Control Subsystem. Flight control can be either manual or automatic. The Guidance, Navigation, and Control Subsystem is divided into four sections: Primary Guidance and Navigation Section; Abort Guidance Section; Control Electronics Section; and the Radar Section.

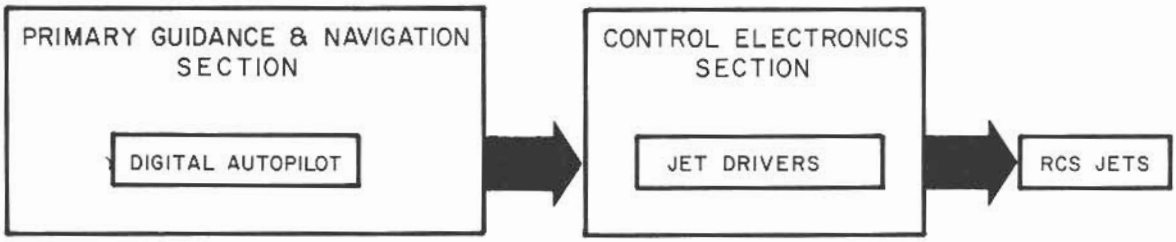


Circle the correct answer:

Normal stabilization and control of the Lunar Module is accomplished by the (Primary Guidance and Navigation Section/ Abort Guidance Section).

Answer. Primary Guidance and Navigation Section

The Primary Guidance and Navigation Section contains a Digital Autopilot which compares program defined attitude or crew commanded attitude to actual vehicle attitude and computes jet commands for controlling spacecraft attitude. The Digital Autopilot houses the jet select logic for determining the most efficient combination of jet firings for performing attitude maneuvers. The commands are routed to the Control Electronics Section (CES), which provides the jet drivers required to fire the RCS jets.



Place a T next to the correct statements and an F by the false statements:

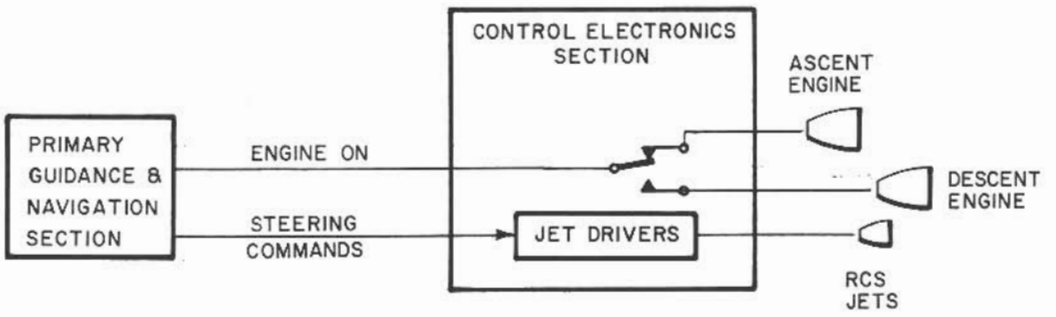
_____ 1. The Digital Autopilot operates in the manual and automatic control modes.

_____ 2. RCS jet firings provide attitude control.

_____ 3. RCS jet commands are initiated by the CES.

Answer. T 1.
T 2.
F 3.

In addition to attitude control, the Primary Guidance and Navigation Section controls translation of the LM by issuing automatic engine On-Off commands. The Control Electronics Section routes the commands to the ascent or descent engine. The engine used will depend on the mission phase, and must be selected by the astronaut.



Place a T next to the correct statements and an F by the false statements:

_____1. Ascent and Descent Engine firings control translation.

_____2. RCS jets normally control attitude, but may also control translation.

_____3. Engine selections are automatic in the Control Electronics Section.

_____4. Translation is movement along an axis.

Answer. T 1.
T 2.
F 3.

The Primary Guidance and Navigation Section LM Guidance Computer (LGC) calculates LM state vectors based on inertial data and radar data. These state vectors are utilized within the LM Guidance Computer for determination of LM trajectory parameters and used to update the Abort Guidance Section (AGS) computer calculations.

Place a T next to the correct statements and an F by the false statements:

_____1. Primary Guidance and Navigation Section controls the CSM trajectory.

_____2. Abort Guidance Section is updated with Primary Guidance and Navigation Section computed state vectors.

_____3. Primary Guidance and Navigation Section contains a Digital Autopilot.

_____4. The LM Guidance Computer is updated by the CSM.

Answer. F 1.
T 2.
T 3.

The Abort Guidance Section (AGS) is the back-up guidance mode of operation designed to control the flight of the LM to rendezvous with the Command Service Module (CSM) in the event of a Primary Guidance and Navigation Section malfunction. The Abort Guidance Section computes automatic engine On commands and automatic steering commands and routes these commands through the Control Electronics Section to the main engines and the RCS jets for spacecraft attitude and translation control.

Circle the correct answer:

In the event of a Primary Guidance and Navigation Section failure, the (Control Electronics Section/Abort Guidance Section) will control the LM flight.

Answer. Abort Guidance Section (AGS)

The Radar section consists of a Rendezvous Radar and a Landing Radar. The Rendezvous Radar (RR) tracks a transponder mounted on the CSM. Rendezvous Radar information is LM-CSM relative range and range rate data and line-of-sight tracking angles.

Place a T next to the true statements and an F by the false statements:

_____ 1. Rendezvous Radar tracks an Earth station to give position fix.

_____ 2. Command Service Module tracks the LM Rendezvous Radar transponder.

_____ 3. Rendezvous Radar determines the relative distance between the LM and CSM.

Answer. F 1.

F 2.

T 3.

The Landing Radar is mounted on the Descent Stage and supplies the required LM altitude and altitude rate with respect to the lunar surface.

Circle the correct answer:

The Landing Radar (can, cannot) be used as a back-up for the Rendezvous Radar.

Answer. (cannot)

The proper mode of operation of the Guidance, Navigation, and Control Subsystem depends on crew selection and recognition of normally operating modes. To make these decisions, it is important to know what each section is required to do. Test your knowledge of the Guidance, Navigation, and Control Subsystem by doing the following exercise.

Match the following statements to the proper Guidance, Navigation, and Control Subsystem by writing Primary Guidance and Navigation Section (PGNS); Abort Guidance Section (AGS); Control Electronics Section (CES); or Radar next to the appropriate statement in the space provided:

_____ a. Back-up guidance section

_____ b. Routes all commands for RCS jets

_____ c. Tracks Command Service Module transponder

_____ d. Contains digital autopilot

_____ e. Normal guidance section

_____ f. Routes all ascent and descent engine commands

_____ g. Provides updates to Abort Guidance Section

Answers. AGS a.

CES b.

Radar c.

PGNS d.

PGNS e.

CES f.

PGNS g.

EXPLOSIVE DEVICES

The explosive devices used on the LM contain an explosive charge which, when ignited electrically, detonates, producing the required mechanical actuation. Once the explosive device is detonated, its resultant mechanical movement is irreversible.

Fill in the appropriate word:

a. Detonation of the explosive charge in the LM explosive device is initiated by an _____ signal.

b. The resultant detonation produces sufficient force to enable a _____ actuation.

c. The explosive device, once fired, _____ (can, cannot) be returned to its original configuration.

Answer: a. electrical

b. mechanical

c. cannot

The electrical signal used to fire the LM explosive device is provided by two batteries which are electrically isolated from the LM electrical power subsystem. Either battery has sufficient capacity to satisfy total LM explosive devices operational requirements.

Circle the appropriate word:

a. There are (2, 4, 6, 8) batteries on the LM to fire the explosive devices.

b. Loss of one battery (will, will not) limit the number of explosive devices that can be detonated.

c. In an emergency, the LM electrical power subsystem batteries (can, cannot) be used to fire the explosive devices.

Answer: a. two

b. will not

c. cannot

The mechanical actuations that are accomplished with detonation of explosive devices on the Lunar Module will provide:

1. Landing gear deployment.
2. Pressurization of propellants for ascent engine, descent engine, and reaction control engines.
3. Structural and electrical separation of ascent and descent stages.

Place a check (✓) in front of the functions listed below that are accomplished with an explosive device:

_____ a. Demating of ascent and descent stages.

_____ b. Emergency opening of the ingress/egress hatch.

_____ c. Unlock the descent engine gimbal ring.

_____ d. Landing gear deployment.

_____ e. EVA antenna deployment.

_____ f. Descent engine propellant pressurization.

_____ g. Deploy landing radar antenna.

Answer. ✓ a. Demating of ascent and descent stages

____ b.

____ c.

✓ d. Landing gear deployment

____ e.

✓ f. Descent engine propellant pressurization

____ g.

Circle the correct answer:

A. One LM explosive device battery can fire off:

1. 1/2 of all the explosive devices.
2. Six (6) explosive devices.
3. Eight (8) explosive devices.
4. All explosive devices.

B. The number of explosive device batteries on the LM is:

1. One
2. Two
3. Three
4. Four

C. Each explosive device:

1. Is detonated mechanically.
2. Is detonated electrically.
3. Produces a reversible mechanical actuation.
4. All of the above.

D. The LM explosive devices batteries:

1. Can be connected to the Commander's DC bus.
2. Can be connected to the LM Pilot's DC bus.
3. Can be connected to Emergency DC bus.
4. None of the above.

E. Explosive devices are used on the LM to:

1. Deploy radar antenna, deploy landing gear, pressurize the propellants.
2. Deploy landing gear, separate ascent and descent stages, pressurize propellants.
3. Separate ascent and descent stages, pressurize propellants, deploy radar antenna.
4. None of the above.

Answer. A (4) All explosive devices

B (2) Two

C (2) Is detonated electrically

D (4) None of the above

E (2) Deploy landing gear, separate ascent and descent stages, pressurize propellants

The Instrumentation Subsystem interfaces directly with all of the LM subsystems. This is accomplished through the individual subsystem sensors or measuring devices. One function of the Instrumentation is to form or modulate the sensor outputs into telemetry formats. A complete telemetry link would not only include the sensors and modulation section, but also a means of transferring the measurement to a remote display point.

To complete a telemetry link with the Manned Space Flight Network (MSFN) on Earth, the telemetry output of the Instrumentation Subsystem must be routed to what LM subsystem? (Check the correct subsystem from the list below.)

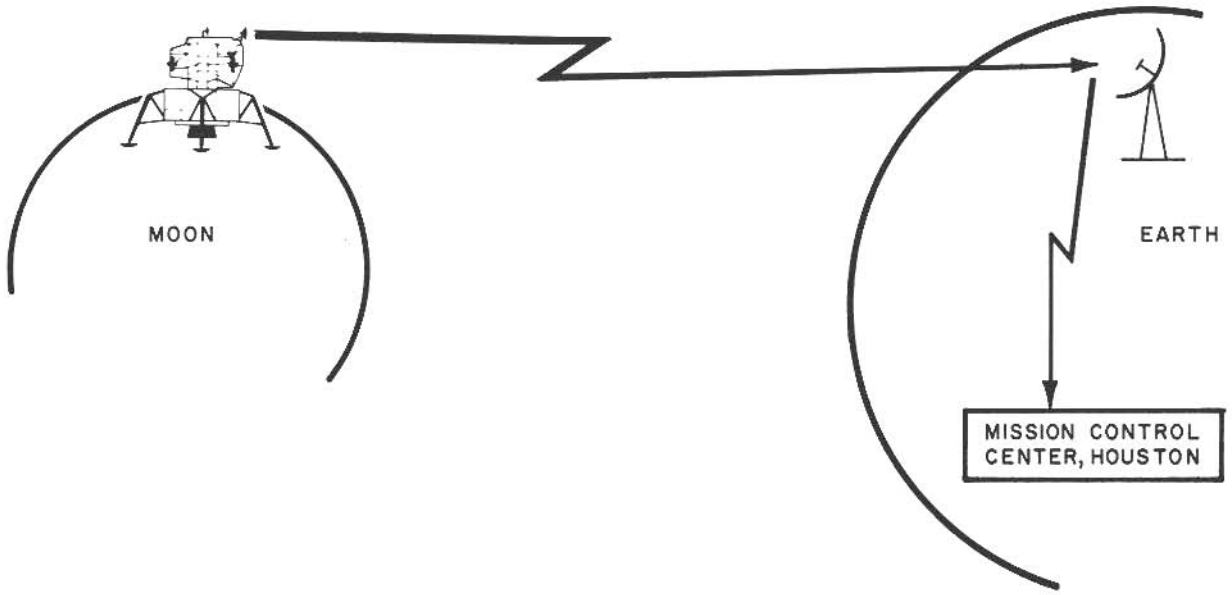
_____ a. Control Electronics

_____ b. Communications

_____ c. Environmental Control

Answer: ✓ b. Communications

The telemetry link from the LM to the Manned Space Flight Network allows the Flight Controller to monitor the status of the LM.



Complete the following sentence by circling the correct word:

The drawing depicting the LM telemetry link indicates that there is a (<u>one, two</u>) way link.

Answer: (one) The LM telemetry link has only a one-way link; a down-link. However, a separate uplink exists using the LM Digital Uplink Assembly. This allows Computer updates from the MSFN.

The Manned Space Flight Network, with receiving stations placed throughout the world, maintains a nearly constant telemetry link with the LM. The receiving stations record information to ensure that there is no loss of data. Data is relayed to the Mission Control Center, in Houston, to allow real-time display.

Place a T or F by the following statements to indicate True or False:

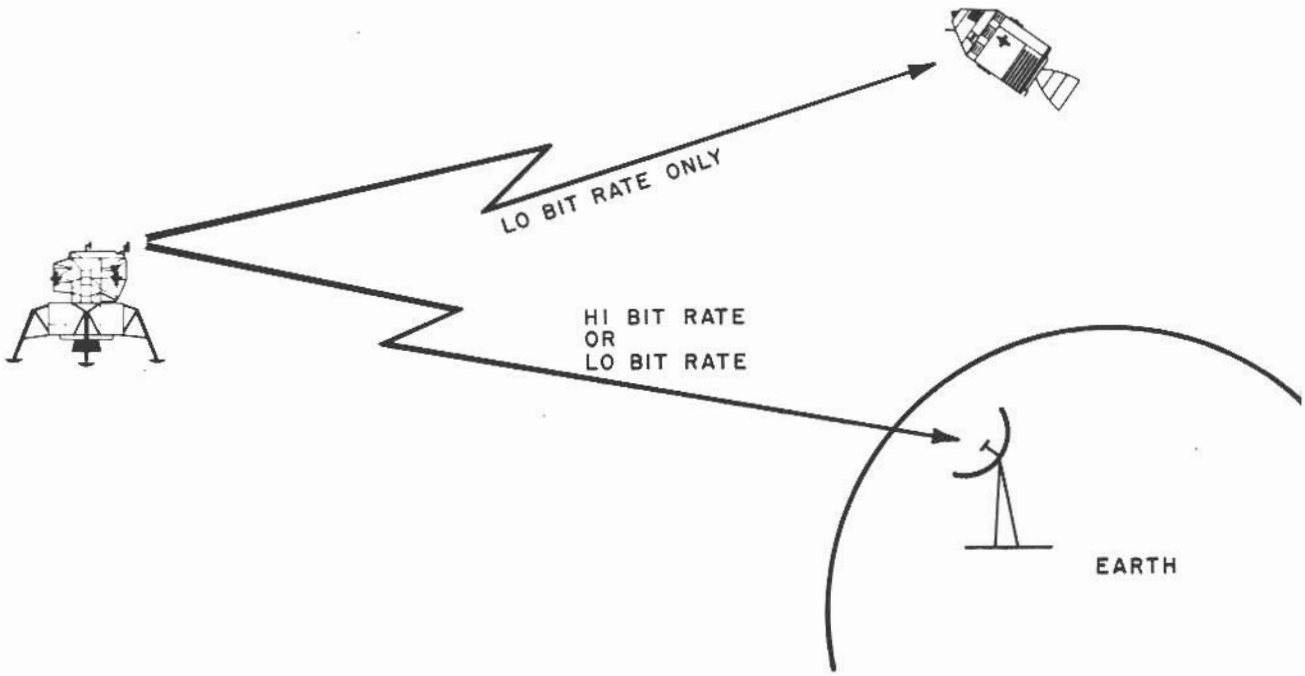
____ 1. Real-time telemetry displays allow the Flight Controller to detect changes in the LM status.

____ 2. LM telemetry is sent directly from the LM to the Mission Control Center.

Answer: T 1.

F 2.

The LM telemetry may be transmitted in one of two modes; Hi Bit Rate or Lo Bit Rate. The two bit rates vary the amount of information being transmitted. Hi Bit Rate is the normal telemetry output. Lo Bit Rate data is transmitted to the CSM for recording at a time when the LM and CSM are out of line-of-sight with the Earth.



Place a T or F in the space provided to indicate whether the statement is True or False:

____ Hi Bit Rate and Lo Bit Rate are transmitted simultaneously.

Answer: F Telemetry is transmitted either Hi Bit Rate or Low Bit Rate.

Many of the LM parameters are not in the proper format for telemetry or crew displays. These parameters are conditioned into useful measurements by the Instrumentation Subsystem.

Place a check by the following statements that are examples of Conditioning:

_____ 1. Heater temperature to DC voltages

_____ 2. Converts AC voltages to DC voltages

_____ 3. Hi Bit Rate to Lo Bit Rate

_____ 4. Propellant pressure to DC voltage

Answer: You should have checked 1, 2, and 4. Hi to Lo Bit rate is a variation in the mode of telemetry operation, not a form of conditioning.

Conditioning the signals allows the telemetry system and the displays to accept common input voltages. In order to isolate the telemetry inputs and the display instruments, the Instrumentation Subsystem will act as a buffer or isolator. This signal isolation will be accomplished by the Conditioning equipment.

Circle the correct answer:

Signal isolation (will, will not) minimize the transfer of noise interference between the crew displays and the telemetry system.

Answer: (will)

Up to this point, the Instrumentation Subsystem has enabled the Flight Controller to determine the status of the LM. The crew members themselves must also know the condition of the LM. To eliminate the necessity of constantly watching all of the instruments, a Caution and Warning section has been installed on the LM. The Caution and Warning section will monitor the LM and automatically notify the crew to an out-of-tolerance condition. As the name Caution and Warning implies, this section separates malfunctions as to importance (a more critical malfunction is a Warning).

Circle the correct answer:

1. To alert the crew to a malfunction, the Caution and Warning section will (constantly, periodically) check the LM subsystem sensor outputs.
2. All malfunctions (are, are not) given the same importance.

Answer: 1. constantly

2. are not

The crew is notified as to a malfunction by a series of lights. Two Master Alarm lights will tell the crew that there is a problem; the specific problem area will be indicated by a Caution or Warning light. By using these lights, and the proper instruments, the crew members can locate the problem.

Place a T or F in the space provided to indicate True or False:

_____ 1. The two Master Alarm lights tell the crew the specific problem area.

_____ 2. The Caution and Warning section corrects malfunctions.

_____ 3. The Master Alarm lights and Caution and Warning lights are troubleshooting aids for the crew.

Answer: F 1.

F 2.

T 3.

Listed below are a group of Instrumentation Subsystem functions. Label these functions Telemetry, Caution and Warning (C&W), or Conditioning, in the space provided:

_____ 1. Separates malfunctions as to importance.

_____ 2. Changing resistance to voltage for display purposes.

_____ 3. Alerts the crew to out-of-tolerance conditions on the LM.

_____ 4. Enables Flight Controllers to determine the LM status.

_____ 5. Provides isolation of measurements.

_____ 6. Hi Bit Rate and Lo Bit Rate

_____ 7. Master Alarm to the crew.

_____ 8. Real-time subsystem measurements to the Flight Controller.

Answer: C&W 1.

Conditioning 2.

C&W 3.

Telemetry 4.

Conditioning 5.

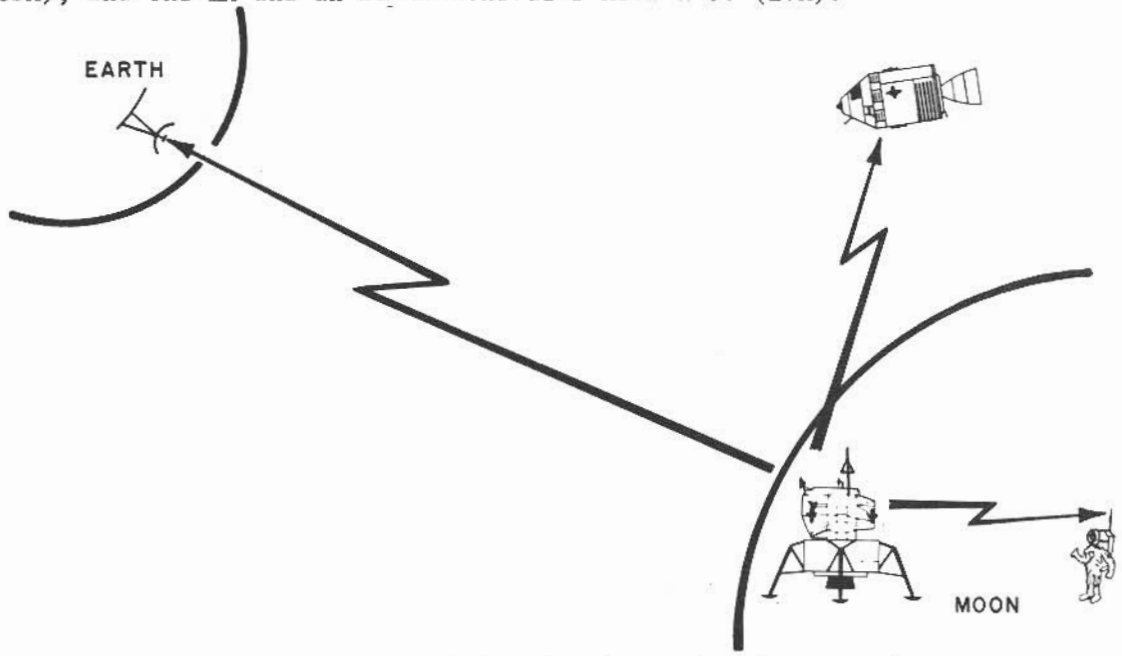
Telemetry 6.

C&W 7.

Telemetry 8.

COMMUNICATIONS

The Communications Subsystem provides the capability of a voice and data link between the Lunar Module (LM) and the Manned Space Flight Network (MSFN); the LM and the Command and Service Module (CSM), and the LM and an Extra-vehicular Astronaut (EVA).



To accomplish these links, two Communications sections are utilized; S-Band for long range link, and VHF for the short range link.

Identify the Communication links listed below as S-Band or VHF:

_____ LM to Manned Space Flight Network

_____ LM to Extra-vehicular Astronaut

_____ LM to Command Service Module

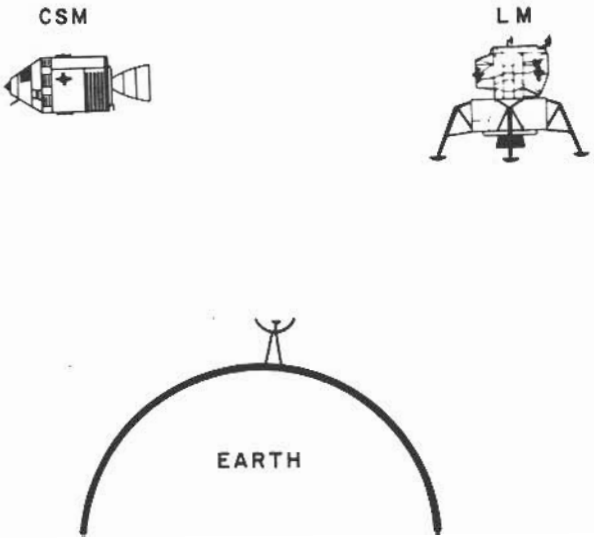
Answer. S-Band LM to MSFN

VHF LM to EVA

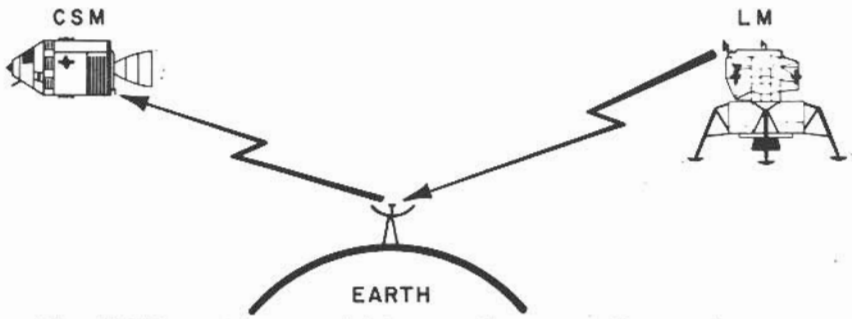
VHF LM to CSM

As determined, the LM to CSM Communications link is VHF. The LM and CSM S-Band frequencies are not compatible, thereby restricting direct S-Band communications.

Draw and label the LM to CSM Communications link during a VHF malfunction.



Answer. Your diagram should look like this:



The MSFN station would be used as a relay point.

The S-Band link, which is utilized between the LM and MSFN, has both up-link and down-link intelligence present. This intelligence can be broadly categorized as data, voice, and ranging.

The ranging link is a Pseudo-Random Noise (PRN) ranging signal. This signal is developed and transmitted by the MSFN, received and returned by the LM.

A ranging capability also exists between the LM and CSM.

Circle the correct answer:

The LM to CSM ranging link is accomplished utilizing the (S-Band, VHF) communications section.

Answer: (VHF)

The Ranging Tone Transfer Assembly (RTTA) provides for the transponding of ranging signals received from the Command Service Module. The VHF ranging function has a maximum operational range of 200 nautical miles and is designed for use whenever the Lunar Module is unable to be the active rendezvous member.

The LM to Command Service Module range determination equipment is aboard the Command Service Module with the LM providing a transponding function only. There is no readout available aboard the LM

Label the following statements as true or false:

_____ 1. The LM has onboard indications as to LM-Command Service Module range from the Ranging Tone Transfer Assembly (RTTA).

_____ 2. The VHF ranging equipment is used as contingency equipment.

_____ 3. The LM generates the VHF ranging signal.

Answer: False 1.

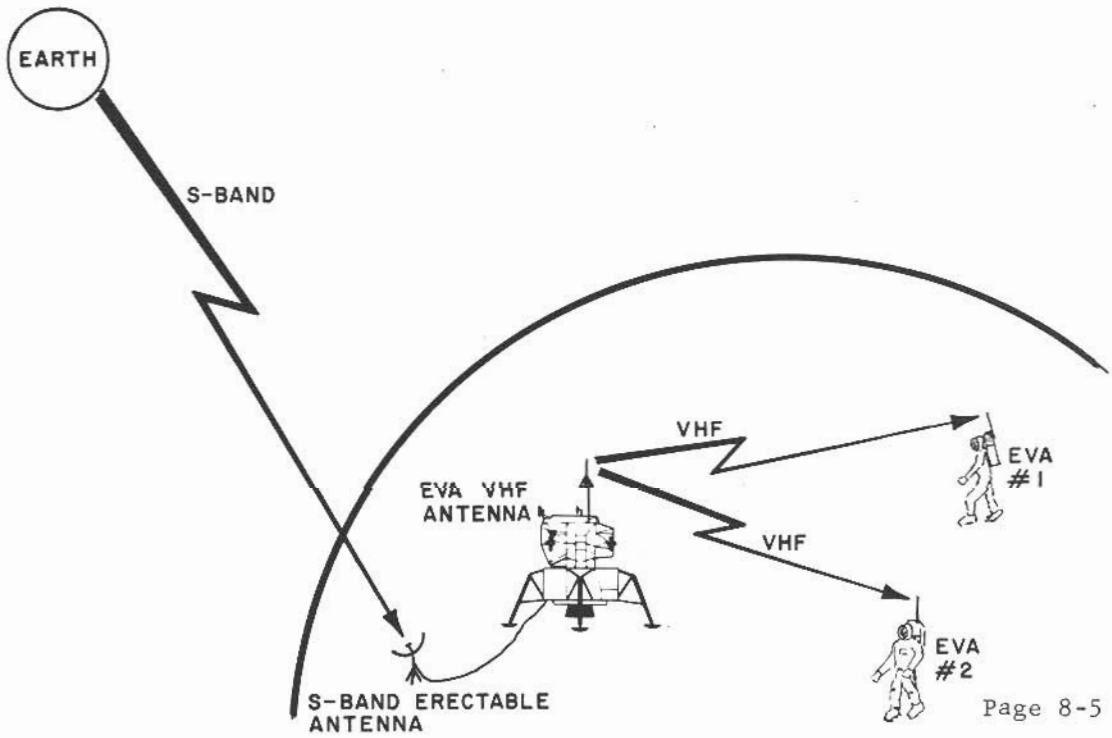
True 2.

False 3.

Once on the lunar surface, both astronauts will be conducting extra-vehicular activities. The Portable Life Support System (PLSS) will provide the astronauts with an artificial atmosphere and a VHF communications link.

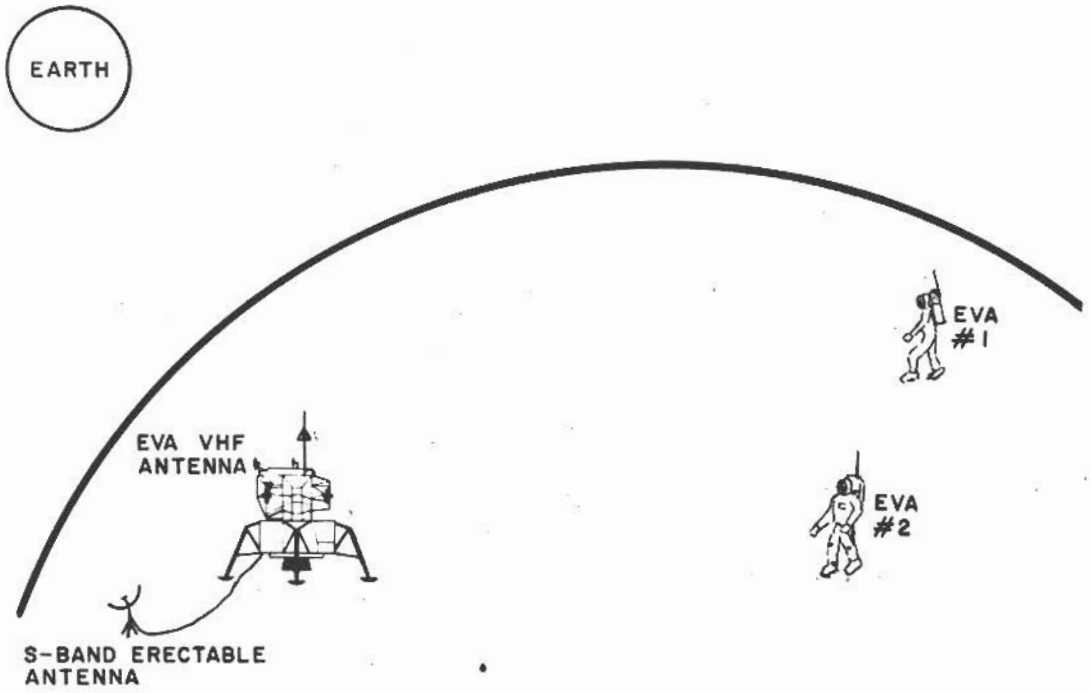
To communicate between the Manned Space Flight Network and the two Extra-vehicular Astronauts, the LM will be used as a relay station.

The drawing below indicates the Manned Space Flight Network to Astronaut uplink.

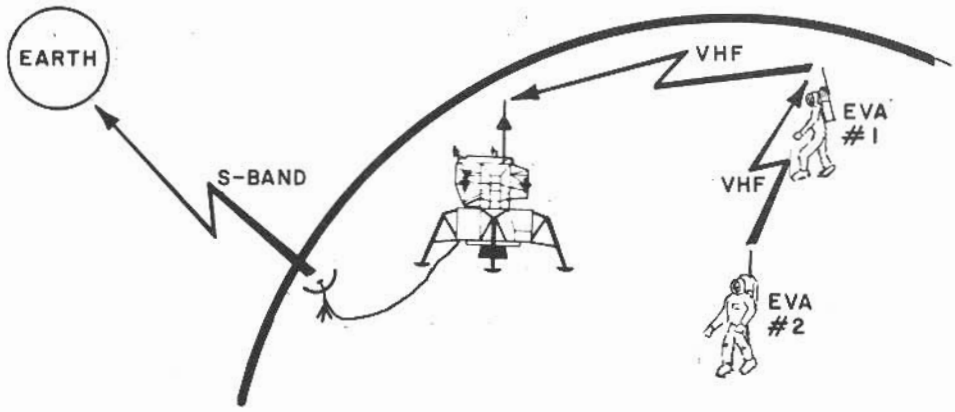


In normal dual EVA operations, the EVA #1 will be used as a relay for transmittal of EVA #2 voice and biomedical data. During a single EVA, direct communications to the LM exist for portable life support systems #1 and #2.

Draw the normal transmitted communication down-links between EVA #1 and EVA #2, and the Manned Space Flight Network. Label the links VHF or S-Band.

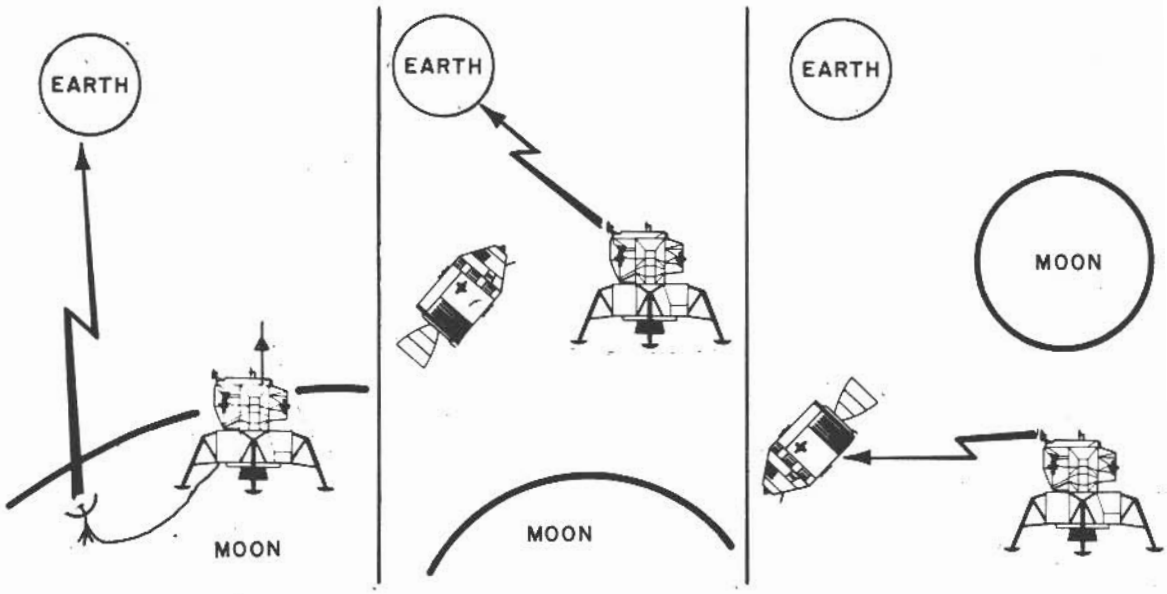


Answer.



Up to this point, the majority of the signals discussed have been voice and ranging. The MSFN can also receive LM telemetry signals. The S-Band section transmits high-bit-rate (HBR) or low-bit-rate (LBR) telemetry. The telemetry information tells the Flight Controller the status of the LM.

VHF low-bit-rate capability exists between the LM and CSM. This link is used during the phase of the mission when the LM and CSM are out of line of sight with the MSFN.



CONDITION #1 CONDITION #2 CONDITION #3

Check the correct statements below:

_____ 1. Condition #2 depicts the VHF Telemetry link.

_____ 2. Condition #1 depicts the S-Band Telemetry link.

_____ 3. Condition #3 does not exist.

_____ 4. Telemetry is lost when the LM is on the Moon.

Answer: You should have checked 2.

Label the following communication signals as S-Band or VHF:

_____ 1. LM-CSM ranging

_____ 2. EVA voice

_____ 3. Pseudo Random Noise (PRN) ranging

_____ 4. LM to Manned Space Flight Network telemetry

_____ 5. Manned Space Flight Network to LM voice

_____ 6. EVA biomedical data

_____ 7. LM-Command Service Module voice

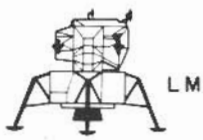
Answer: VHF 1. S-Band 4.

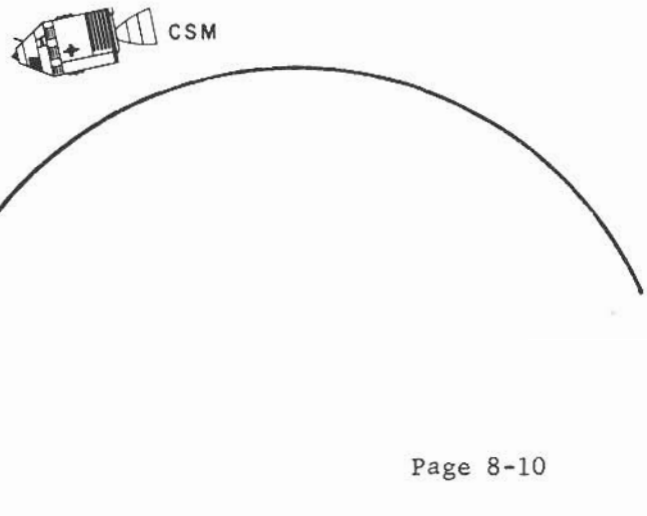
VHF 2. S-Band 5.

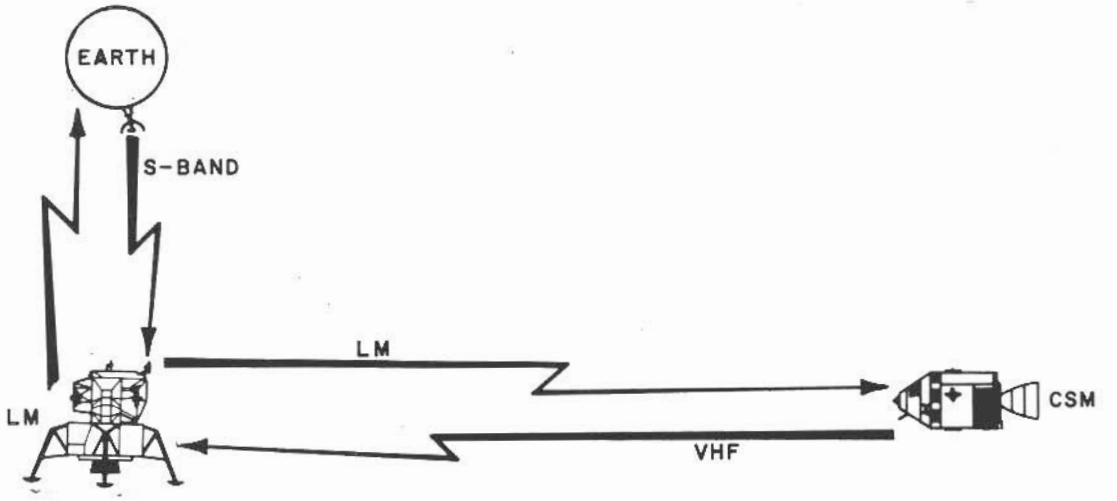
S-Band 3. VHF 6.

VHF 7.

Draw in and label the communication up and down-links between the Manned Space Flight Network and LM, and the link between the LM and Command Service Module. Indicate direction with arrowheads.







Draw and label the normal communication up and down links in the following diagram. Indicate direction of communications with arrow-heads.