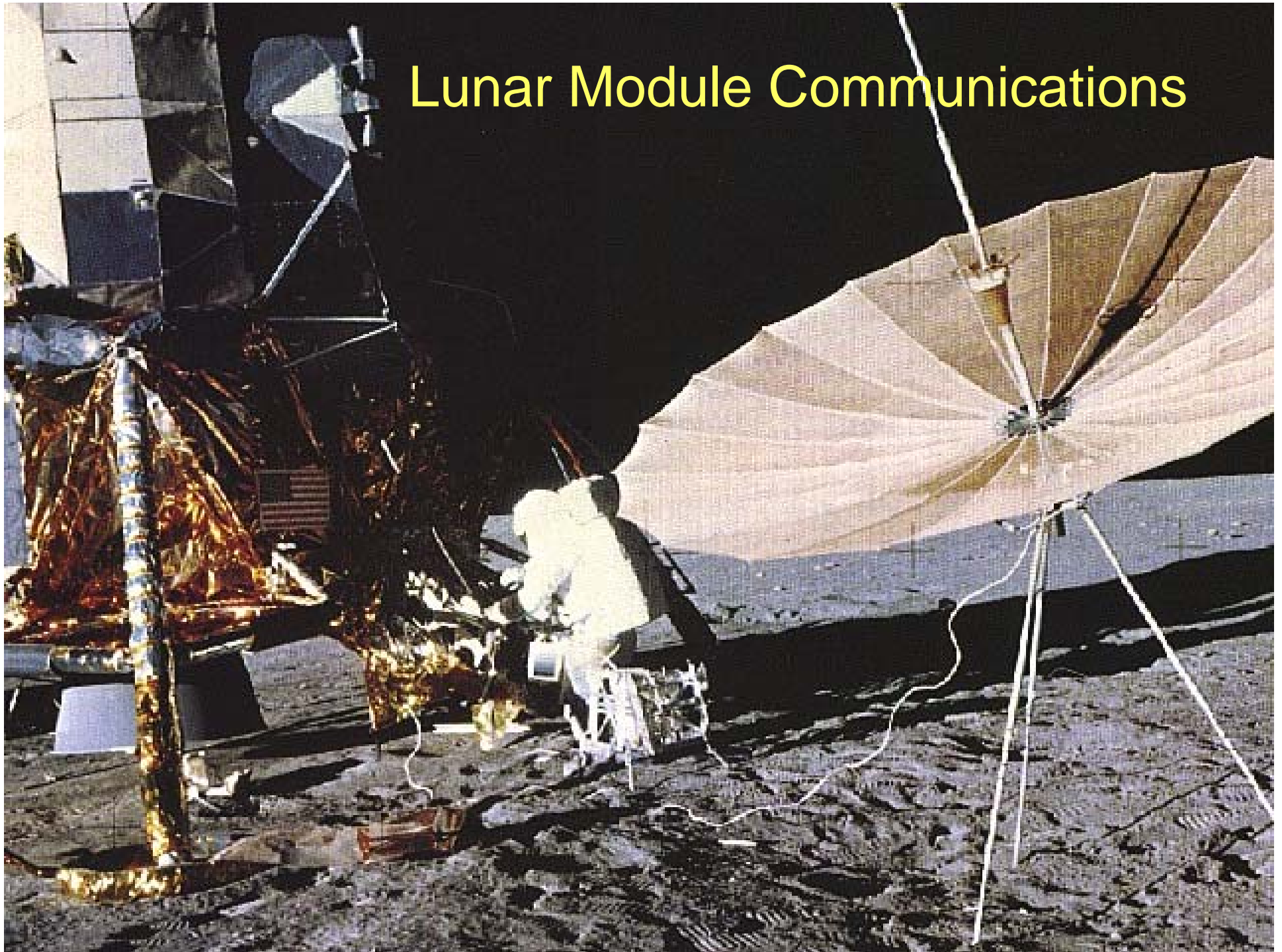


Lunar Module Communications



Objectives

- Describe the different types of antennas on the Lunar Module
- Describe the different communications paths during Earth line of sight periods
- Describe the different communications paths during periods when there was no Earth line of sight
- Describe the different communications paths during Lunar Surface operations
- Describe the interfaces to and function of the Signal-Processing Assembly (SPA)
- Describe the interfaces to and function of the Instrumentation system

Lesson Outline

1. Gotchas in reading the Apollo era documents
2. Lunar Module Antennas and Functions
3. Earth Line of Sight Communications Links
4. No Earth Line of Sight Communications Links
5. Lunar Surface Communications Links
6. Signal-Processing Assembly
7. Instrumentation System
8. Some Communications Problems Encountered

Apollo Document Terminology

Line of Sight (LOS) – non-obstructed, point to point path. Don't confuse with the modern term of Loss of Signal.

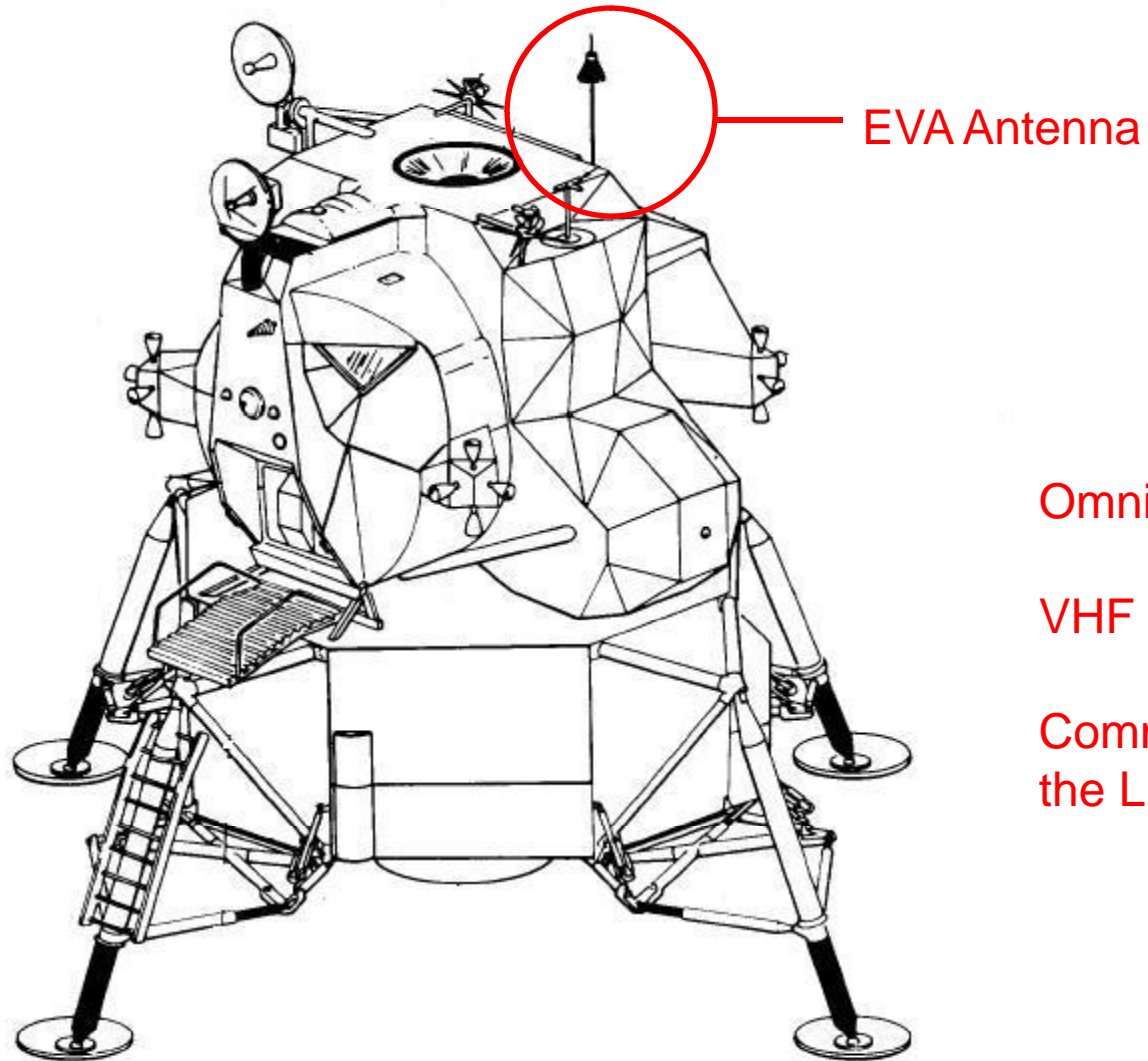
Very High Frequency (VHF) – a frequency band used by the Lunar Module for communications. We now call the specific frequencies used by the LM, Ultra-High Frequency (UHF). They are the same set of frequencies used by the shuttle program.

Manned Spaceflight Network (MSFN) – the ground communications network that support communications links between the control center and the vehicles. We now refer to these assets as the Ground and Space Network.

Megacycles (MC) – an older terminology used in Apollo era documents for what we now more commonly call megahertz (MHz).

Ranging – the determination of the distance to a target based upon sub-carrier, turnaround tones (S Band and VHF)

Antennas



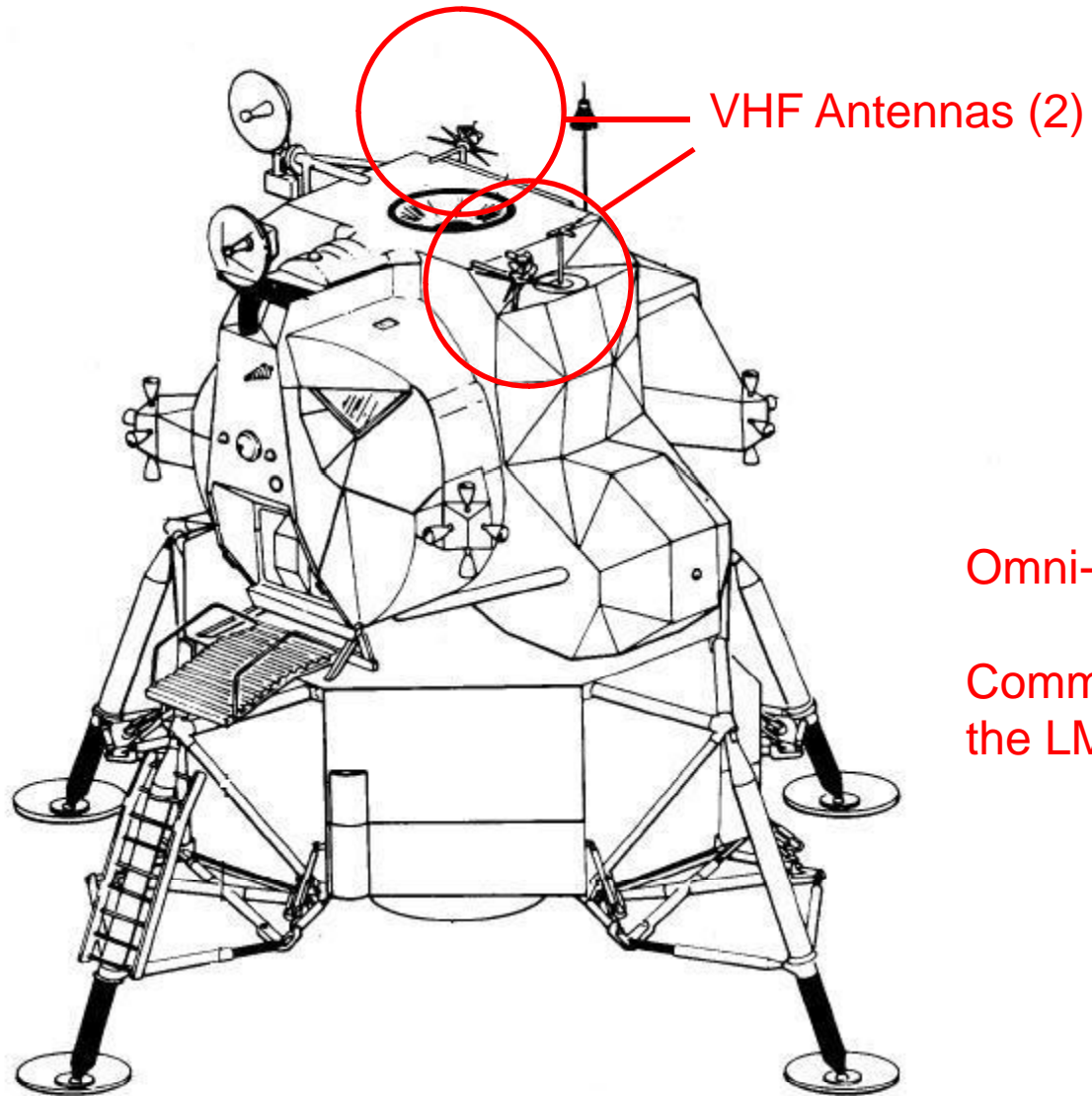
EVA Antenna

Omni-directional

VHF

Communications between
the LM and the EVA crew

Antennas

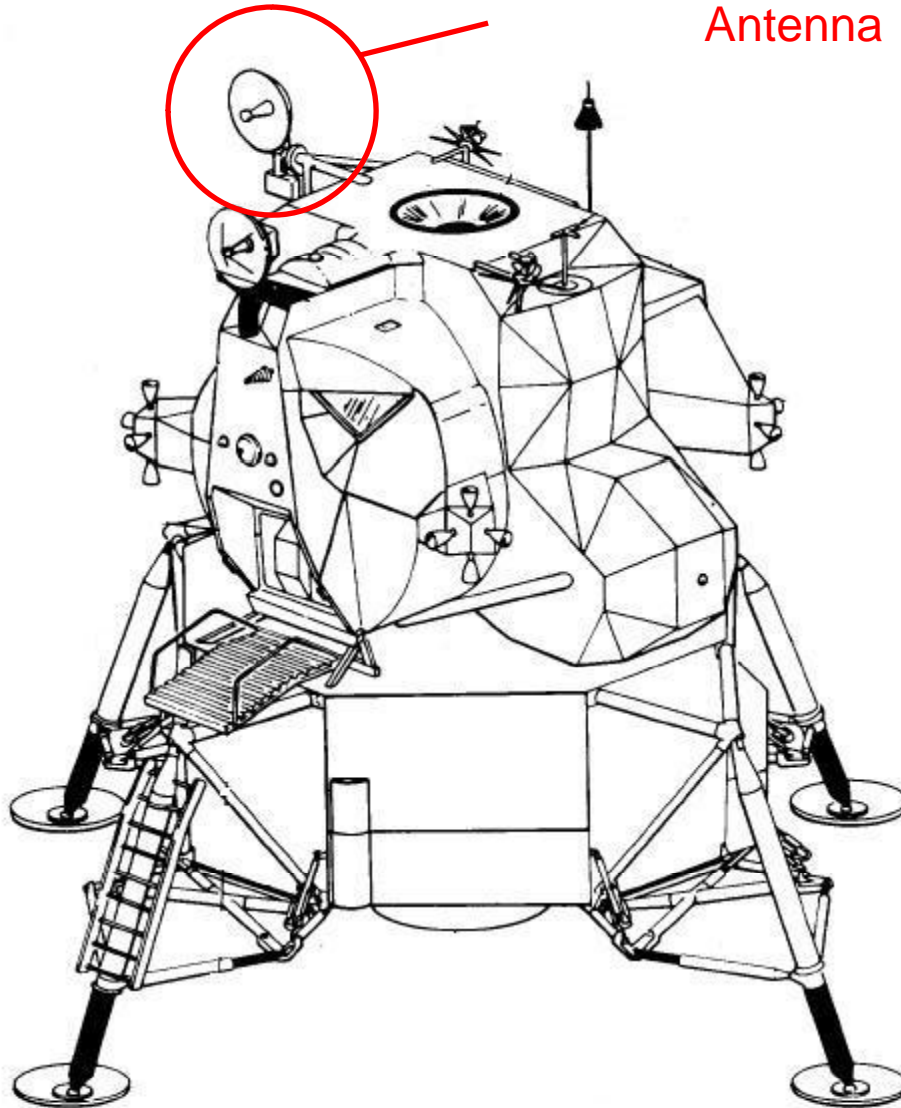


Omni-directional

Communications between
the LM and CSM

Antennas

S Band Steerable
Antenna



Unidirectional

Gimbaled Movement

Crew Manually Points

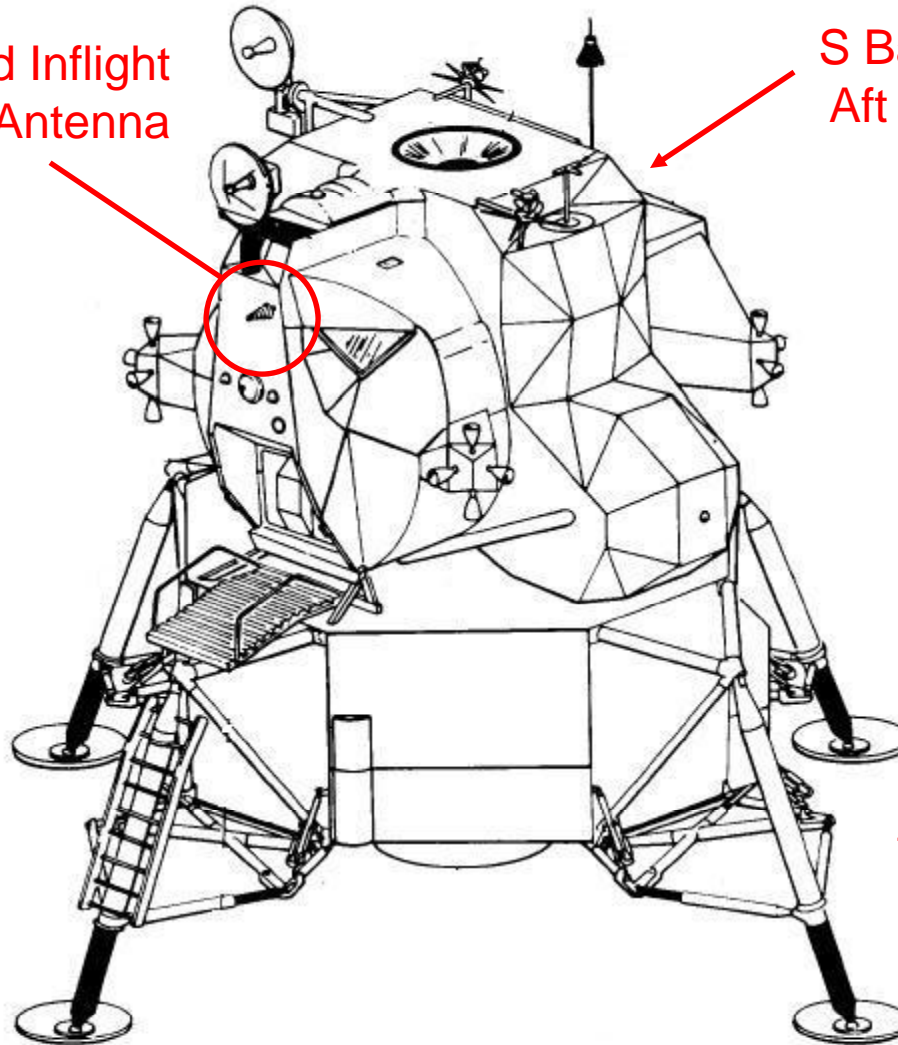
Auto-tracking

Communications between
the LM and MSFN

Antennas

S Band Inflight
Forward Antenna

S Band Inflight
Aft Antenna



Omni-directional

Only one antenna at a time

Communications between
the LM and MSFN

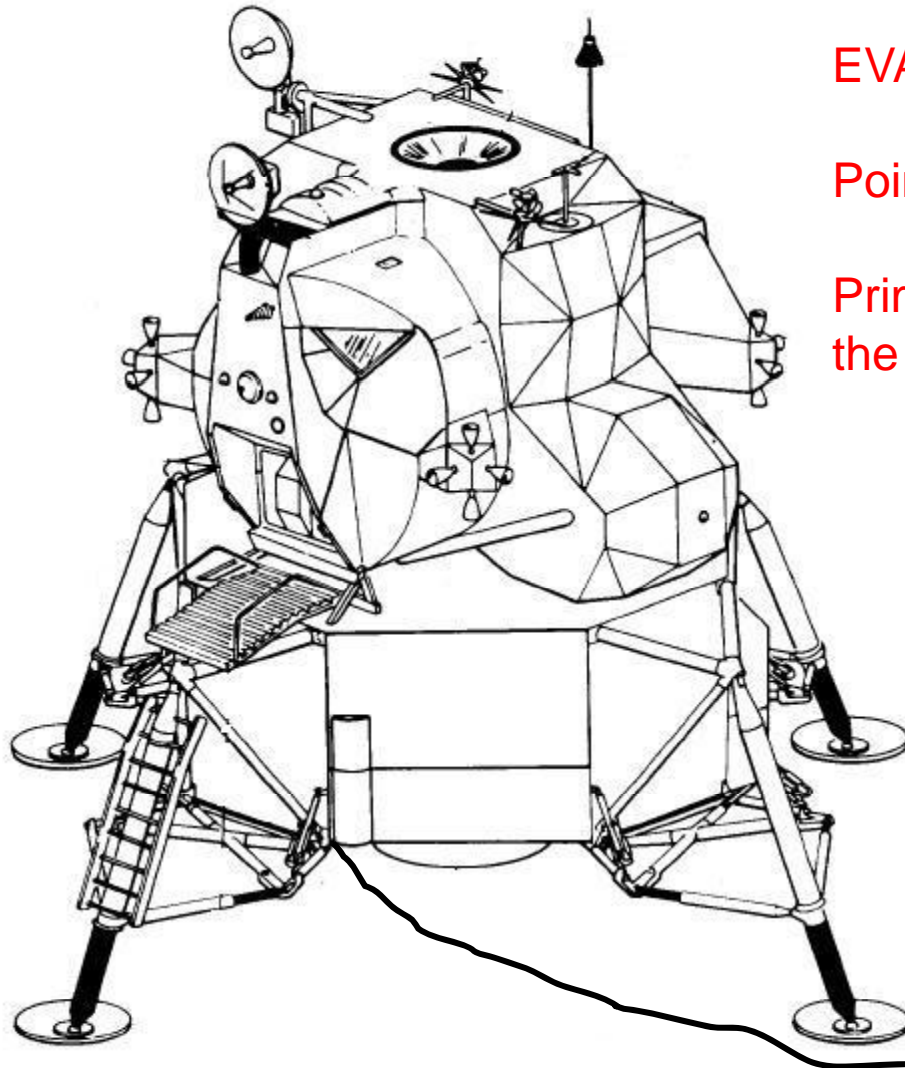
Antennas

Lunar Stay usage

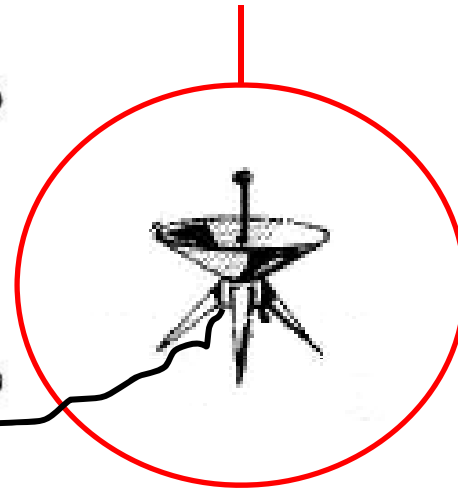
EVA Setup

Point at Earth

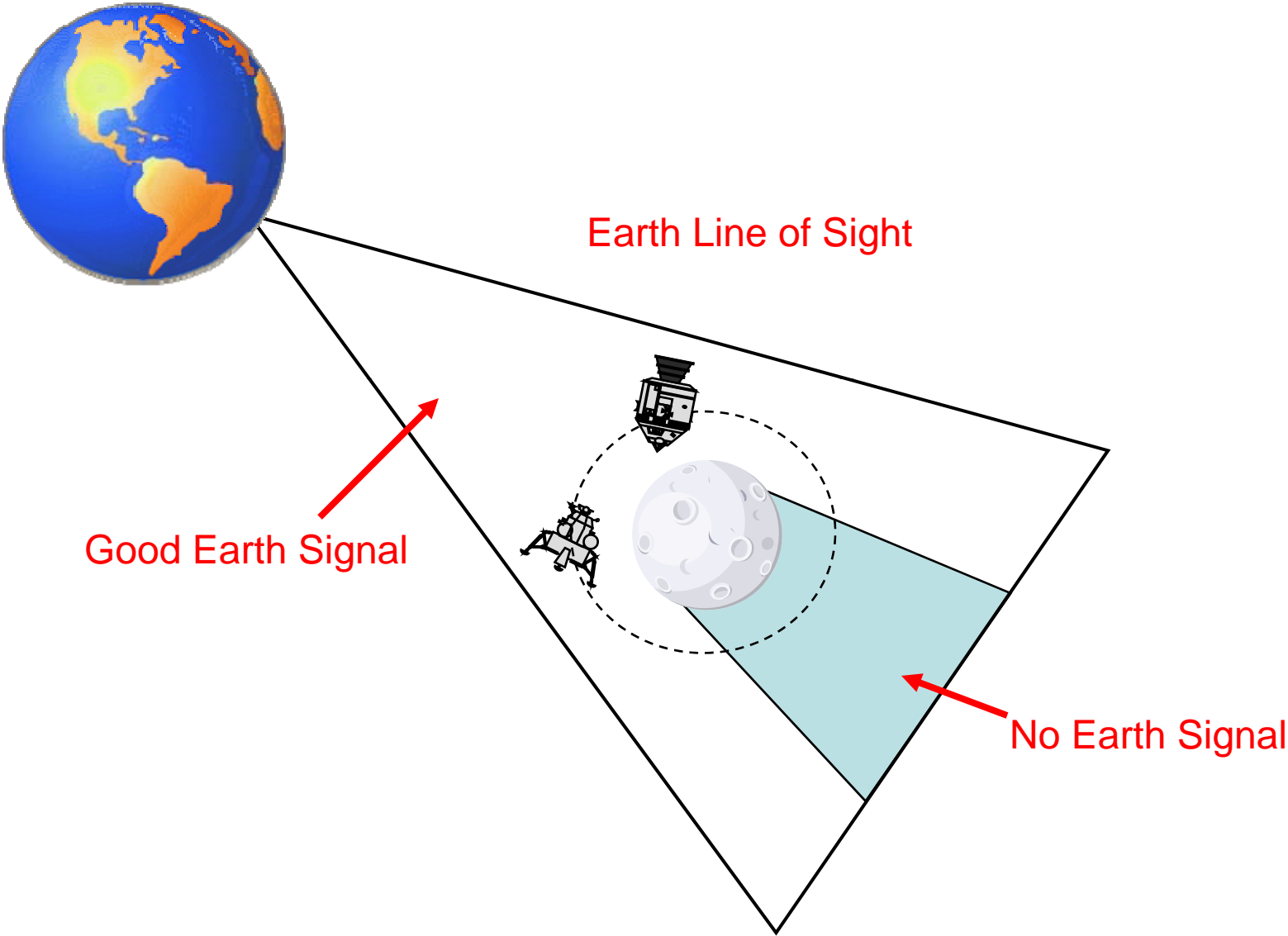
Prime communications link between the LM and MSFN during lunar stay



S Band Erectable
Antenna



Line of Sight



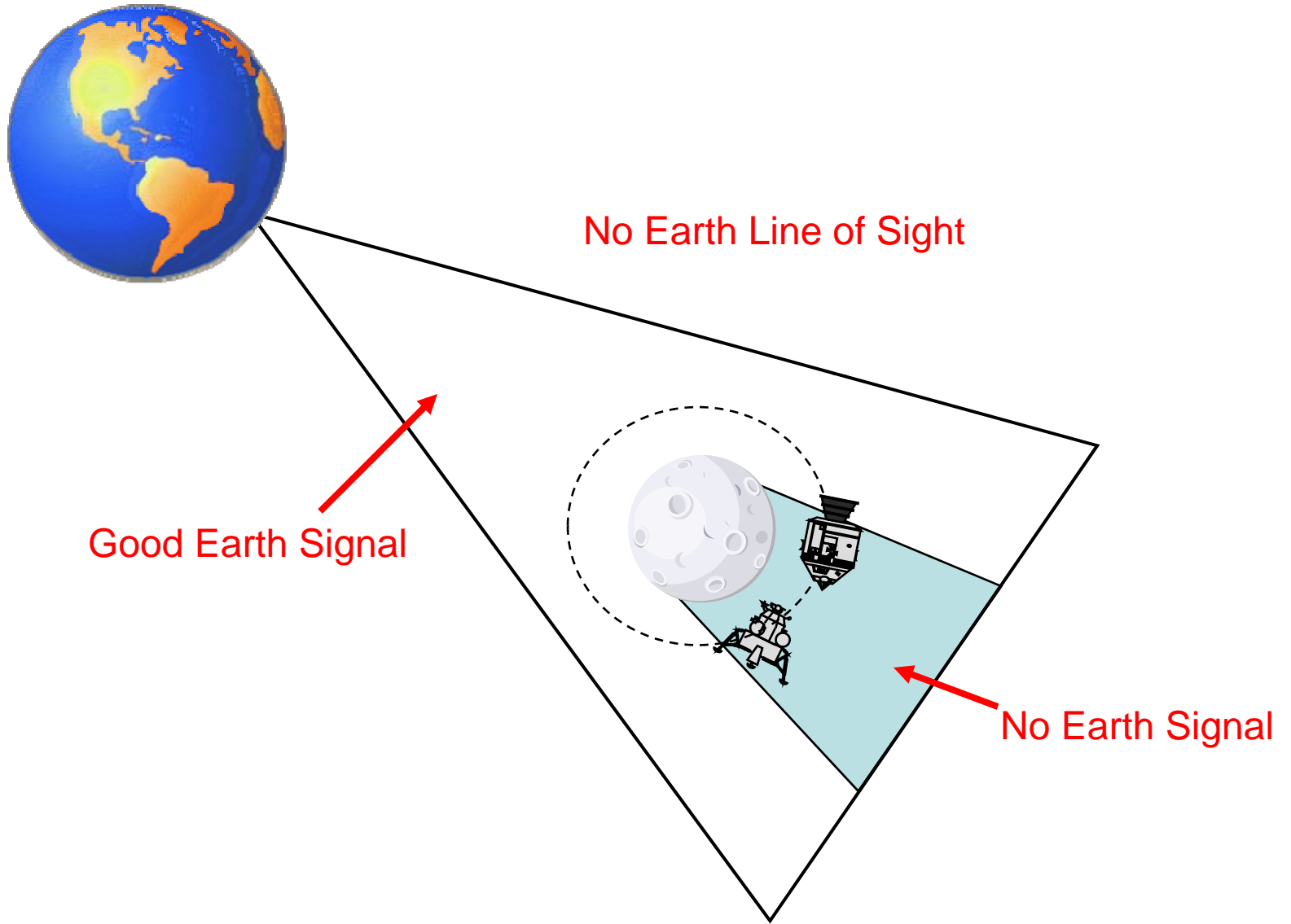
Good Earth Signal

Earth Line of Sight

No Earth Signal

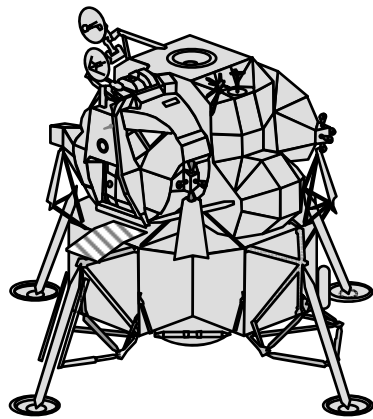
Not To Scale

Line of Sight

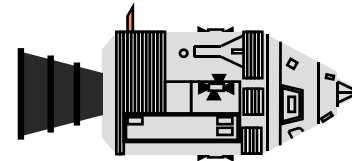


Not To Scale

Earth Line of Sight Comm



VHF
Voice



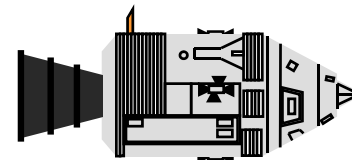
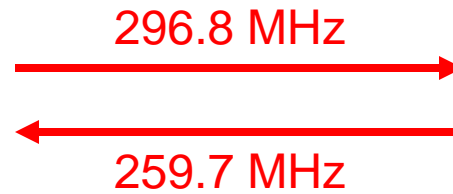
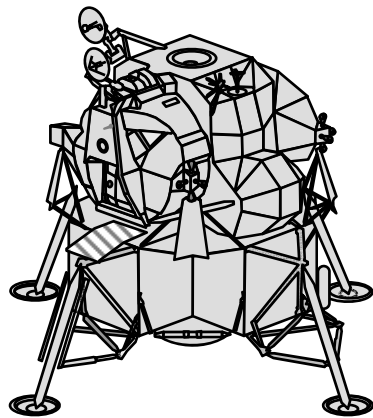
Earth Line of Sight Comm



Note:

296.8 MHz = VHF Channel A

259.7 MHz = VHF Channel B



Duplex Operations = Transmit and Receive on different frequencies

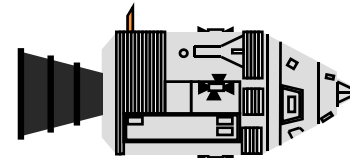
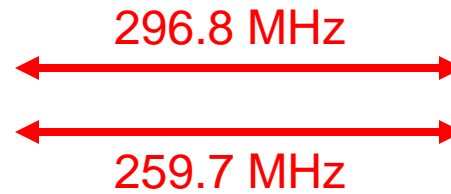
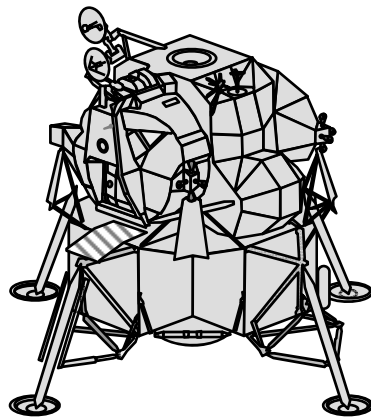
Earth Line of Sight Comm



Note:

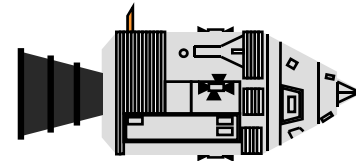
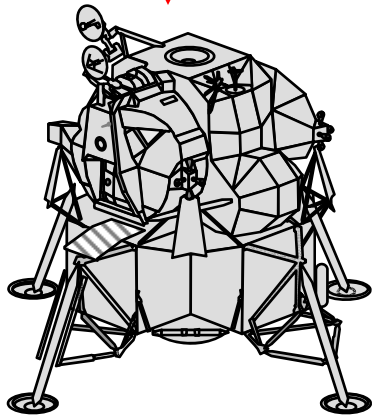
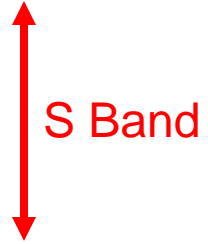
296.8 MHz = VHF Channel A Prime

259.7 MHz = VHF Channel B Backup



Simplex Operations = Transmit and Receive on the same frequency.

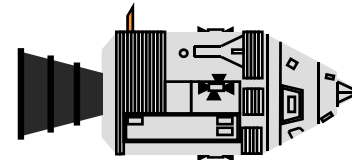
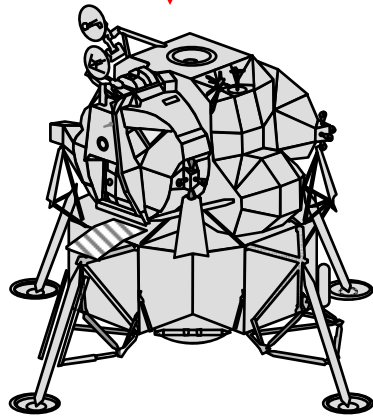
Earth Line of Sight Comm



Earth Line of Sight Comm



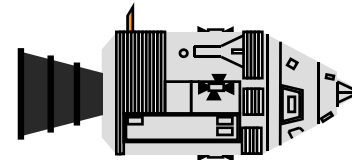
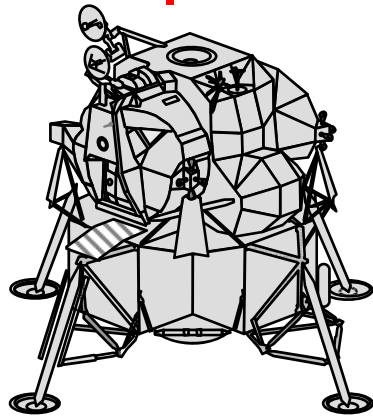
Voice
Ranging
2101.8 MHz



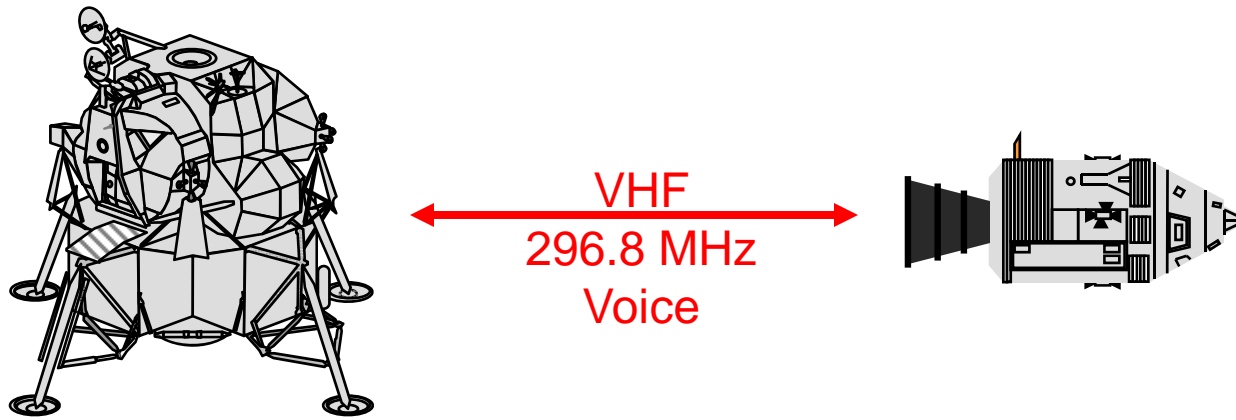
Earth Line of Sight Comm



↑ Voice
Data (51.2 kbps)
Ranging
2282.5 MHz

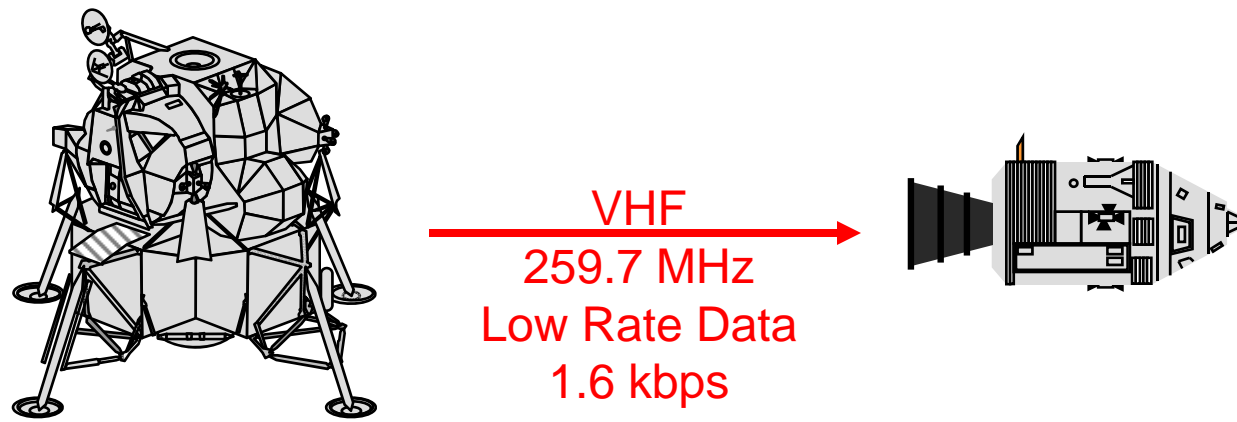


No Earth Line of Sight Comm



Simplex Operations = Transmit and Receive on the same frequency

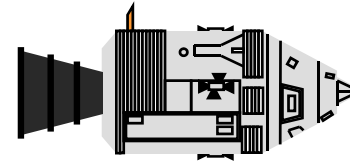
No Earth Line of Sight Comm



Data from the LM would be recorded on the CSM and played back to the ground when the CSM was in Earth LOS.

About two hours of recording time on the CSM

Lunar Stay Comm

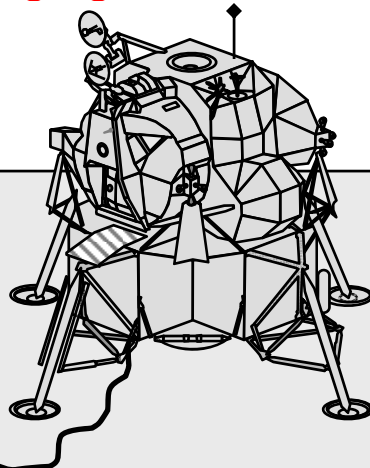


2282.5 MHz
Voice and Data
Ranging

2101.8 MHz
Voice
Ranging



S Band
Antenna



Mode 1 = Frequency Modulation, High Power (20 watts)
included TV

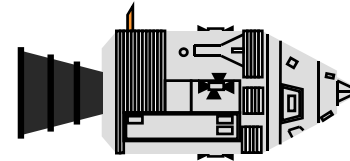
Mode 2 = Phase Modulation, Low Power (.75 watts)
without TV

Lunar Stay Comm



2282.5 MHz

2101.8 MHz

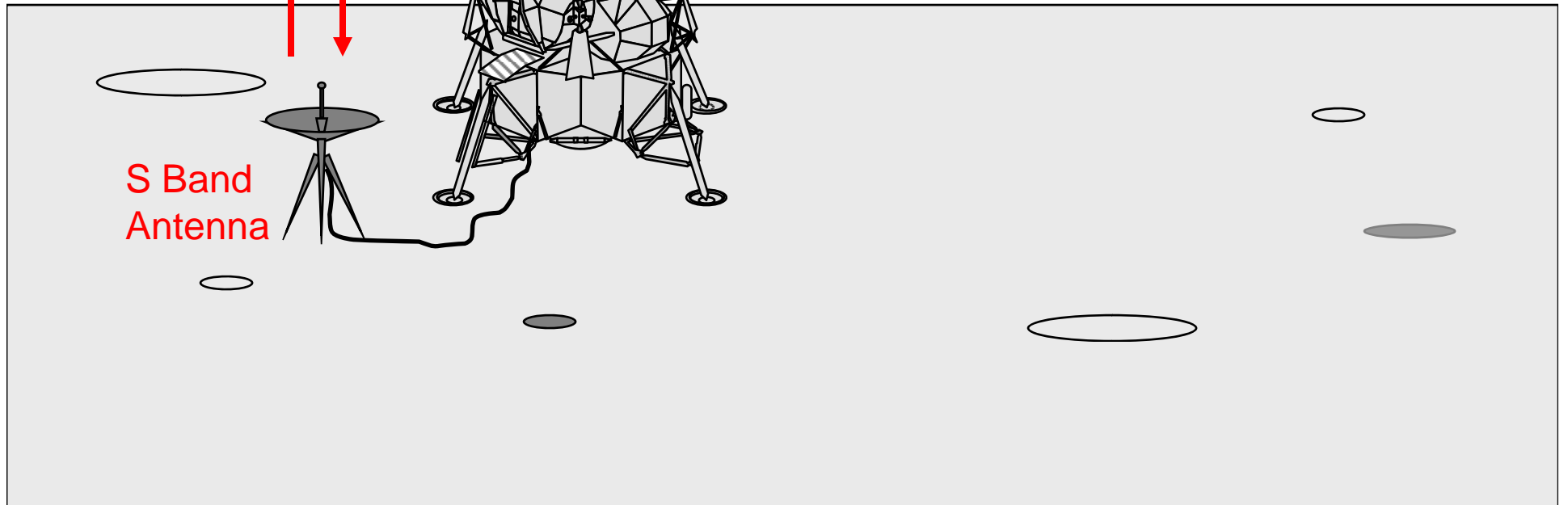


2282.5 MHz

2101.8 MHz

Each leg of communications took about 1.5 seconds, so turnaround time was a total of 6 seconds for response.

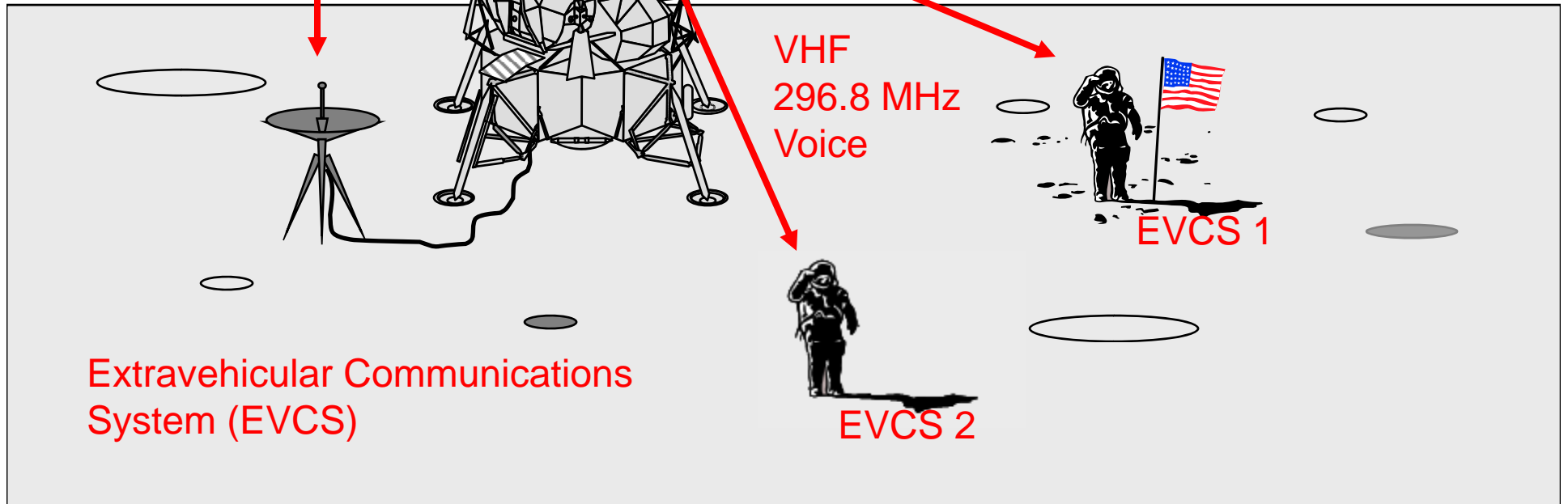
S Band
Antenna



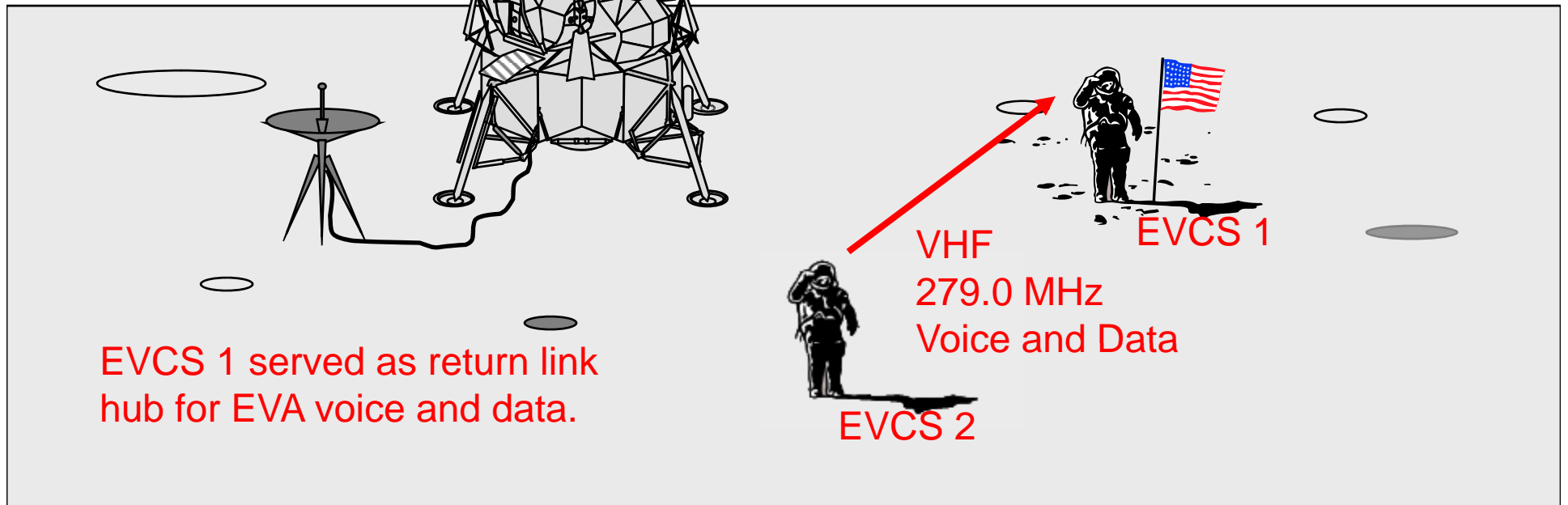
Lunar Stay Comm EVA Communications



S Band
2101.8 MHz
Voice



Lunar Stay Comm EVA Communications

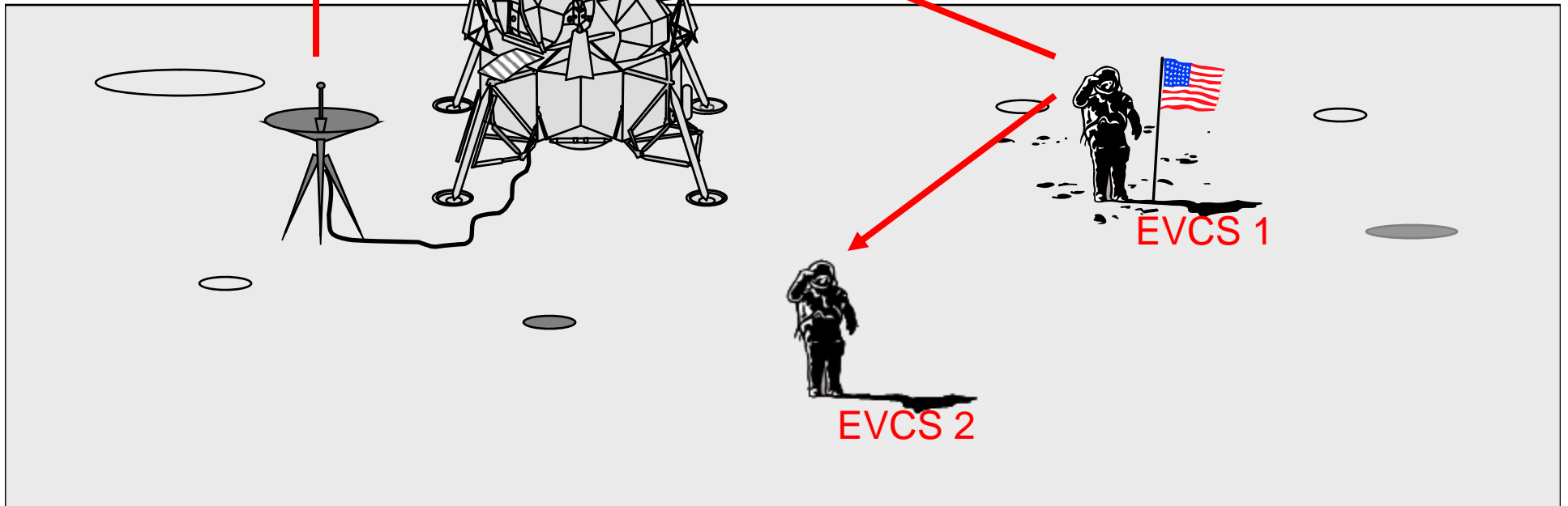


Lunar Stay Comm EVA Communications

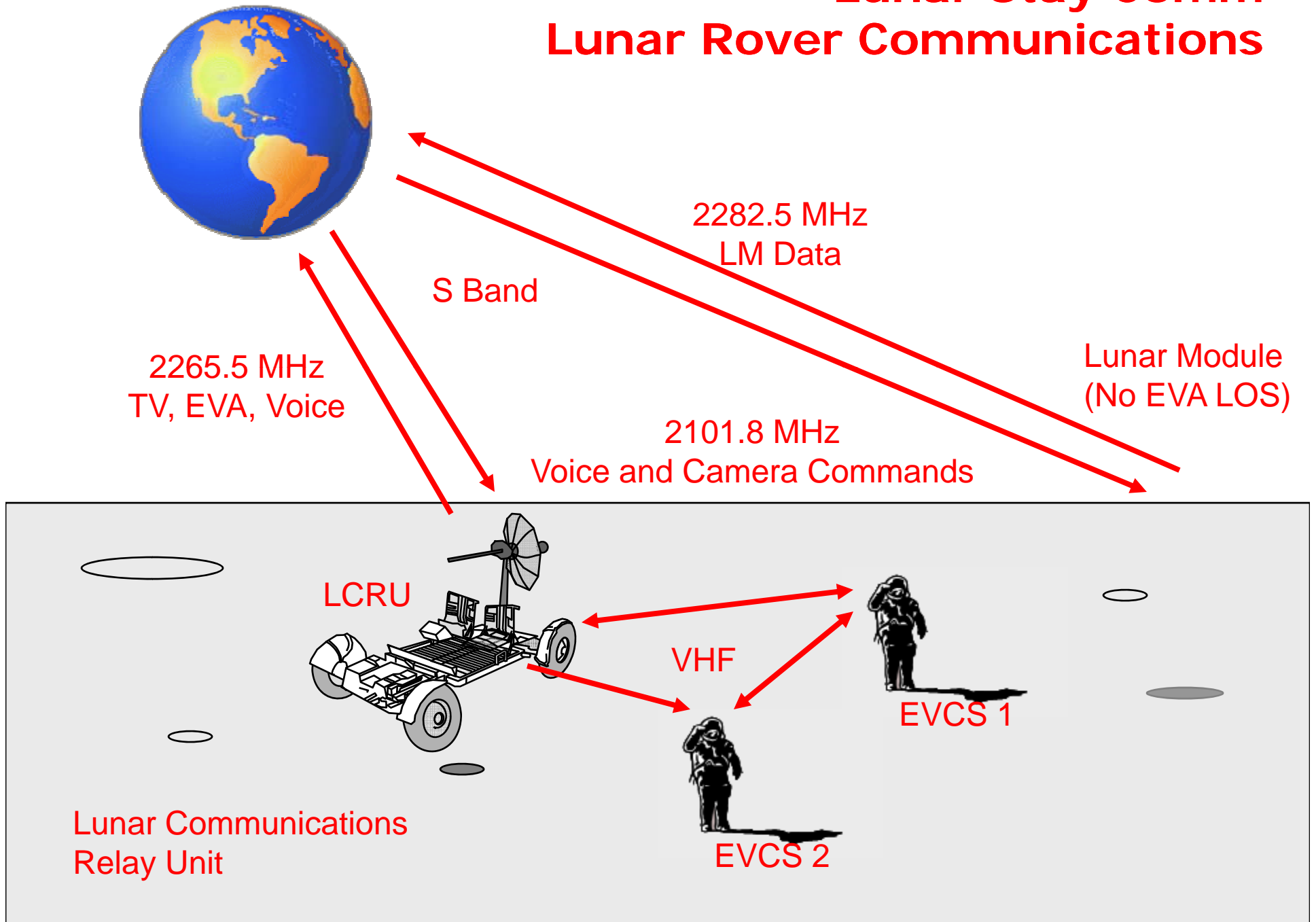


S Band
2282.5 MHz
Voice and Data (LM, TV and EVA)

VHF
259.7 MHz
Combined Voice and Data

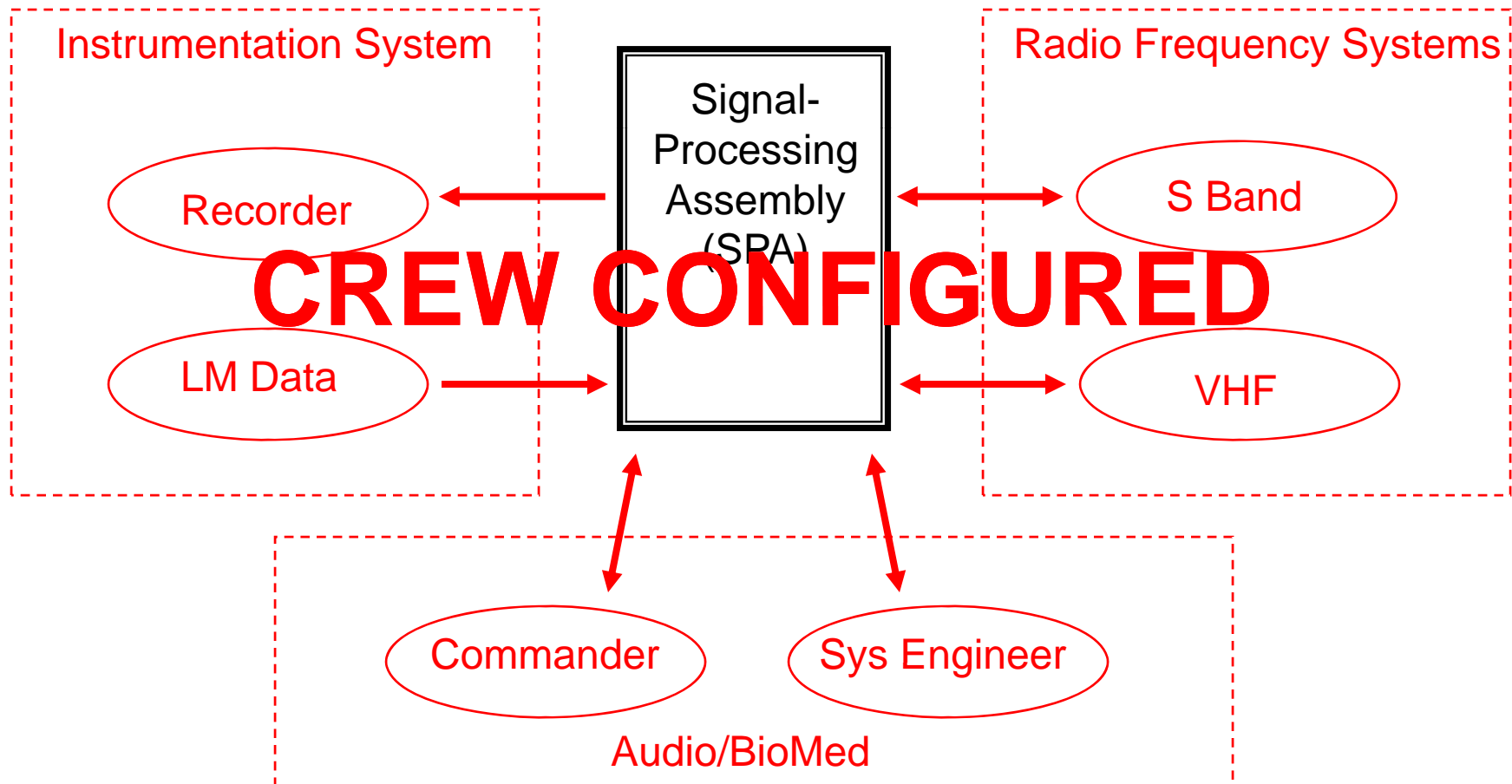


Lunar Stay Comm Lunar Rover Communications

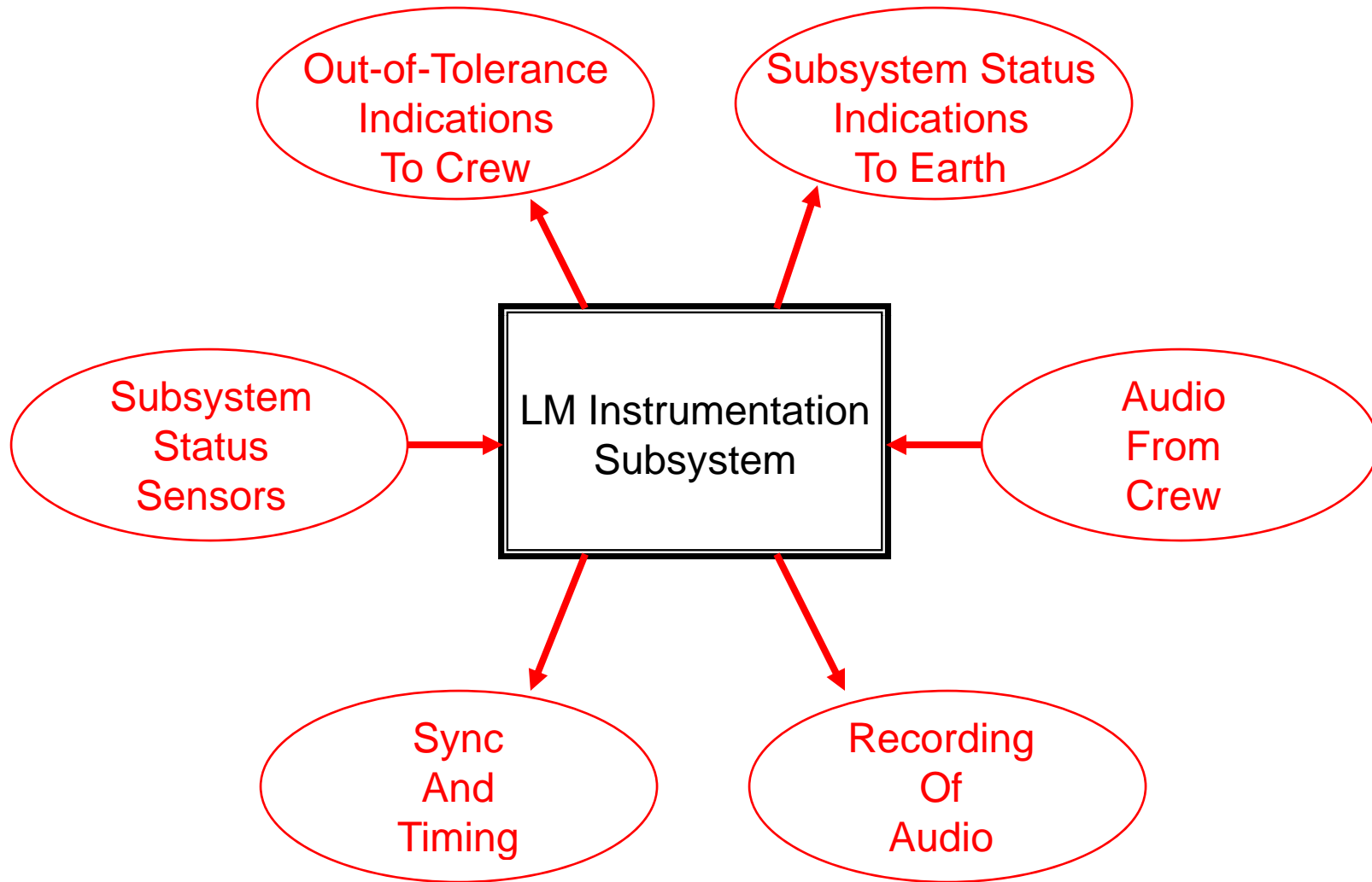


Signal Processing Assembly

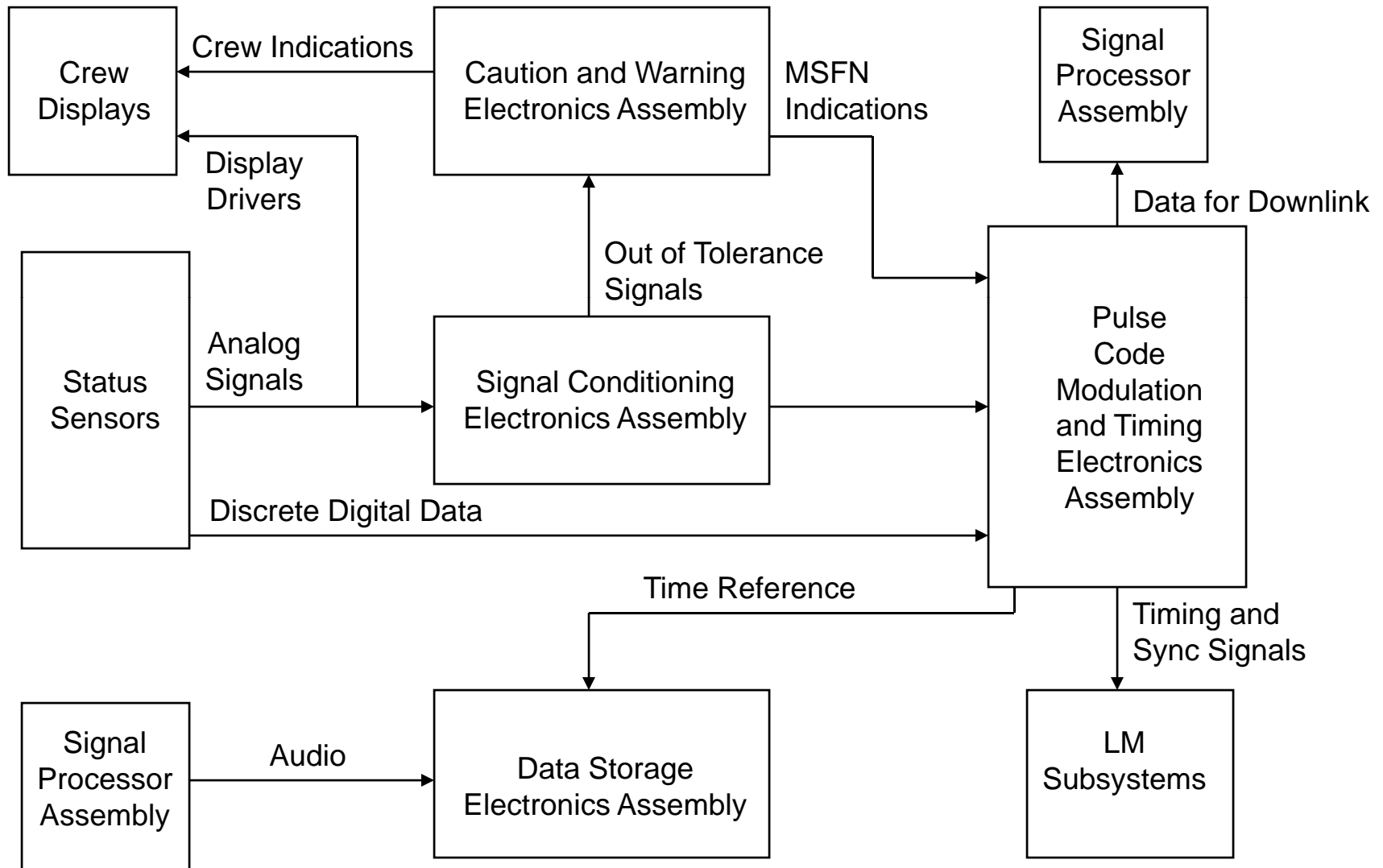
All signals transmitted or received by the comm subsystems are processed here.



Instrumentation System



Instrumentation System



LM Communications Problems

Improper Systems Configuration

MSFN Configurations

Apollo 9 – Loss of Voice to LM

Crew Configurations

Apollo 11 – LM Pilot Intermittent EVA Voice

Apollo 14 – No EVA Voice During Checkout

Apollo 15 – No CSM/LM VHF Voice During Lunar Descent

S Band Steerable Antenna Problems

Antenna Oscillations

Gimbal Hardstops/LM Body Blockage

Hardware Failures

Apollo 9 LM Pilot Audio System

Apollo 16 Steerable Antenna Failure

Lunar Module Communications Systems

S Band System – Voice and Data link between LM and MSFN
Ranging Data between LM and MSFN

VHF System – Voice and Data link between LM and CSM
Voice and Data link between LM and EVA
Ranging Data between LM and CSM

Radio Frequency Systems Usage – During Earth Line of Sight
During No Earth Line of Sight
During EVA Operations

Function and Interfaces of the Signal Processing Assembly and the Instrumentation System

Objectives

- Describe the different types of antennas on the Lunar Module
- Describe the different communications paths during Earth line of sight periods
- Describe the different communications paths during periods when there was no Earth line of sight
- Describe the different communications paths during Lunar Surface operations
- Describe the interfaces to and function of the Signal-Processing Assembly (SPA)
- Describe the interfaces to and function of the Instrumentation system

Lunar Module Communications

