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

VHF Antennas (2)

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

Earth Line of Sight

Good Earth Signal

No Earth Signal

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

S Band
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

VHF
259.7 MHz
Low Rate Data
1.6 kbps

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
Each leg of communications took about 1.5 seconds, so turnaround time was a total of 6 seconds for response.
Lunar Stay Comm
EVA Communications

S Band
2101.8 MHz
Voice

VHF
296.8 MHz
Voice

Extravehicular Communications System (EVCS)
Lunar Stay Comm
EVA Communications

EVCS 1 served as return link hub for EVA voice and data.
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

EVCS 1

EVCS 2
Lunar Stay Comm
Lunar Rover Communications

2282.5 MHz
LM Data

2265.5 MHz
TV, EVA, Voice

S Band

2101.8 MHz
Voice and Camera Commands

Lunar Module
(No EVA LOS)

LCRU

VHF

EVCS 1

EVCS 2

Lunar Communications Relay Unit
Signal Processing Assembly

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

Instrumentation System
- Recorder
- LM Data

Radio Frequency Systems
- S Band
- VHF

CREW CONFIGURED
- Commander
- Sys Engineer
- Audio/BioMed
Instrumentation System

LM Instrumentation Subsystem

- Out-of-Tolerance Indications To Crew
- Subsystem Status Indications To Earth
- Subsystem Status Sensors
- Audio From Crew
- Sync And Timing
- Recording Of Audio
Instrumentation System

- Crew Displays
  - Crew Indications
  - Display Drivers
- Status Sensors
  - Analog Signals
  - Discrete Digital Data
- Signal Processor Assembly
  - Audio
- Caution and Warning Electronics Assembly
  - Out of Tolerance Signals
- Signal Conditioning Electronics Assembly
- Pulse Code Modulation and Timing Electronics Assembly
  - Data for Downlink
  - Time Reference
  - Timing and Sync Signals
- MSFN Indications
- LM Subsystems
- Signal Processor Audio Data Storage
  - LM Subsystems
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
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