

The slide features a dark background with a NASA logo in the top right corner. The title 'CONSTELLATION Lunar Surface Communications' is centered at the top. Below the title is a large image of the Earth and Moon with a satellite orbiting. The date 'January 22, 2007' is on the left, and contact information for Gary K. Noreen is on the right. The text 'CCSDS Wireless Workshop' is at the bottom left.

**CONSTELLATION**  
**Lunar Surface Communications**

NASA

January 22, 2007

*CCSDS Wireless Workshop*

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The slide has a dark background with a NASA logo in the top right corner. The title 'Agenda' is centered at the top. Below the title is a list of agenda items. The background image shows a lunar surface with a rover and astronauts. The date 'January 22, 2007' is at the bottom left, the title 'Constellation Lunar Surface Communications - CCSDS Wireless Workshop' is at the bottom center, and 'GKN-2' is at the bottom right.

**Agenda**

- NASA Exploration Program Overview
- Shackelton Crater Outpost
- Lunar Relay Constellation
- ECANS Proximity Link Study
- Strawman Lunar Surface Communications & Navigation Architectures
- Issues
- NASA Studies

NASA

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Constellation Lunar Surface Communications - CCSDS Wireless Workshop

GKN-2

# NASA Exploration Organization

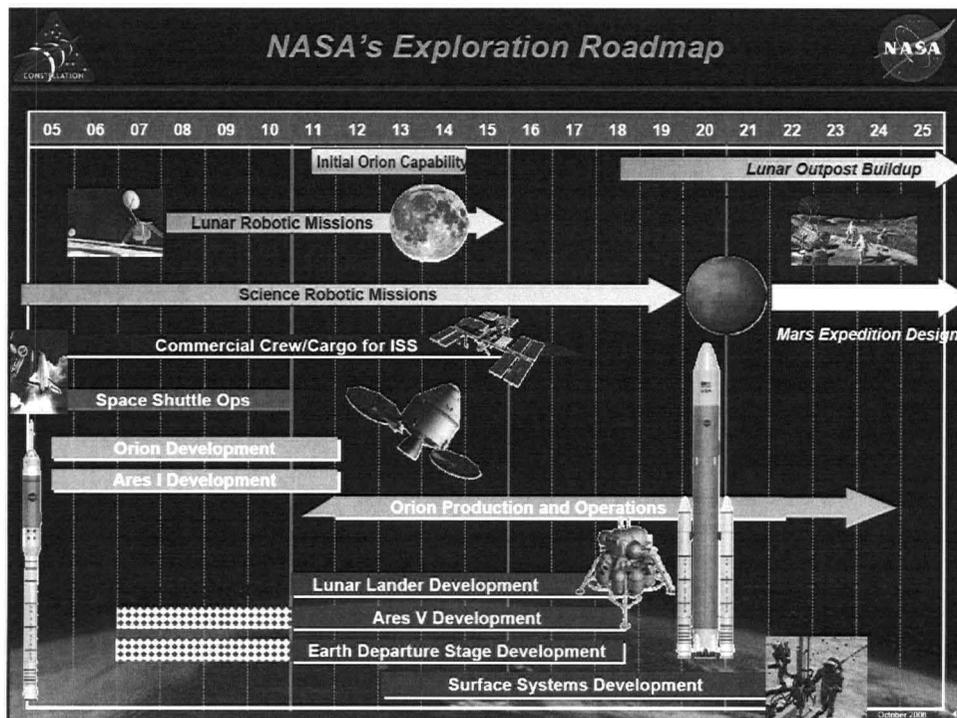


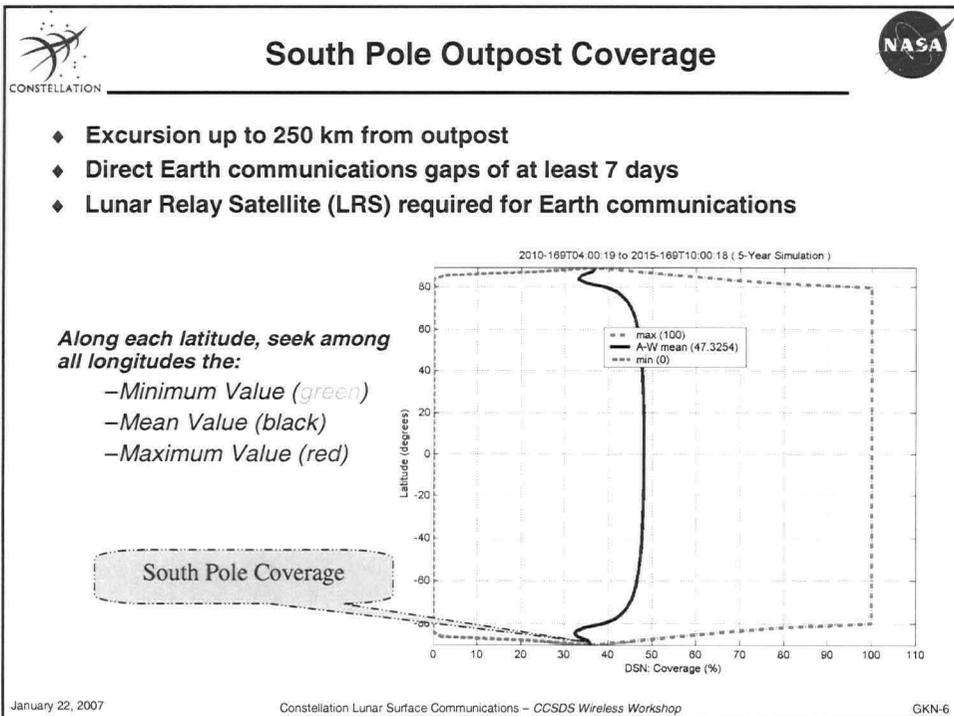
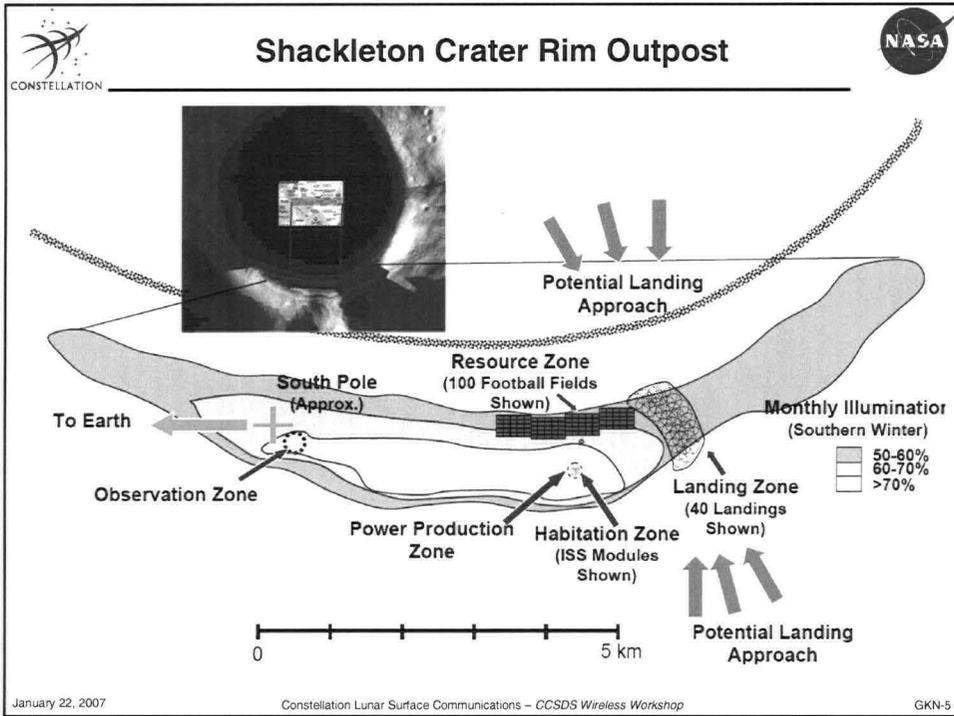
- **Vision for Space Exploration: humans return to moon no later than 2020**
- **NASA Exploration Systems Mission Directorate**
  - **Constellation Program**
    - [http://www.nasa.gov/mission\\_pages/constellation/main/index.html](http://www.nasa.gov/mission_pages/constellation/main/index.html)
    - Command, Control, Communications and Information System Integration Group responsible for lunar surface communications
  - **Exploration Communications and Navigation Systems (ECANS)**
    - Responsible for space infrastructure (Lunar Relay Satellites)
    - To be incorporated into NASA Space Communications Program in the Space Mission Operations Directorate
- **NASA Lunar Architecture Team (LAT)**
  - NASA Headquarters-led study defining Constellation lunar campaign
  - Initial strategy and architecture report on December 4, 2006
    - [http://www.nasa.gov/pdf/163896main\\_Exploration-LAT\\_Briefing\\_120406.pdf](http://www.nasa.gov/pdf/163896main_Exploration-LAT_Briefing_120406.pdf)
    - South Pole outpost
    - US will build the initial communication & navigation systems
    - Open architecture: development of lunar surface infrastructure welcome

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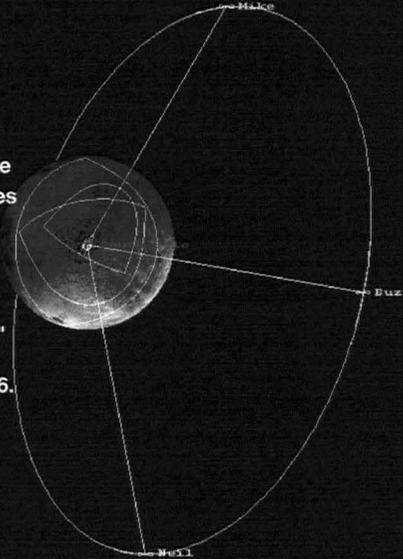




# Lunar Relay Constellation



- **Quasi-stable pole lingering orbit**
  - Effective for both surface-Earth relay and surface-surface relay
  - 2 for continuous relay
  - 3 for continuous redundant relay
  - Apoapses stay in southern hemisphere
  - Widely varying periapses, eccentricities
  - Nearly constant relative phase if in same orbit plane
  - Ely, T. A., Lieb, E., "Constellations of Elliptical Inclined Lunar Orbits Providing Polar and Global Coverage," The Journal of the Astronautical Sciences, Vol. 54, No. 1, Jan - Mar 2006.



- **Relay Payload**
  - Space Network emulation
  - S-band operational
  - Ka-band high rate
  - ~1 m diameter antenna

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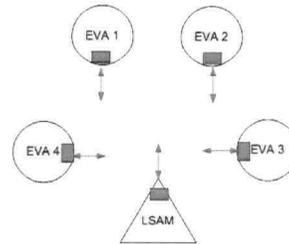


# ECANS Proximity Link Study



- ◆ **Conducted in late 2005/early 2006**
- ◆ **Communications protocol focus**
- ◆ **Operating scenarios**
  - Everyone converses with everyone else
  - HDTV within 100 m
  - SDTV to ~1 km
  - Voice to ~10 km
- ◆ **Many protocols considered**
  - Commercial, military, NASA
- ◆ **Focused on:**
  - 802.11e & 802.16e
  - Custom Shuttle/ISS-derived TDMA
- ◆ **Recommended delaying decision**
  - Rapidly developing technology
  - Operating scenarios developed internally
  - No urgent need for decision

Scenario 3B, 4B, 5B  
Surface EVA from LSAM  
All Broadcast Voice, Command, Telemetry @ 64 kbps  
EVA Video rate is a function of Range

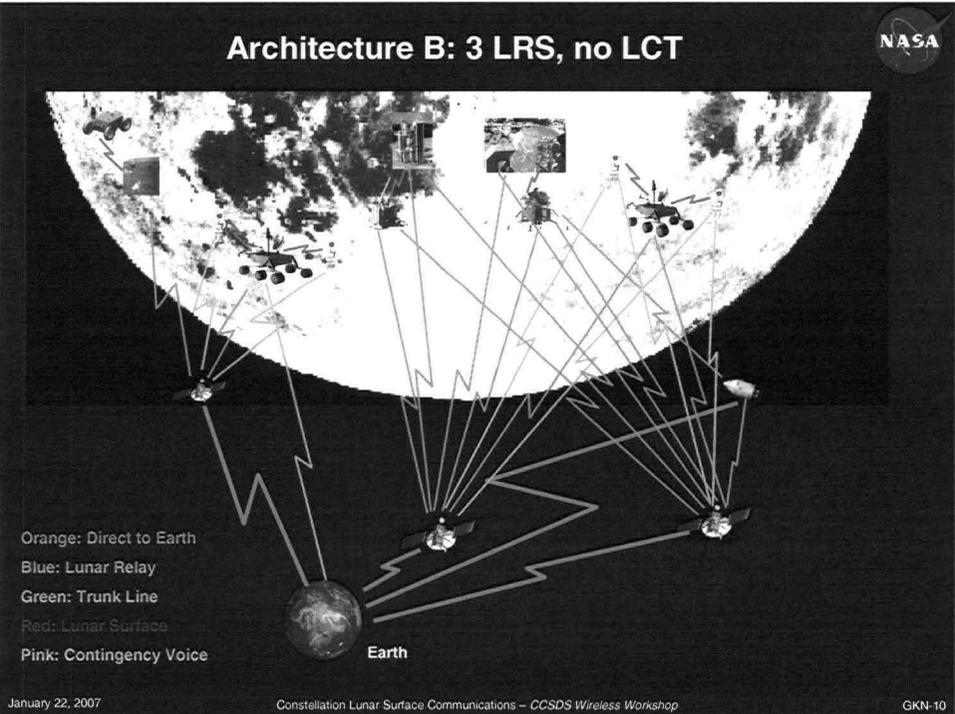
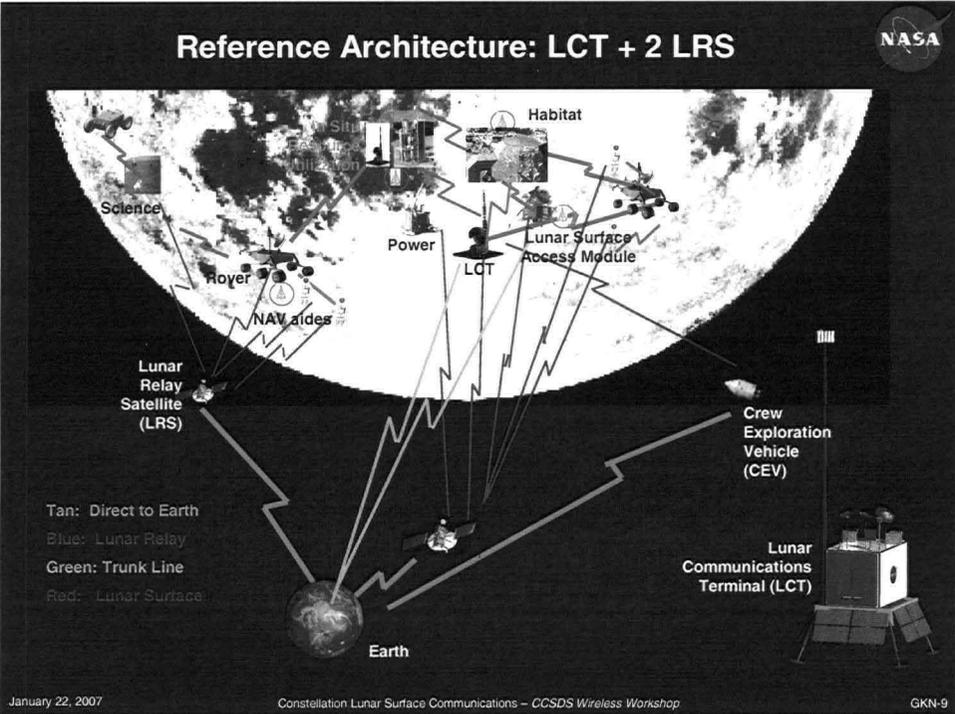


Scenario	Range	Data Type	Rate
5B	5 nm (9.3 km)	VCT No TV	64 kbps NA
4B	.5 nm (.93 km)	Std. Definition from 4 EVA's	4*6 Mbps
3B	300 feet (100 m)	Std. Def. + HDTV from 2 EVA's	2*6 Mbps 2*20 Mbps

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## Issues

**Concept of Operations Configuration**

- Lunar Communications Terminals vs. Lunar Relay Satellites for long range surface-surface links
- LCT placement

**Spectrum**

- How do terrestrial links and spectrum regulations relate to lunar surface links?
- Surface link spectrum

**Protocol**

- Lunar relay links (Constellation baseline: TDRSS-compatible)
- Direct surface-surface links

**Requirements**

- Range of operation
- Applications, data rates, etc.

**Contingency Voice**

- Constellation requires dissimilar systems
- Different frequency, modulation (possibly analog), equipment, etc.

**Reliability**

- How many serial links?
- How likely is each to fail?
- Alternate paths?
- Redundancy?

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## NASA Studies

**Lunar surface Concept of Operations (CONOPS)**

- Constellation Advanced Projects Office (APO)

**SCAWG Coding, Modulation, & Link Protocol Study**

- NASA Space Communications Architecture Working Group
- Wide-ranging look at NASA RF links
- Addressing relay & direct Earth links, but not direct lunar surface-surface links

**Lunar Architecture Team may issue lunar surface com & nav infrastructure study contracts to industry/academe**

**Lunar Surface Communications and Navigation Architecture Study**

- Joint Lunar Architecture Team/Constellation
- LAT objective: describe architecture
- Constellation objective: resolve requirements
- Generate strawman alternative architectures
  - Protocols
  - Frequencies
  - Combination & Placement of LCTs and LRSs
  - Desire innovative approaches
- Evaluate performance of the alternative architectures for the APO CONOPS
- Estimate infrastructure cost & assess user burden for viable alternative architectures

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