LunaNet: A Space Mobile Network at the Moon
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Space Mobile Network

**High-Availability Links**
- Maximize coverage and availability
- Maximize link performance, while maintaining availability

**High-Performance Links**
- Maximize link performance
- Minimize complexity of required scheduling

**User Spacecraft**
- Maximize comm & nav performance
- Minimize size, weight and power
- Maximize autonomy

**Near Space Network**
- Maximize service capabilities
- Minimize operations costs
- Relays and ground stations provide access points to larger network
- Automated real-time and store-and-forward data delivery
- Position, Navigation, and Timing Services
- Maximize interoperability between NASA, domestic and international partners, and commercial providers

**User Mission and Science Ops Center**
- Maximize mission return
- Minimize complexity
- Minimize operations costs

**Link = Network Access**
Space Mobile Network at the Moon

High-Performance Links

High-Availability Links

NEAR side of the Moon

NEAR and FAR side of the Moon
LunaNet Services

**Networked Communication Services**
- Critical data transmitted in real time.
- Data aggregated and transmitted in store-and-forward mode from orbiting and surface relays.
- Data exchanged among lunar users with no need for transfer to and from Earth.
- Data sent on demand by user or scheduled to better manage Earth stations loading & spectrum use.

**PNT Services**
- Precise position, velocity and time for autonomous nav and collision avoidance.
- Fusion of multiple data types including radiometrics, optimetrics, celestial nav, optical nav, terrain relative nav, & GNSS.
- Broadcast service supplies time transfer and metric tracking to synchronize users.

**Detection and Information Services**
- Alerts for events such as space weather, collision avoidance, & surface impact predictions sent to all LunaNet subscribers.
- Mission sensors for space weather and other measurements distribute information services to other users via LunaNet information services.

**Science Services**
- Use RF & optical assets (part of) as scientific instruments.
- Supports Radio & Radar Sciences, Radio Astronomy / Very Long Baseline Interferometry (VLBI) & other space sciences.
LunaNet Service Provider Interfaces

- Any LunaNet Service Provider (LNSP) operates a LunaNet System (LNS) that provides Communications and PNT (CPNT) services to Service Users.

- Only two interfaces must be public and standardized:
  - User Services Interface defines services that may be offered by an LNS and service characteristics required for interoperability.
  - Internetwork Interface defines the network management and network data exchange between two LNSs required for interoperability.

- Choice of services offered by an LNS is up to the LNSP owner/operator.

- Internal design of an LNS is the responsibility of the LNSP owner/operator.

User Services Interface
LNS-User interoperability covering:
- Space-Space, Space-Ground, & Ground-Ground
- CPNT Services, SLA & Service Management
- Cross support (a.k.a. roaming) ability to use additional or alternate LNSP for standard services
Store and Forward Relay from Lunar Farside

**Diagram:**
- **Moon** to **Lunar Farside Telescope**
  - Files
    - CFDP
    - BP
    - TCP
    - IP
- **Lunar Farside Optical Terminal**
  - High Speed Optical Relay
- **Earth Optical Terminal**
- **Earth DTN Node** to **Science Fileserver**
  - Files
    - CFDP
    - BP
    - TCP
    - IP

**Nodes:**
- Lunar DTN Node
- Lunar Farside Optical Terminal
- Earth Optical Terminal
- Earth DTN Node
- Science Fileserver

**Connections:**
- Moon to Lunar Farside Telescope
- Lunar Farside Telescope to Lunar Farside Optical Terminal
- Lunar Farside Optical Terminal to Earth Optical Terminal
- Earth Optical Terminal to Earth DTN Node
- Earth DTN Node to Science Fileserver

**Technology:**
- High Speed Optical Relay
- CFDP
- BP
- TCP
- IP

**Files:**
- Lunar Farside Telescope
- Earth
- Moon
- Earth Moon

**Network Protocols:**
- TCP
- IP
- CFDP
- BP
Store and Forward Relay from Earth South Pole

South Pole Fileserver → South Pole DTN → South Pole Optical Terminal

High Speed Optical Relay

CONUS Optical Terminal → CONUS DTN → CONUS Fileserver

Files

CFDP

BP

TCP

IP

MEM

IP

Optical

MEM

Optical

Optical

MEM

BP

TCP

IP

UNCLASSIFIED
“Local” Space Mobile Networks Interconnect to form the Solar System Internet

SMN: LEO/MEO/GEO

SMN: Cis-lunar

SMN: Lagrange Points

SMN: Deep Space

Legend

Link = Network Access
** = Net. Access Point
High-Performance Links
High-Availability Links

In-Situ PNT

High-Performance Links

High-Availability Links

In-Situ PNT

Trunk line
Conclusions

- **Space Mobile Networks differ from terrestrial mobile networks**
  - Space-based users
  - Significant amount of user data applications do not require minimum latency
  - Non-continuous accessibility of systems
  - Difficult to deploy, repair, and upgrade

- **Key technologies enable Space Mobile Networks**
  - Delay/Disruption Tolerant Networking for store-and-forward end-to-end networking
  - Optical communications for high-performance links
  - User Initiated Services for autonomous and more rapid acquisition of services
  - Multiple access technologies for increased availability
  - PNT technologies for autonomous navigation, guidance and control

- **LunaNet is an implementation of a SMN to expand the Solar System Internet to the Moon**