Delay/Disruption Tolerant Networks (DTN): Testing and Demonstration for Lunar Surface Applications

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Background

- A surface analog for wireless infrastructure is under development

  The analog will provide for connectivity between multiple analogs and facilities on site at JSC
  - Wireless Habitat Test Bed
  - Habitat Test Bed (HaT)
  - Habitat Demonstration Unit (HDU)
  - Lunar Electric Rover (LER)
  - Lunar Rock Yard
  - Operations Technology Facility (OTF)
  - Electronic Systems Test Laboratory (ESTL)

- DTN Experimental Network (DEN) permits access and testing by other NASA Centers, DTN Team Members, and protocol developers
Objectives

- Demonstrate DTN for high return applications in lunar scenarios
  - Different data types (video, audio, files, command & control)

- Provide DEN connectivity with analogs of Constellation elements, emulators, and other resources from DTN

- Serve as a wireless communications staging ground for remote analog excursions (e.g., Desert-RATS)

- Enables testing of detailed communication scenarios and long term evaluation of network performance
DTN Lunar Scenarios: Assets & Links

Lunar Relay Satellite

S-Band/Ka-Band

Ground Networks

Electric Rover

Lunar Communications Terminal

S-Band/Ka-Band

Surface link
DTN Lunar Scenario: Rover Motion Imagery
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Operations Concept

• **6-8 HD cameras mounted on each rover**
  - 1 camera per rover selected as “primary”, others “secondary”
    • Rover operators will switch between cameras while driving
    • Second rover may swap motion imagery with first rover
    • Ground operators will select camera(s) for downlink to Earth
  - Front camera for navigation and hazard avoidance
    • Need to know where EVA is with respect to rover – no vehicle-pedestrian accidents
  - Side cameras for situational awareness
  - Minimum 1 motion imagery stream while under way
  - All motion imagery stored locally for later forwarding
• Surface communication infrastructure does not have to support real-time peak loads

Data is not lost when channels are over-subscribed

Increased video quality for science, public interest
Motion Imagery Data Flow
Rover Communications Stack Diagram

LER

H.264
MPEG-2 TS
RTP
BP Tunnel App
BP
UDP
IP
802.16

PCT

BP
UDP
IP
802.16

LRS

BP
UDP
IP
Encap
AOS
RF

GS

BP Tunnel App
UDP
IP
Encap
AOS
RF

MCC

BP Tunnel App
UDP
IP
Encap
AOS
RF

H.264
MPEG-2 TS
RTP
BP Tunnel App
BP
UDP
IP
Encap
AOS
RF

ETH
Motion Imagery Scenario at Surface Analog

- Single motion imagery stream to lunar communications terminal (rover collision avoidance – Screen 1)
- Second rover video is stored via DTN for later forward (Screen 2)
Payload = ELM
Utility Palette

DTN Lunar Scenario: Voice Transcript/RFID

S-Band/Ka-Band
Ground Networks
Lunar Relay Satellite
Lunar Habitat

Proximity Surface Link (data)
Handheld RFID
Rock samples
DTN Lunar Scenario: Voice Transcript/RFID Operations Concept

- EVA traverses up to 100 meters from the rover

  EVA reports geologic setting and conditions on audio channel
  - Audio transcript constitutes part of the scientific record for geologic specimens

- EVA collects geologic specimens and places in bags

- RFID interrogator captures bag ID

  Audio and specimen ID are transmitted to the rover, which associates a location estimate with the data
Audio/RFID Scenario: DTN Value

- RFID data from the specimen bag, audio transcript, and coordinates are associated with each sample

- All of these constitute part of the scientific record

- Scientific field data is vulnerable to link disruptions along any segment of a multi-hop network

- DTN prevents loss of science
Audio Data Flow
EVA Communications Stack Diagram
DTN Lunar Scenario: Navigation Telemetry
Ground crew views tracking telemetry from autonomous robot in habitat proximity.

Tracking telemetry is routed through multi-hop network that is subject to disruptions.

DTN technology prevents loss of situational awareness data:
- Provides “last known location” and promotes anomaly resolution.
Link restored

autonomous robot

Live telemetry

Link disrupted

DTN - enabled Telemetry (recovered)
Conclusion

- A surface communication analog is under development
  - Experiments and demonstrations can incorporate multiple Constellation element analogs and facilities
  - DEN connectivity will permit DTN team members access to wireless communication links

- Three scenarios are targeted for demonstration in FY10
  - Motion imagery
  - Voice and sensor telemetry
  - Navigation telemetry