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

October, 2010

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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 (HDRU)
  - 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

EVA

Lunar Rover Communications Terminal

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
Motion Imagery Scenario: DTN Value

- 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
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)
DTN Lunar Scenario: Voice Transcript/RFID
- 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

G.729
RTP
IP
802.11
G.729
RTP
IP
802.11
BP Tunnel App
BP
UDP
IP
802.16
BP
UDP
IP
Encap
AOS
RF
BP
UDP
IP
Encap
AOS
RF
BP
UDP
IP
Encap
AOS
RF
BP
UDP
IP
Encap
AOS
RF
BP
UDP
IP
Encap
AOS
RF
802.16
G.729
RTP
IP
ETH
G.729
RTP
IP
ETH

EVA
LER
PCT
LRS
GS
MCC
Audio/RFID Scenario at Surface Analog
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.
DTN Lunar Scenario: Navigation
Telemetry Demonstration

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
Backup