Opportunistic MSPA: An Overview of the Proof-of-Concept Demonstration

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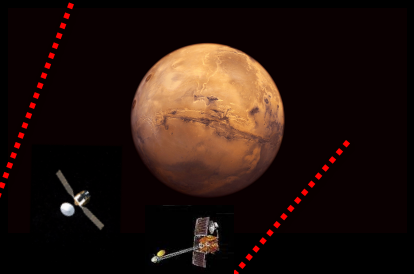
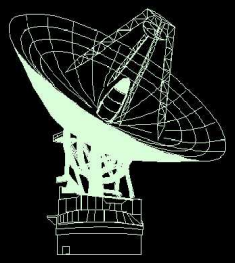
Review of Concept: Multiple Spacecraft Per Antenna (MSPA)

Traditional MSPA

2 spacecraft that will be in same beam formally schedule to share antenna.



Each spacecraft downlinks to a separate receiver.

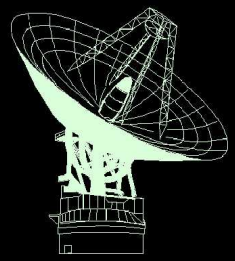


Currently, 2 receivers per antenna, allowing 2-MSPA. DSN moving to 4-MSPA capability on selected antennas.

Opportunistic MSPA

"N" smallsats opportunistically transmit open loop while in beam of a "host" spacecraft.

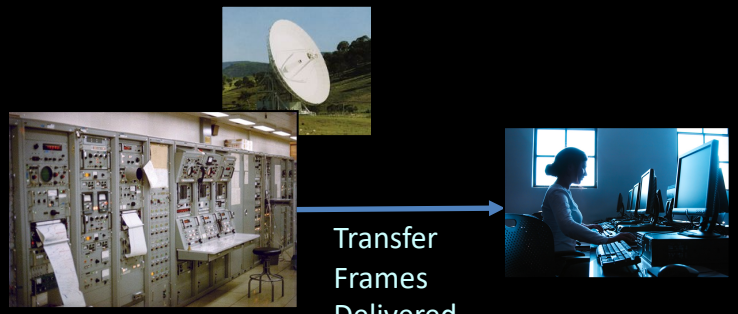
"Host" spacecraft has a formally scheduled downlink to a receiver.



Smallsat open-loop transmissions are captured on a wideband recorder.

Review of Concept: MSPA vs. OMSPA Feature Comparisons

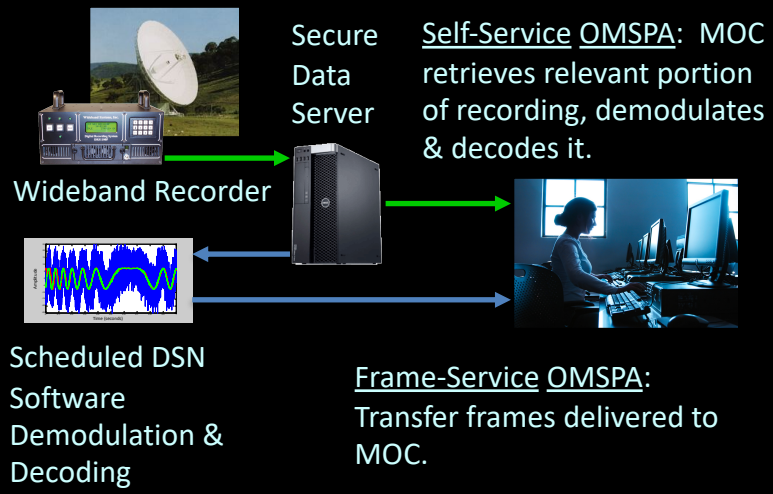
Traditional MSPA
(Existing)



Key Features

- Downlink only
- Reliable
- Very low latency
- Constrained number of users
- Users subject to formal DSN antenna scheduling process

Opportunistic MSPA
(Proposed)



Key Features

- Downlink only
- Reliability depends on implementation
- Latency depends on implementation
- Unconstrained number of users
- Users not subject to formal DSN antenna scheduling process

Demo Purpose & Objectives

- **Purpose** – show prospective users, and prospective service providers, that OMSPA is an operationally viable, low-cost means for obtaining routine downlink telemetry.
- **Objectives**
  1. Demonstrate ability to compute beam intercept times and associated opportunities for opportunistic downlink.
  2. Demonstrate ability to capture an opportunistic downlink on a wideband recorder and retrieve the corresponding portion of the recording via a secure internet site.
  3. Demonstrate ability to demodulate, and decode the recorded signal in an operationally feasible timeframe.
  4. Demonstrate that all of these things can be done within ~1-2 days irrespective of which DSN complex is in view during a pass.

Demo Methodology Overview

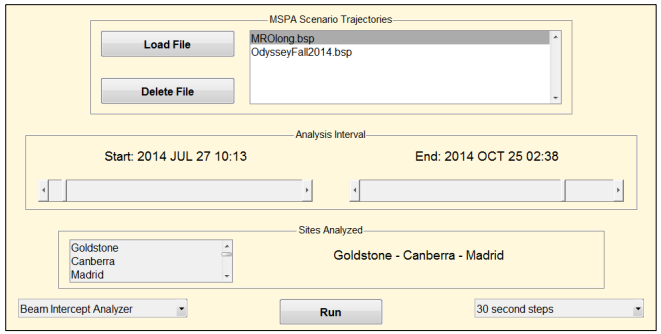
- Determine when Mars Odyssey will be in MRO's antenna beam.
- Record Odyssey's transmission.
- Retrieve recording.
- Demodulate & decode recording.

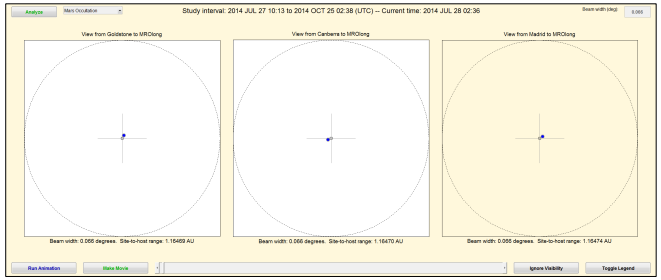
- Validate recovered transfer frames by comparing to those recovered via Odyssey's scheduled downlink.

OMSPA Demo Tools/Systems (1/3)

1. Beam Intercept Planning System (BIPS)

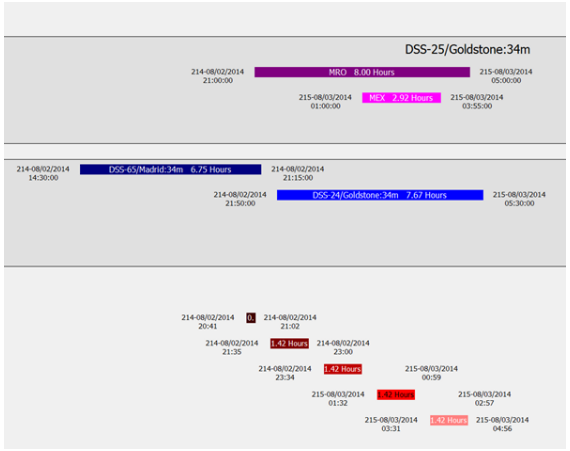
- Compares smallsat and potential “host” spacecraft trajectories to identify beam intercept opportunities.
- Removes planetary occultation periods from the opportunity windows.
- Reports usable intercept timeframes and aggregate statistics.





2. 7-Day Schedule Cross-comparison tool (7-DSC)

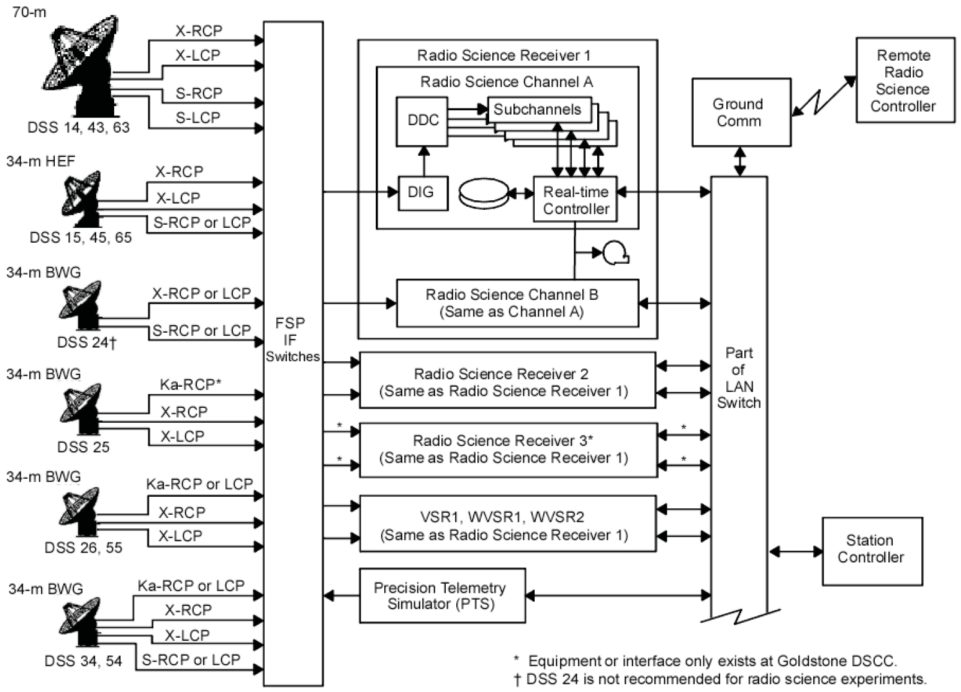
- Compares the BIPS-provided intercept timeframes to the “host” spacecraft downlink times reported in the DSN’s 7-day schedule.
- Identifies potential antenna record times.



OMSPA Demo Tools/Systems (2/3)

3. Very-Long-Baseline-Interferometry Science Receiver (VSR)

- Converts analog IF signal into a digital format and, among other things, provides a recording capability.
- Based on the antenna(s) and recording times identified with 7-DSC, the VSR can be set to record the appropriate DSN station on the selected channel(s) with the appropriate start and stop times.



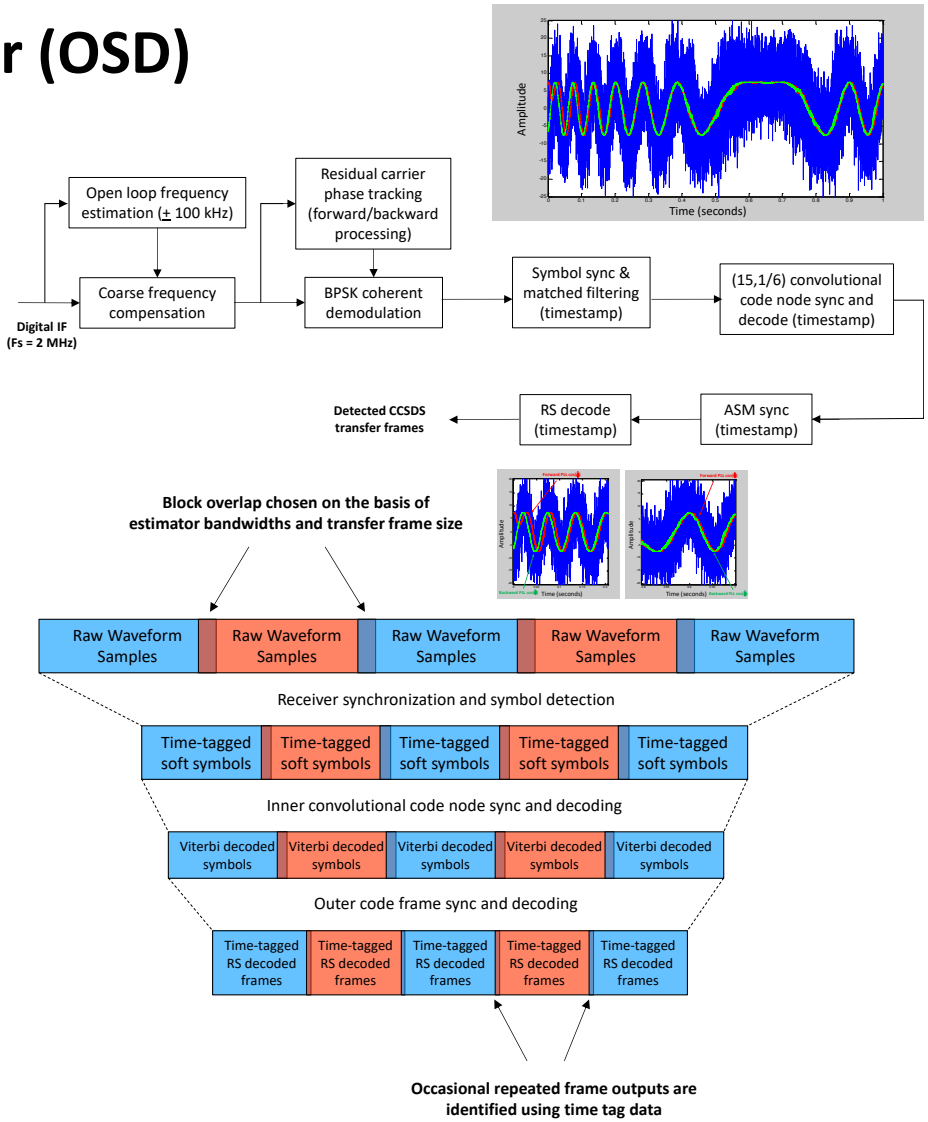
4. Server Repository (“lilypond”)

- Storage destination for playback of the VSR recording.
- Access point for signal processing team.

OMSPA Demo Tools/Systems (3/3)

5. OMSPA Software Demodulator (OSD)

- Based on prior and on-going investment by the DSN Advanced Engineering Office in an analysis tool for low-to-medium rate deep space telemetry downlink waveforms.
- Implemented in MatLab.
- Unlike real-time receivers, it is able to reprocess the recorded data multiple times for improved detection performance.
- The independent, block-oriented nature of its processing enables scalability for increasing the aggregate processing speed by allowing concurrent processing of different data blocks.



Results

- **Identification of OMSPA Opportunities**
  - BIPS and 7-DSC were able to compute beam intercept and associated record times to within a minute or so of the observed times.
- **Playback of Recordings from VSRs at Complexes to "lilypond"**
  - Transfer times were 1 hour 23 minutes from Goldstone, 6 hours 40 minutes from Canberra, and 9 hours 41 minutes from Madrid – each for ~14.4 GB of data.
- **Retrieval from "lilypond" to the OSD Workstation**
  - Transfer times consistently were on the order of 53 minutes, making the total time between VSR and workstation between 2.3 hours and 10.6 hours.
- **Processing via OSD**
  - For all passes, successfully demodulated and decoded the Mars Odyssey data in a timeframe 5 to 6 times longer than the recorded duration.
- **Data Validation**
  - Worst-case demonstration pass had only 11 unresolved frame errors out of 23,624 – equivalent to a 99.95% data return.

Conclusions & Recommendations

- **Conclusions**
  - The proof-of-concept demonstration successfully met all four of its objectives.
    - Beam-intercepts and associated OMSPA opportunities were successfully identified.
    - Recordings were successfully executed and transferred from the Complexes to JPL in less than half a day.
    - Recordings were retrieved, demodulated, and decoded in less than half a day, with an accuracy of 99.95% or better.
    - OMSPA was successfully executed from every Complex.
- **Recommendations**
  - Work to reduce the data transfer times between the Complexes and JPL.
  - Evolve the OMSPA Software Demodulator to have a user-friendly GUI, enable Doppler extraction, and handle more modulations and codes.
  - Conduct a follow-on demonstration with multiple OMSPA-user spacecraft.

For Further Information…

- **For further information about the proof-of-concept demonstration, see:**

  Douglas S. Abraham, Susan G. Finley, David P. Heckman, Norman E. Lay, Cindy M. Lush, and Bruce E. MacNeal, "Opportunistic MSPA Demonstration #1: Final Report," Interplanetary Network Progress Report, 42-200 (February 2015).

  Available at: http://ipnpr.jpl.nasa.gov