Radio Science Receiver Support of the Mars Exploration Rover Landings

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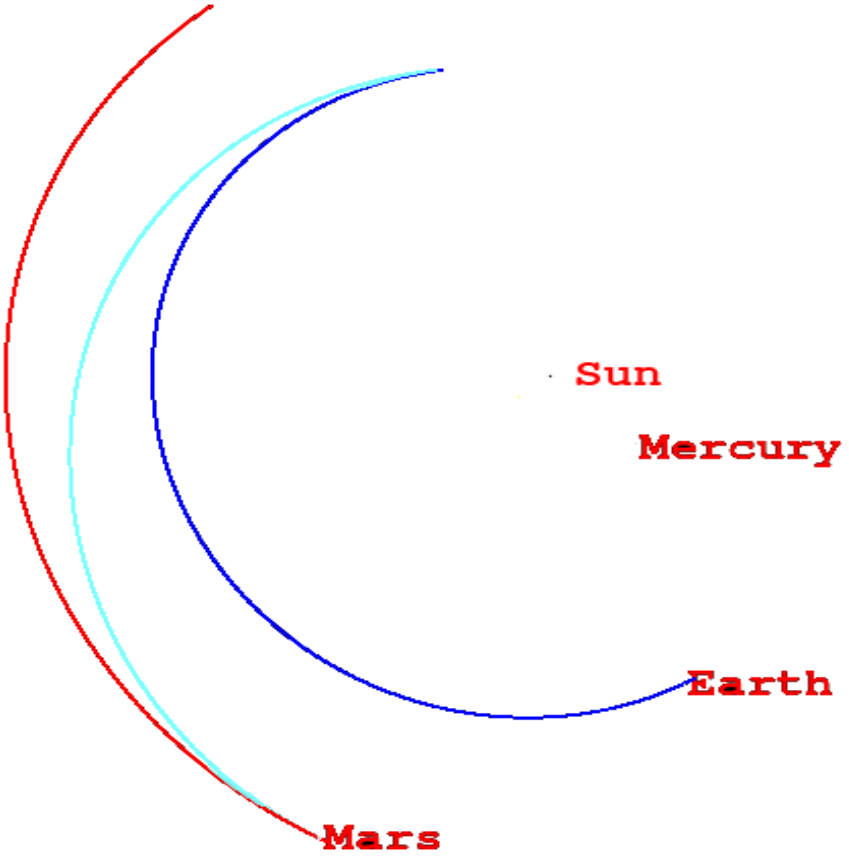
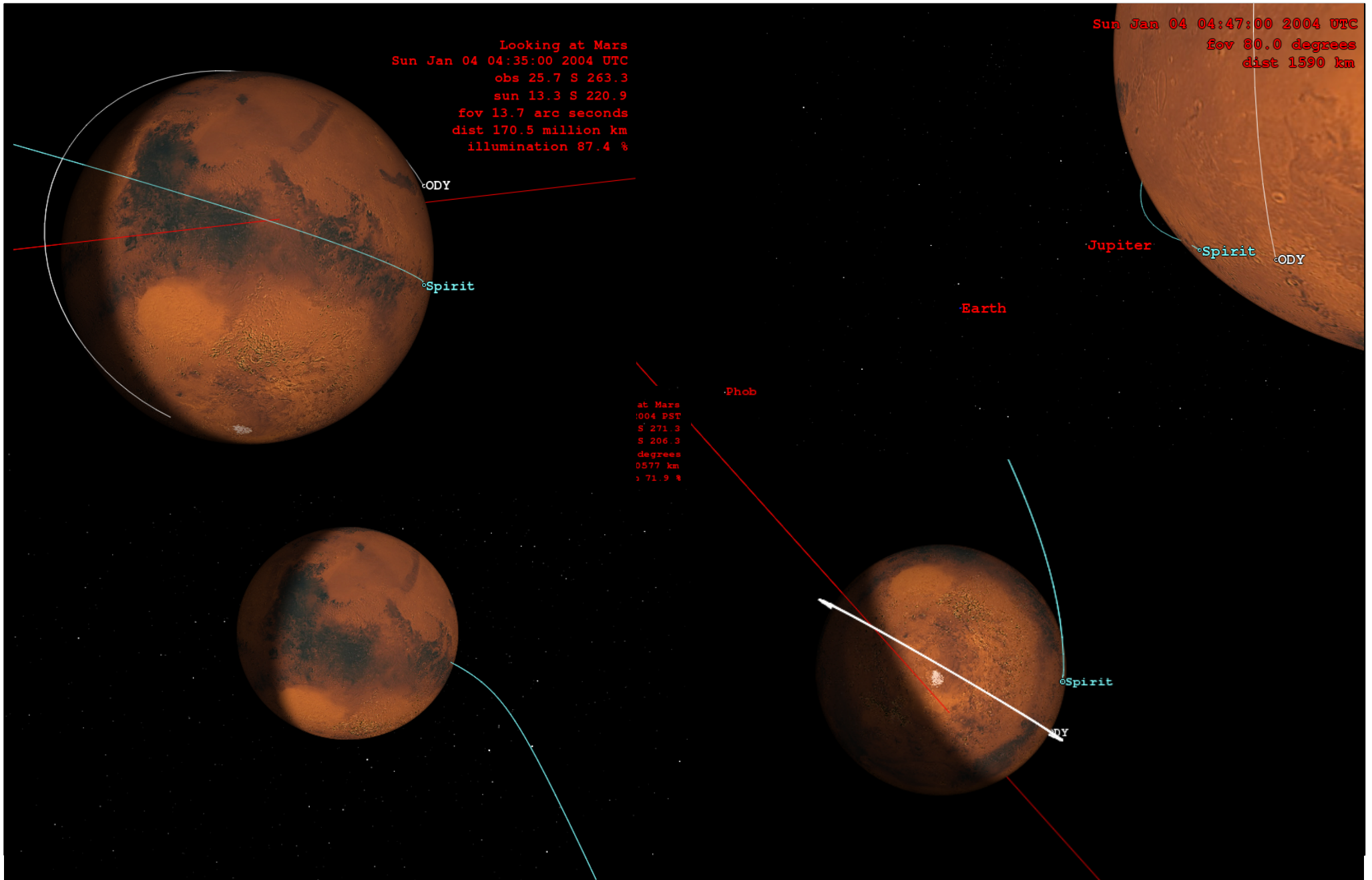
Mission Overview

- MER-A "Spirit"
  - Launched June 10th , 2003
  - Landed Jan 4th , 2004
- MER-B "Opportunity"
  - Launched July 7th , 200
  - Landed Jan 23th , 2004
- Prime Mission of 90 Martian Days
  - Both rovers now operating for over 200 days



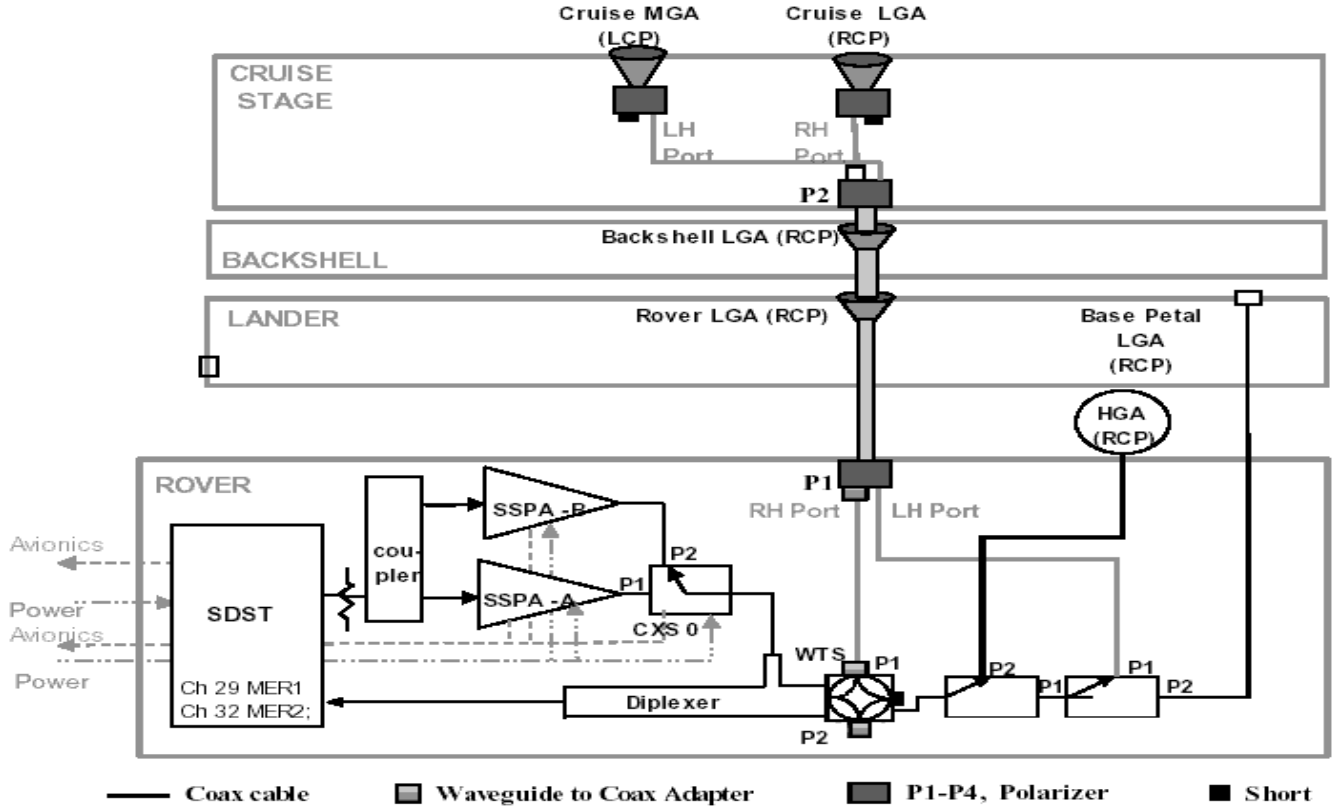
Landing Logistics

Radio Science Systems Group



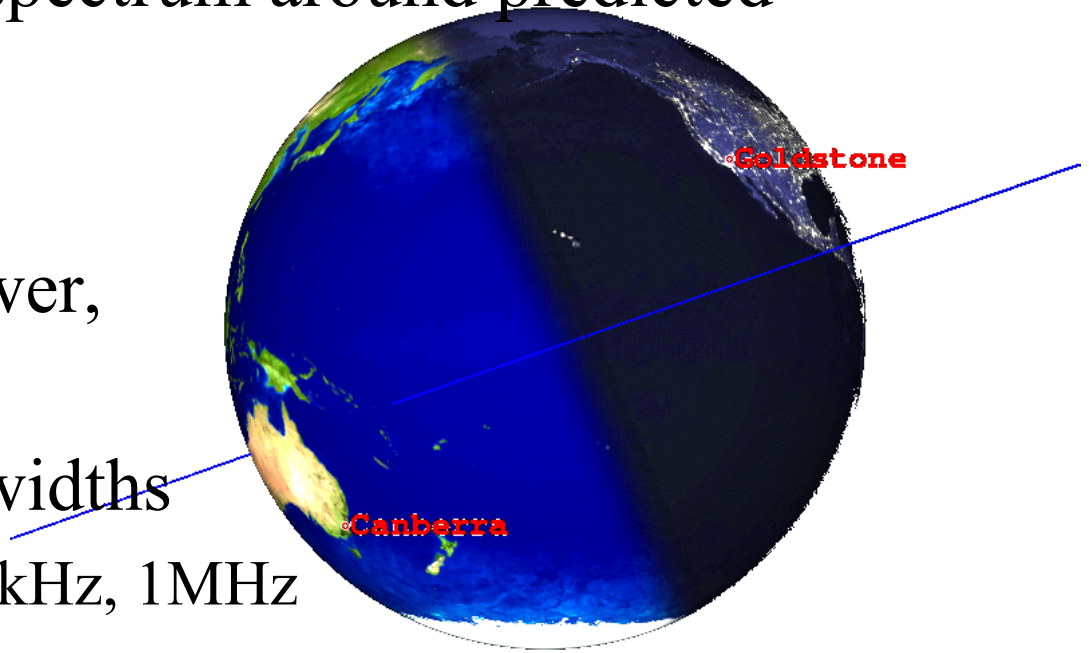
Telecom System

- X-band – main communication system
  - MGA – used during cruise, jettisoned before EDL
  - LGA – used in EDL and as backup on surface
  - HGA – deployable only on rover, used on surface



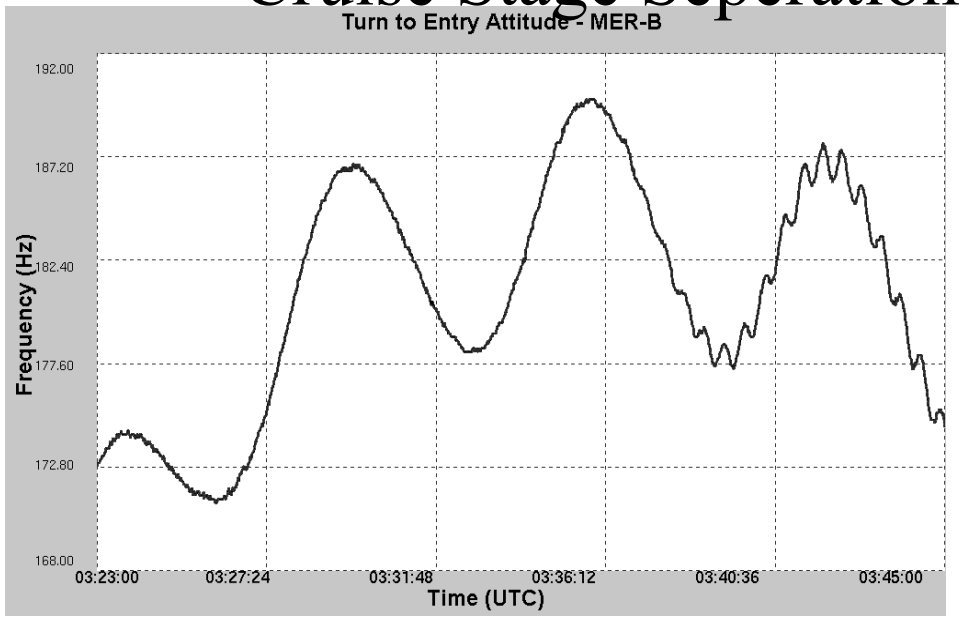
Ground Receivers

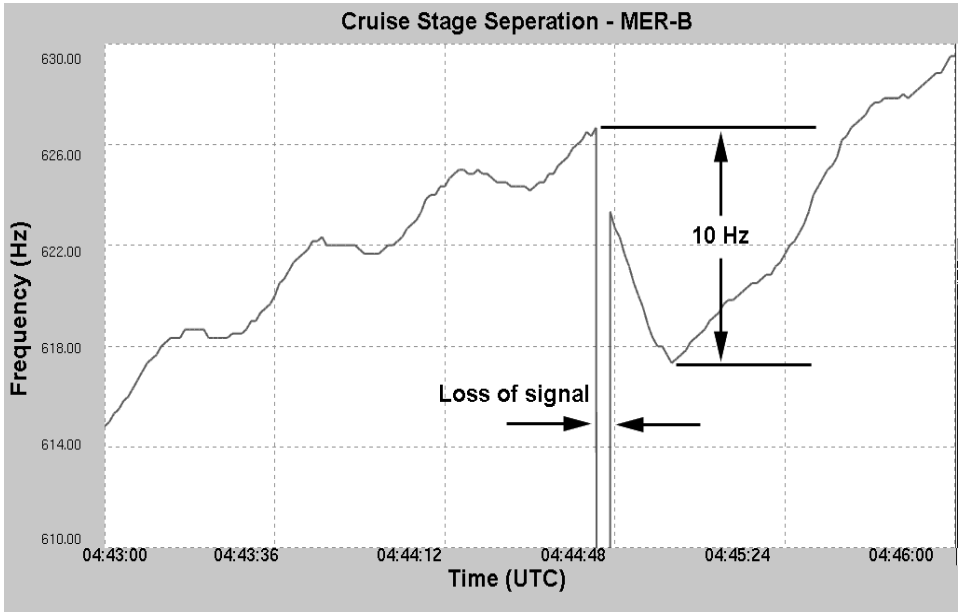
- Radio Science Receiver (RSR)
  - Records frequency spectrum around predicted spacecraft signal
  - Operated from JPL
  - Suitable for low power, unstable signals
  - User Selected bandwidths
    - 4kHz, 100KHz, 250kHz, 1MHz
  - Dual polarizations (RCP & LCP)
  - Used at both Goldstone and Canberra
    - ***ALL*** DSN antennas at GLD and CAN tracked MER (14,15,*24*,25,26,34,43,45)



Pre-Entry

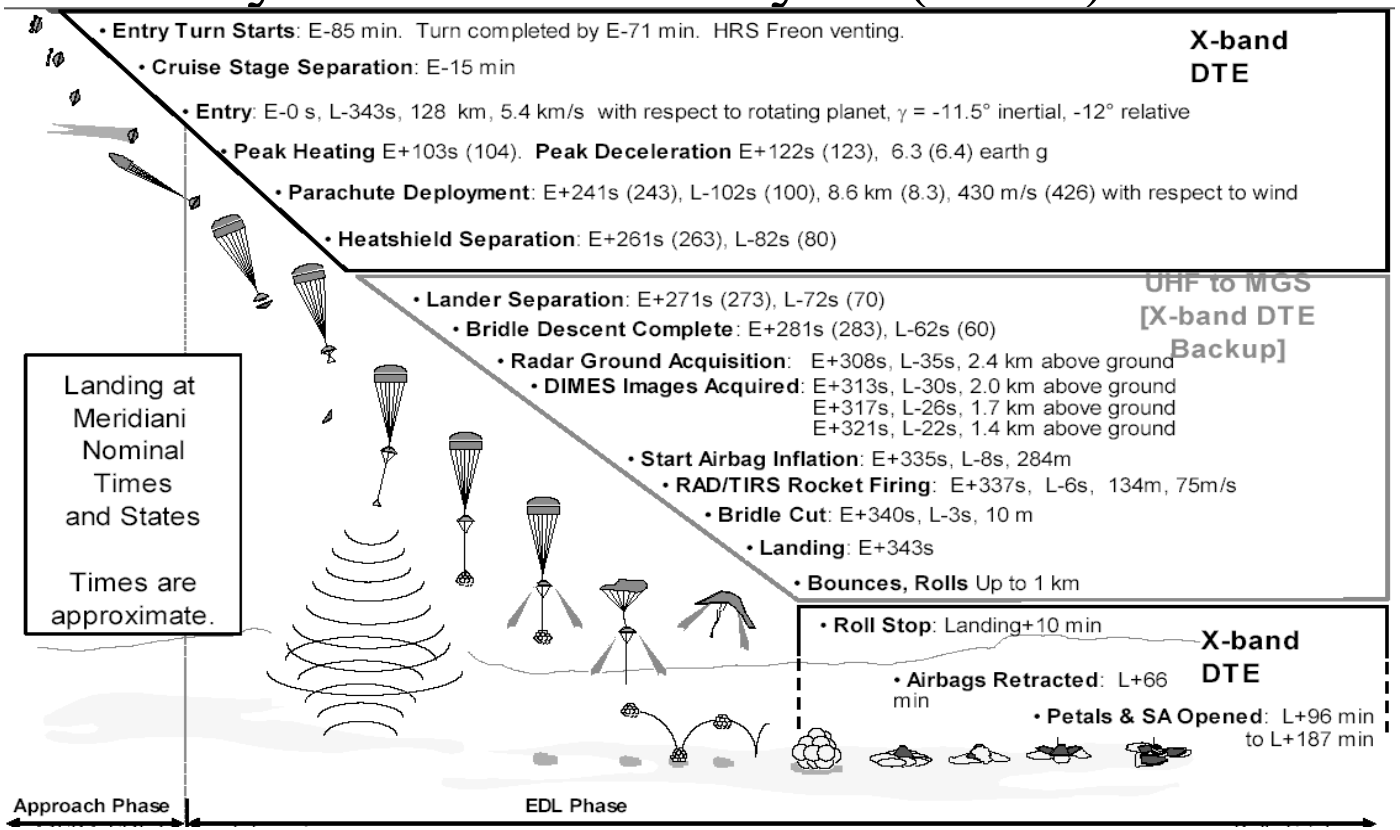
- All key events recognized
  - MGA to LGA transition
  - Turn to Entry Attitude
  - Venting of Heat Rejection System (HRS)
  - Cruise Stage Seperation



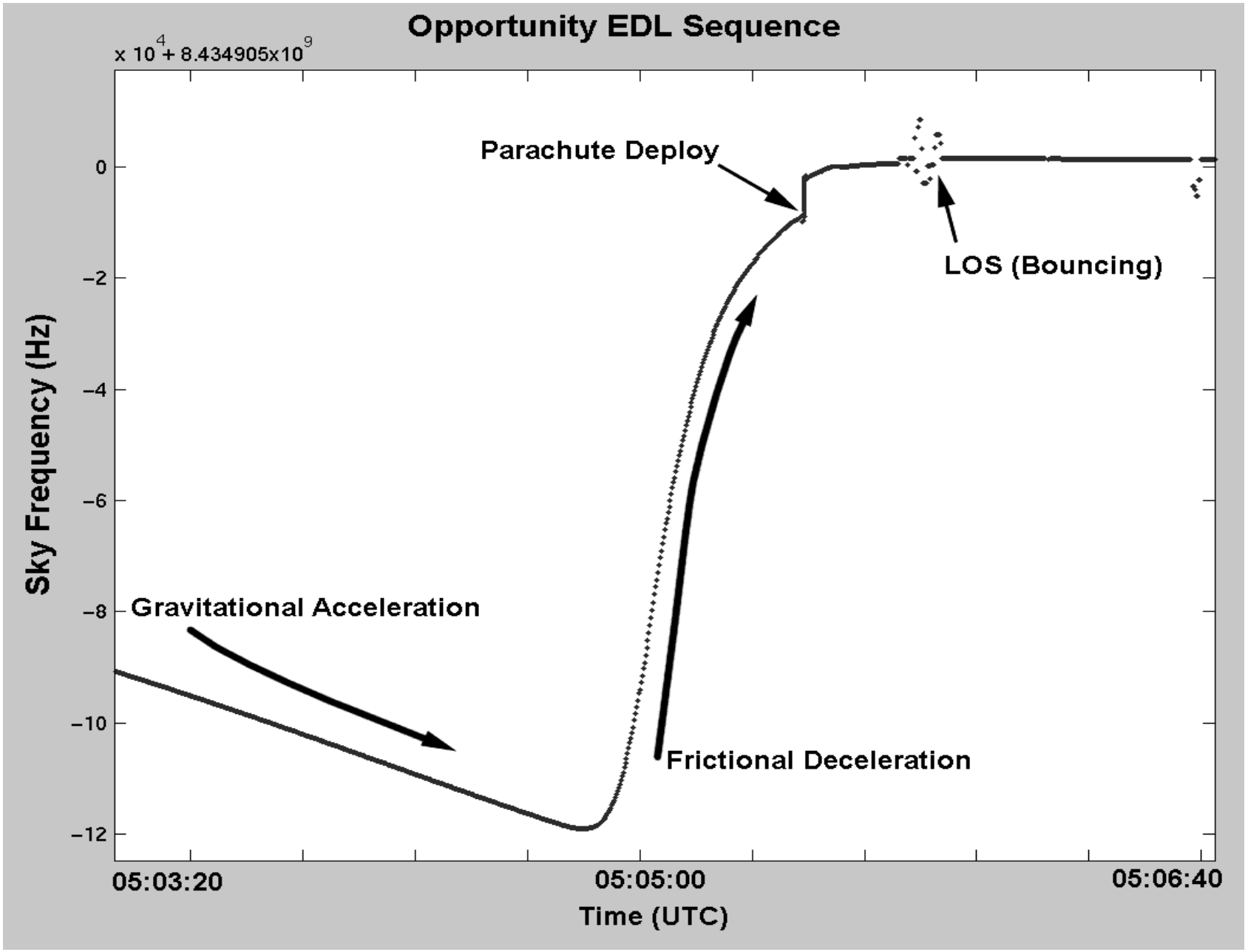


EDL Sequence

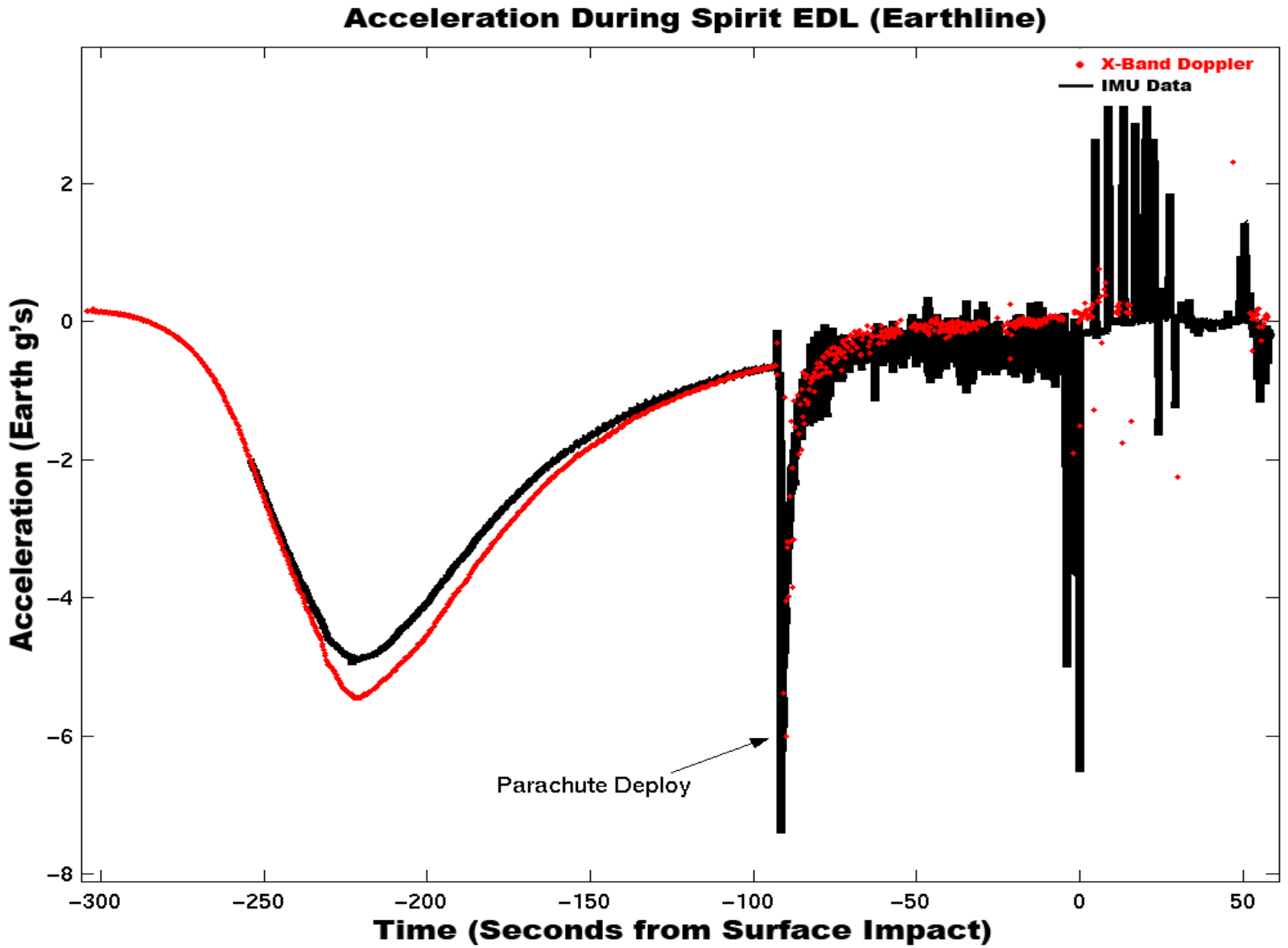
- No telemetry
- Semaphores used to describe 255 conditions
  - Decoded by EDL Data Analysis (EDA) hardware



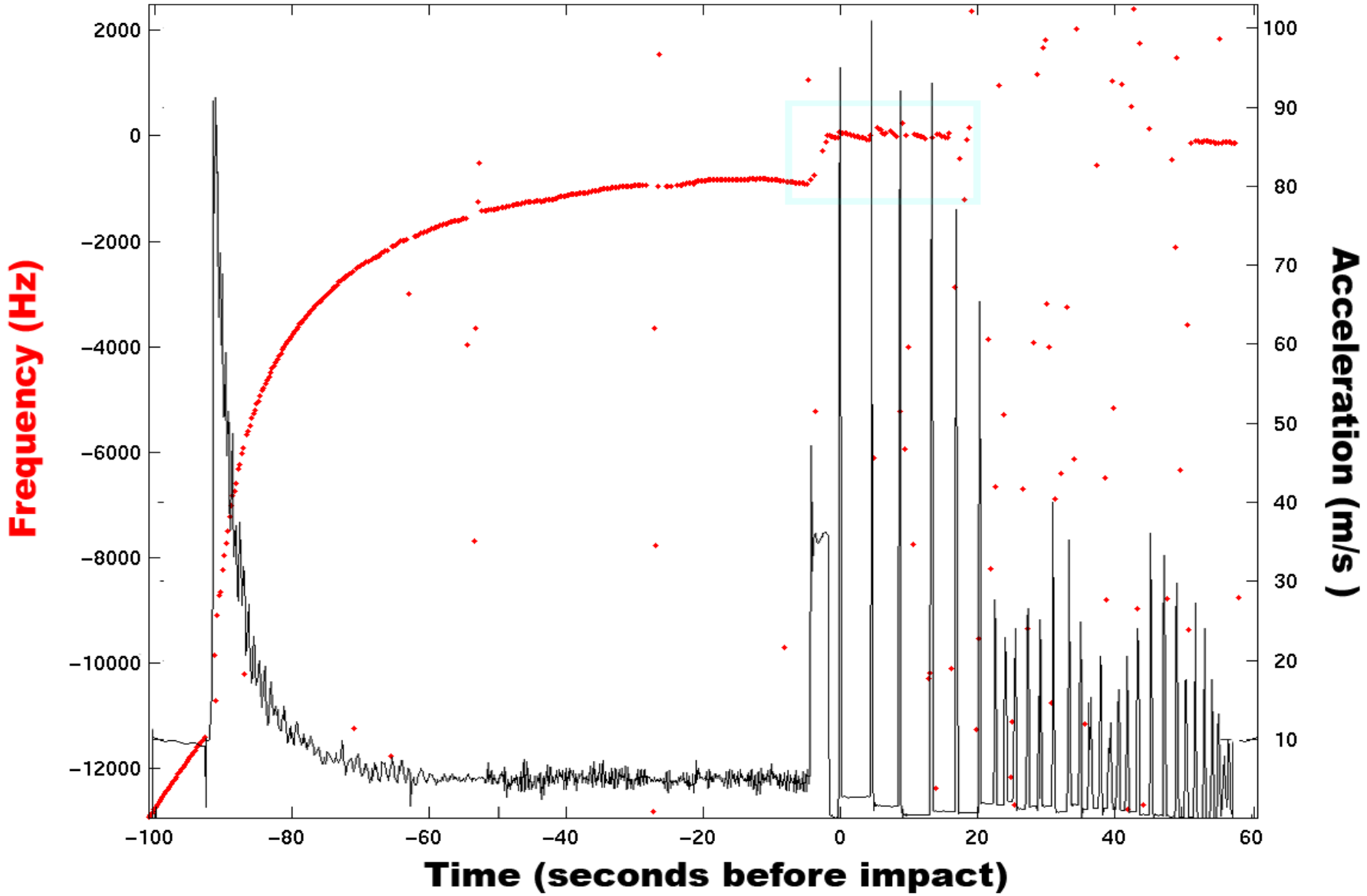
X-band DTE Performance



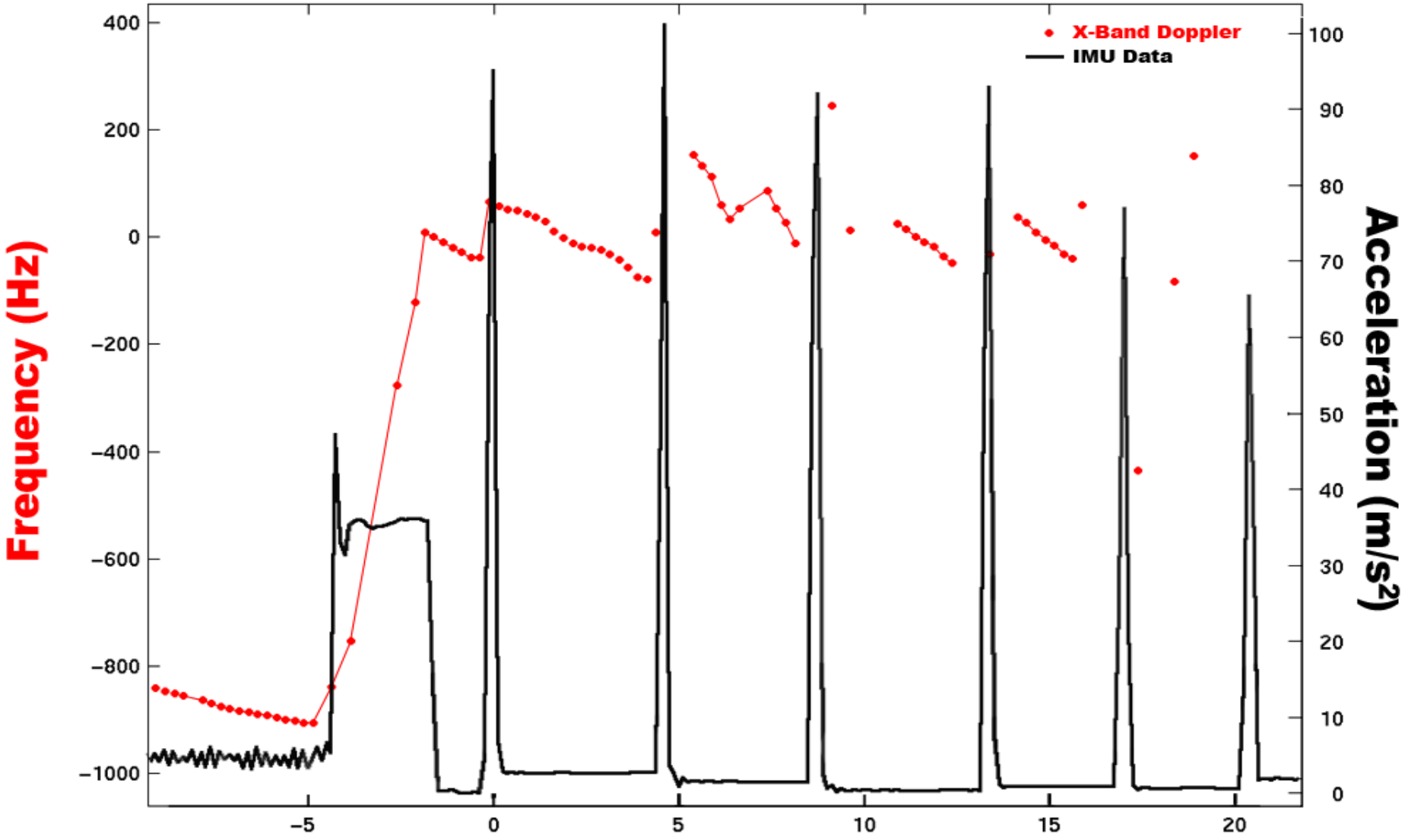
X-band and IMU Data

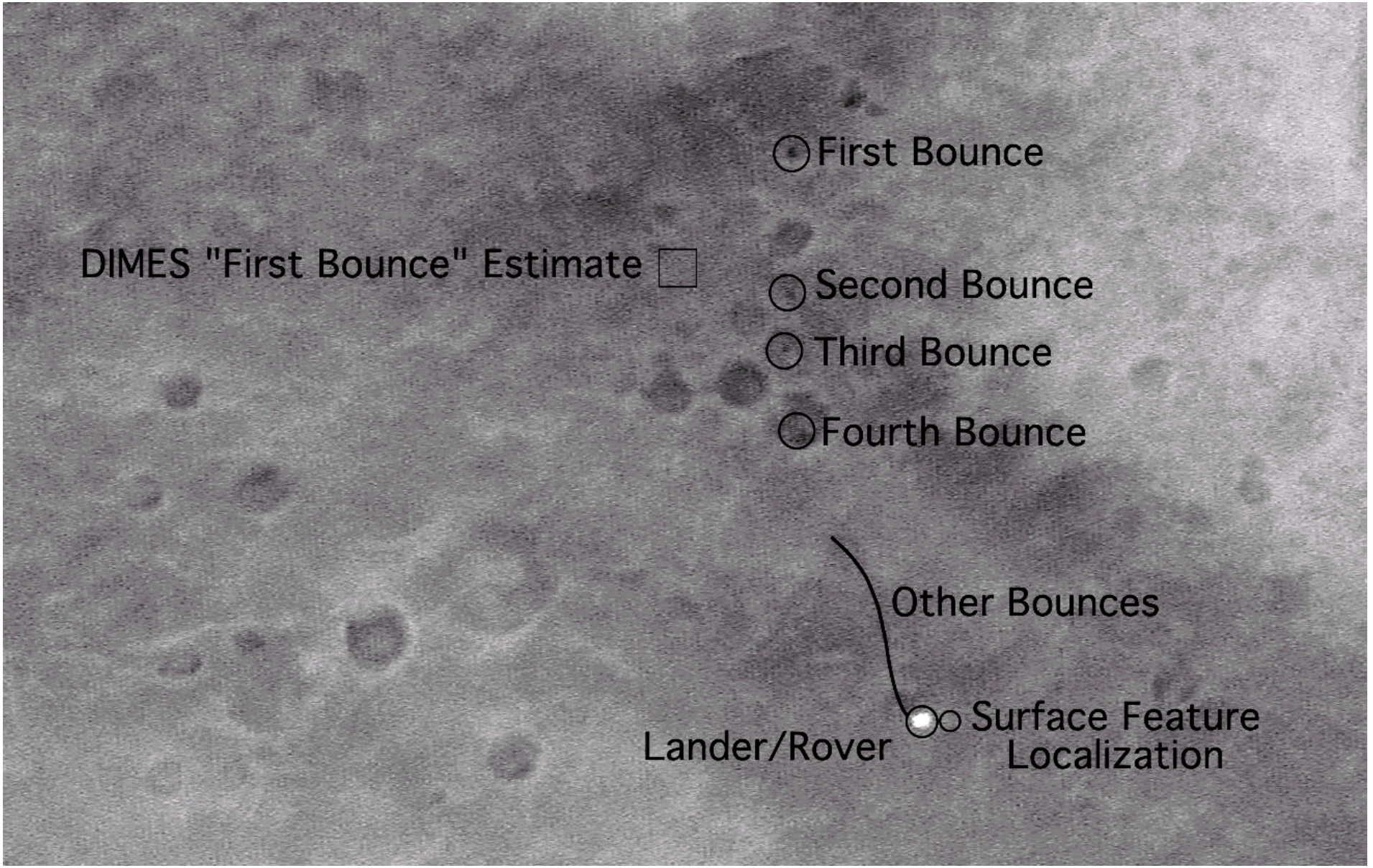


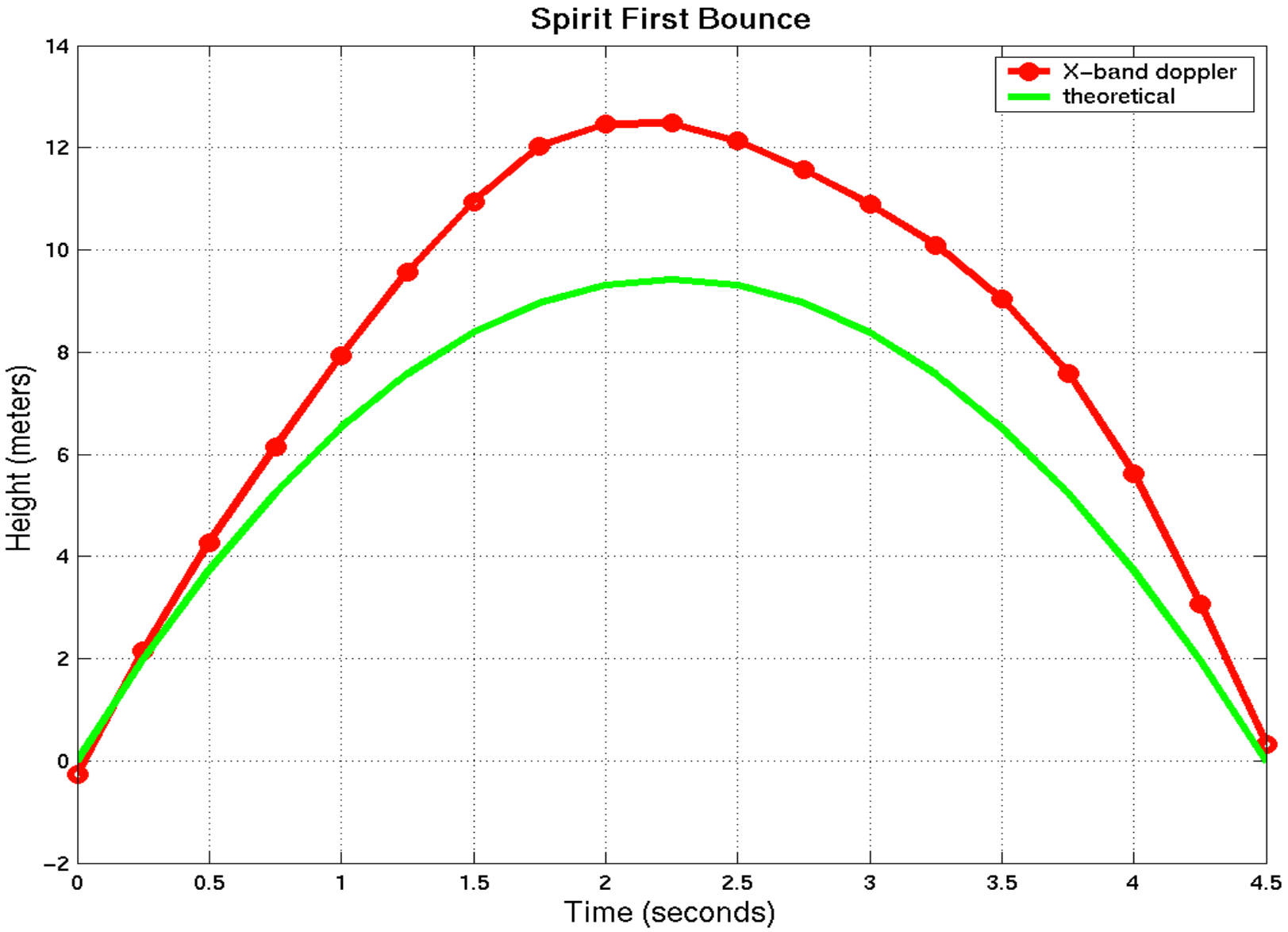
Spirit Descent and Landing



Spirit Rad-rocket and Bouncing

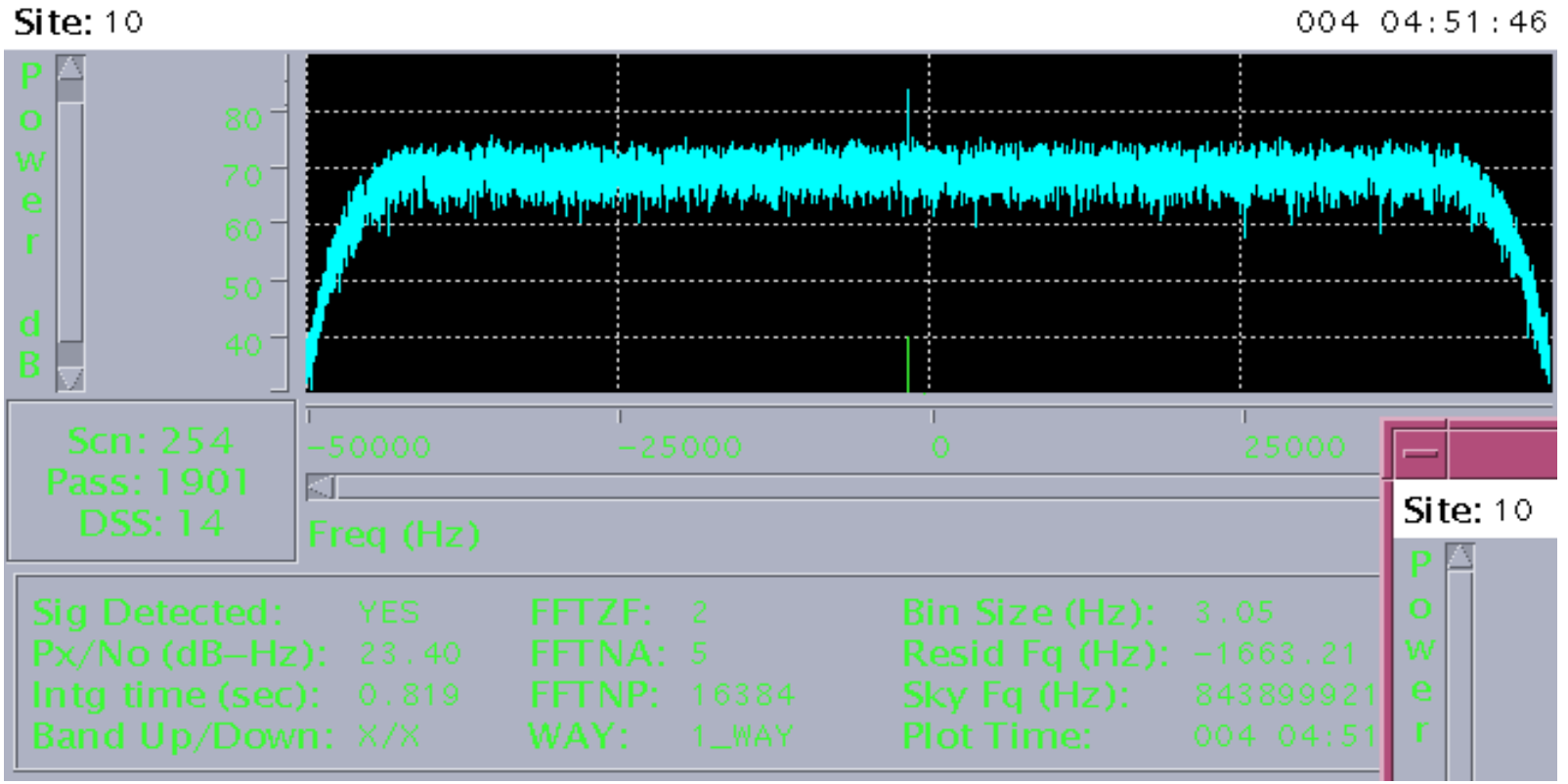



First Bounce
DIMES "First Bounce" Estimate
Second Bounce
Third Bounce
Fourth Bounce
Other Bounces
Surface Feature
Localization
Lander/Rover


Spirit First Bounce
X–band doppler
theoretical
Height (meters)
Time (seconds)
14
12
10
8
6
4
2
0
−2
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

Landing

- Landed signal seen in realtime for both rovers
  - "Spirit" had extra drama due to the resting orientation
    - RLGA transmitted away from earth – not seen
    - PLGA, 5 minutes later, was received



Conclusions

- UHF is great
  - High resolution telemetry
  - Low power
- But!
  - X-band DTE provides realtime feedback
  - Doesn't rely on hardware of other spacecrafts
  - “Simple” interface