MSL DSEND NS EDL Analysis and Operations

P. Daniel Burkhart
Jordi Casoliva

Jet Propulsion Laboratory, California Institute of Technology
Overview

- MSL EDL Overview

- DSEND5 Description
  - Inherited capabilities
  - MSL-specific models
  - Trajectory nominal runs
  - Targeting Analysis and Cruise Stage Recontact

- Initialization

- Landing Hazard Analysis

- Real-Time Doppler

Topics for this presentation
In paper but not discussed here
MSL EDL Overview
Raw hazard map, bounding cases shown

- Hazard map with probability of landing failure defined at each 150x150m pixel
- Ellipses are lower bound, best estimated and upper bound landing uncertainty from Monte Carlo analysis
- These were used to defined total probability of success maps: each pixel is the probability of successful landing for the minimum success percentage of the three ellipses centered at that pixel
Final convolved map

- Each pixel is the minimum probability of success of the three ellipses with the center at that pixel
- Contours vary 0.1% from 99% to 99.6%
• Landing locations as a function of navigation solution data cutoff
• Red and blue points are EDL Monte Carlo means for od202, for reference
• Other points are nominal runouts
Real-Time Doppler

- One-way X-band Doppler was collected by the Deep Space Network (DSN) during EDL through surface occultation after heat shield release.

- Three predictions were used to compute Doppler residuals for event detection
  - Trajectory with no atmosphere: only force is gravity
    - Prediction used by radio science and DSN, residuals shown to the public
  - Open-loop trajectory (drag and vertical lift aerodynamic forces only, no GN&C), no parachute deploy or subsequent EDL events
• HRS vent
Exo-Atmospheric Events 2/2

- Exo events: CSS, antenna swaps
- Note: expected to see EDL GNC start and thruster firings, but no Doppler (cruise stage blocked the signal)
Events from entry through X-band occultation
Prediction: vacuum flyby. Full atmospheric dynamics will show up in residuals
  - DSN had this prediction, main one shown to the public
• Events from entry through X-band occultation
• Prediction: open-loop (in-plane lift, full drag) without parachute deploy or subsequent events. Any out-of-plane lift, chute deploy, etc should be visible
  – Best for events: see reversals, SUFR, chute deploy, HSS, etc
• Highest-fidelity prediction, all events modeled
• Can see both modeled event and actual event: most obvious case is parachute deploy