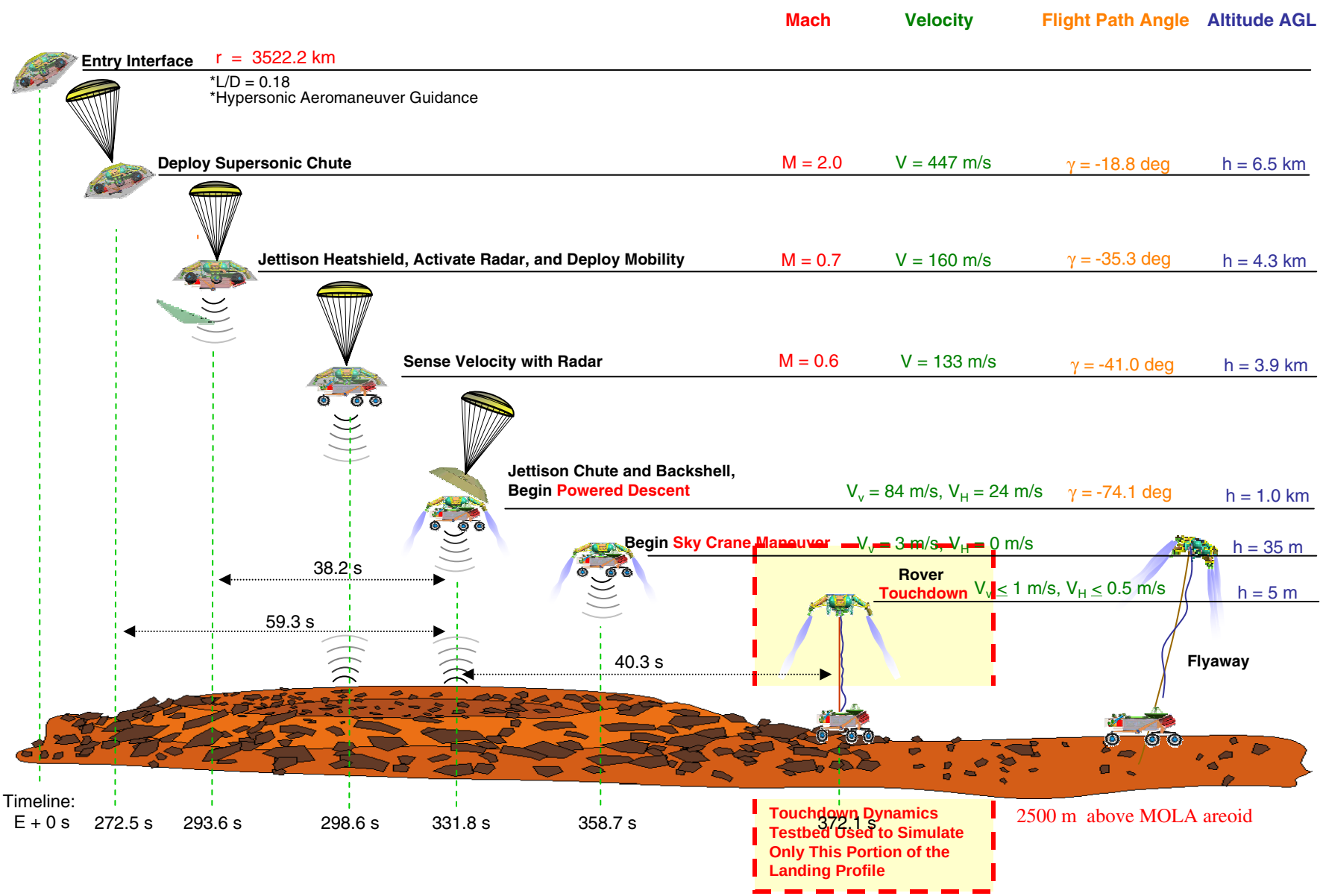
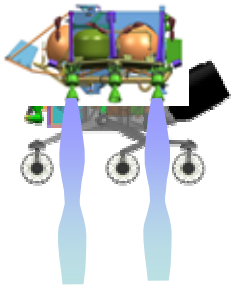
Mars Science Laboratory
Entry, Descent and Landing Overview

Nominal Mars Entry Timeline: (Reference Only)



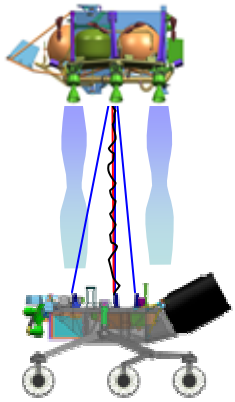
Updated Sky Crane Maneuver Description

(Reference Only)



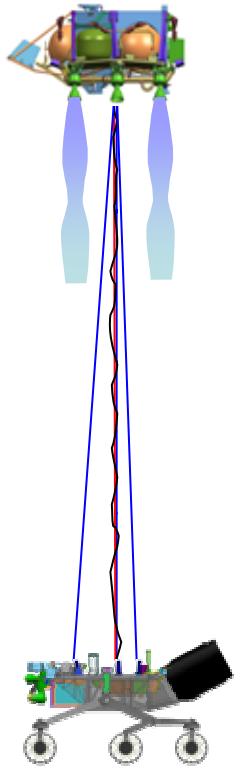
One Body Phase
-Vertical Descent-

1. 35 m. way-point alt reached
2. 2 center thrusters turned off
3. Vertical velocity = 4 m/s, Lateral velocity nulled to ~zero
4. System Z axis aligned with G vector
5. Attitude rates zeroed out
6. 27.3 m way-point alt. reached
7. *Commands sent to pyro devices to release the rover (transition event)*



Two Body Phase
-DRL/Bridle Deployment-

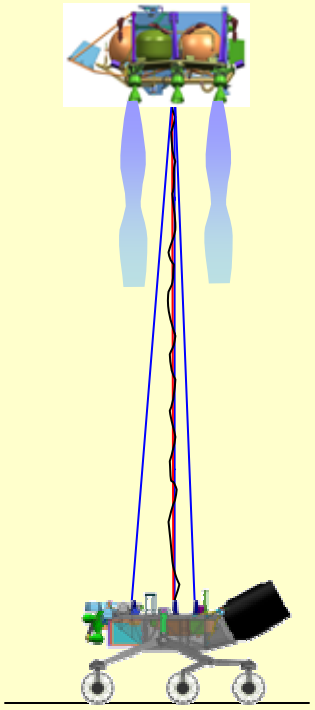
1. Pyro devices release the rover.
2. DRL controls the separation rate while bridle and umbilical are deployed
3. Umbilical maintains data & RF interfaces between rover and DS
4. Bridle comes to full extension and all load is transferred to triple bridle.
5. DS nulls dynamic transients induced by deployment & continues deceleration to .75 m/s



Two Body Phase
-Constant Velocity-

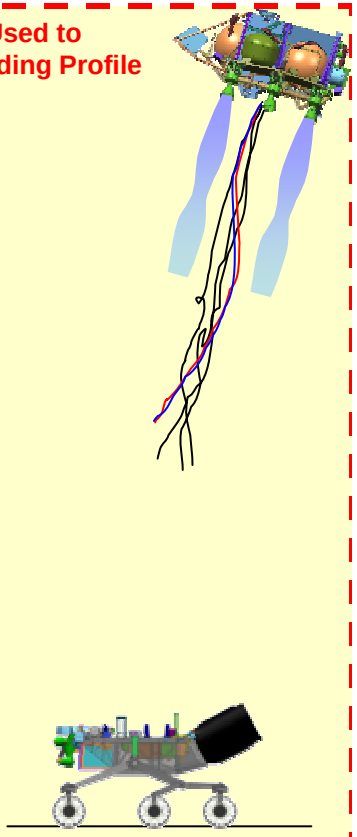
1. 15 m way-point alt, reached
2. Touchdown Logic initiated
3. Target velocity reached; .75 m/s
4. Constant velocity descent starts
5. Rover makes initial contact with surface

Touchdown Dynamics Testbed Used to Simulate This Portion of the Landing Profile



Two Body Phase
-Touchdown Event-

1. .75 m/s downward velocity continues while rover is offloaded to the ground.
2. System throttles down to maintain .75 m/s descent rate, TD logic monitors commanded Z force.
3. Z force thresh-hold & persistence criteria met (rover offloaded), TD confirmed
4. Control handed-off to DS
5. Umbilical lines dead-faced & cut.
6. *Commands sent to pyro devices to cut bridles (transition event)*



Fly-Away Phase

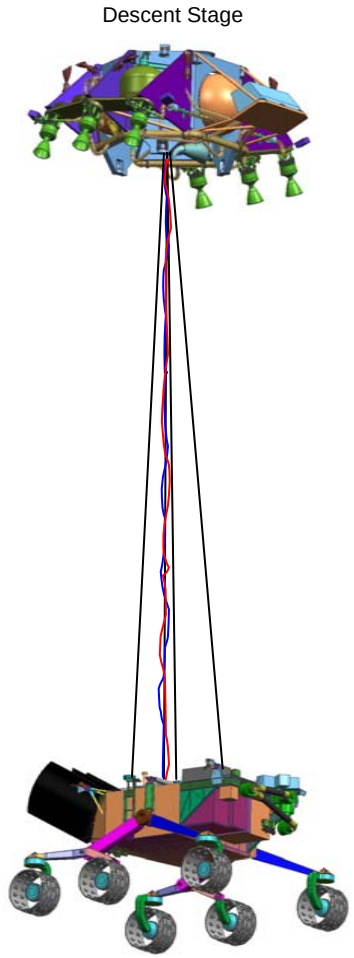
1. DS under control of the DS micro controller.
2. DS ascends to 15 m, pitches over to a 45 degree trajectory angle and flys away.

First Order Analog:

Descent Stage can be thought of as a rocket powered helicopter delivering a slung payload to the surface.

Motion Simulator Use:

Simulate the motion of the Descent Stage during a typical rover landing.



Flight System:

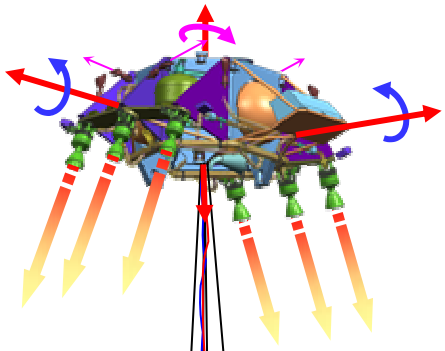
Translations and rotations are effectively decoupled because the Bridle confluence point is located at the Center of Gravity of the Descent Stage structure.

Motion Simulation

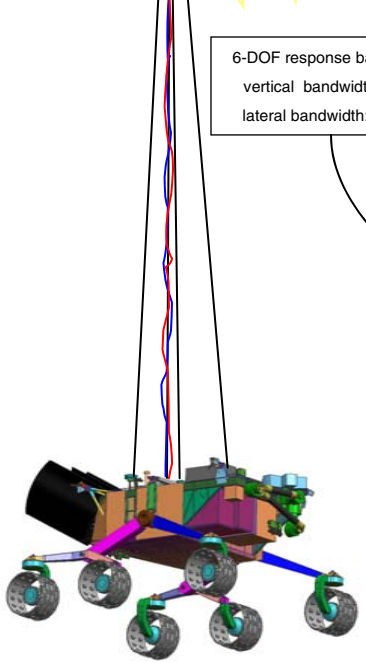
Test System:

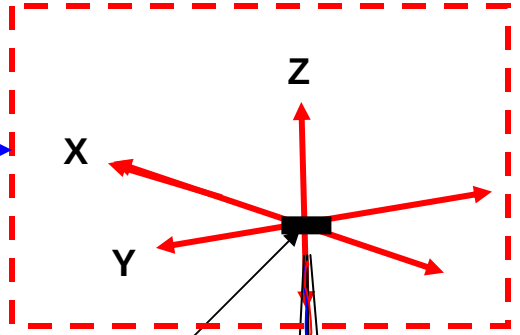
The resultant translational compliance of the Descent Stage system is reproduced using electric motor actuators operated in closed-loop mode.

- Use motion simulator to simulate the translations of the Descent Stage
- Bridle (Cable) confluence point anchored to a 3 axis load cell
- Closed loop control system actuates the 3 degrees of freedom to replicate Descent Stage motion and compliance
- Motion Simulator mimics the closed-loop response of the Descent Stage during the Touchdown event



6-DOF response bandwidth
vertical bandwidth: 2 Hz.
lateral bandwidth: .08 Hz





Force Sensing for feedback control

3-DOF actuator bandwidth
vertical bandwidth: [20] Hz.
horizontal bandwidth: [.8] Hz