



Curiosity's Journey to Mars

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Outline

- Mars Rovers
- Curiosity
- Curiosity's Landing Site
- Atlas V-541 Launch Vehicle
 - Stage 1: Atlas V Rocket
 - Solid Rocket Motors
 - Stage 2: Centaur
 - Payload Fairing
- The Launch Phase
- Hohmann Transfer Orbit
- Corrections to Orbit
- Curiosity's Descent: 7 Minutes of Terror
- Curiosity's Purpose

Mars Rovers

■ USSR

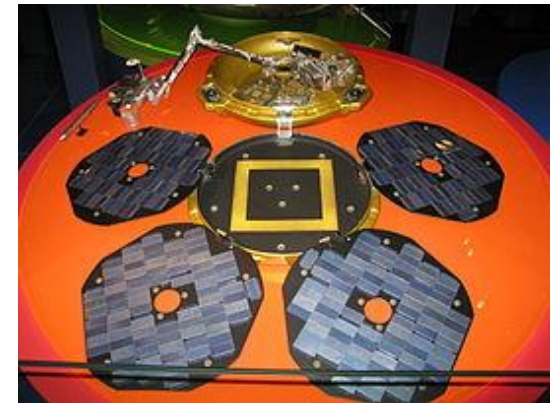
- 1971 - Mars 2 Prop-M Rover
 - Failed landing
- 1971 - Mars 3 Prop-M Rover
 - Lost communication

■ UK

- 2003 - Beagle 2
 - Deployed from Mars Express early
 - Communication was lost



Prop-M Rover Design [7]



Beagle 2 [8]

Mars Rovers (cont.)

■ USA

- 1996 - Sojourner
 - 1997 - Lost communication
- 2003 - Spirit (MER-A)
 - Stuck in 2009, lost contact in 2010
- 2003 - Opportunity (MER-B)
 - Still operational
- 2011 – Curiosity

Sojourner
Rover [9]



Spirit
MER-A
[10]



Opportunity
MER-B [11]

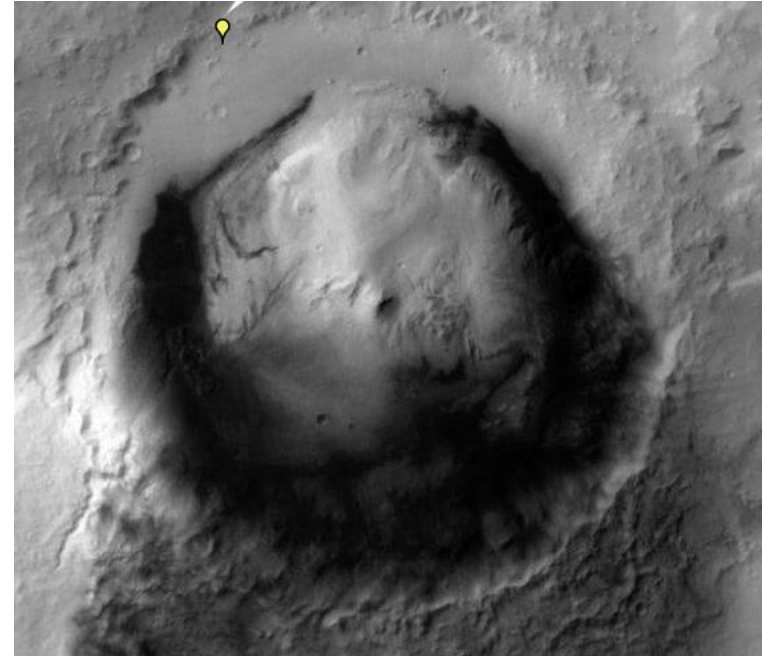




Spirit/Opportunity, Sojourner, Curiosity [12]

Curiosity's Landing Site

- Landing site
 - Mars Reconnaissance Orbiter
 - 30 locations
 - Gale Crater
 - Target area of 12 miles
 - Increase in precision
 - Alluvial fan likely formed from sediments carried by water



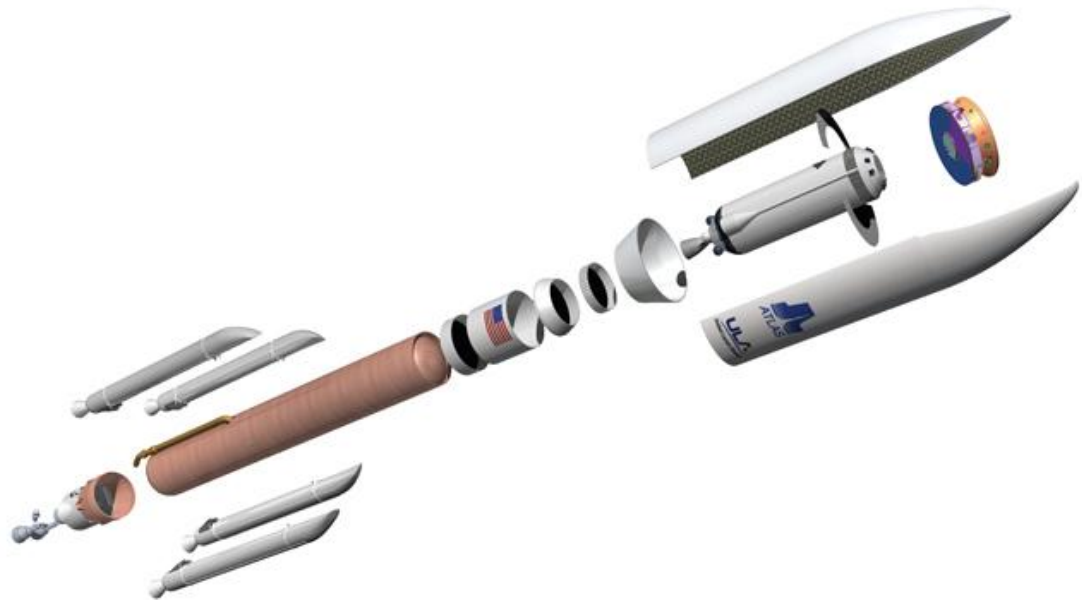
Google Mars Image of Curiosity's landing site

Mars Science Laboratory/Curiosity

- Roll over objects up to 25 in
- Heated fluids pumped
 - -225 °F to 81 °F
 - -67 °F on average
- Launched November 26, 2011
 - Total mass of more than 10^6 lbs
- Landed August 6, 2012
 - Rover mass of 1,980 lbs

Atlas V-541 Launch Vehicle

- Lift off capabilities
- Also used in NASA's Mars Reconnaissance Orbiter and New Horizons missions
- 541 designates the nose cone



[13], [15]

Stage 1: Atlas V Rocket

- Common core booster
- Powers spacecraft into Earth's orbit
- Kerosene fuel
- Liquid oxygen
- Thrust up to 850,000 lbs

[5]



Solid Rocket Motors

- 4 boosters
- 64 ft
- 306,000 lbs



Stage 2: Centaur

- Contains vehicle's "brains"
 - Onboard flight computer
- Liquid hydrogen and oxygen
 - 22,000 lbs of thrust
- Fires twice
 - Low Earth-orbit
 - Accelerate out of orbit

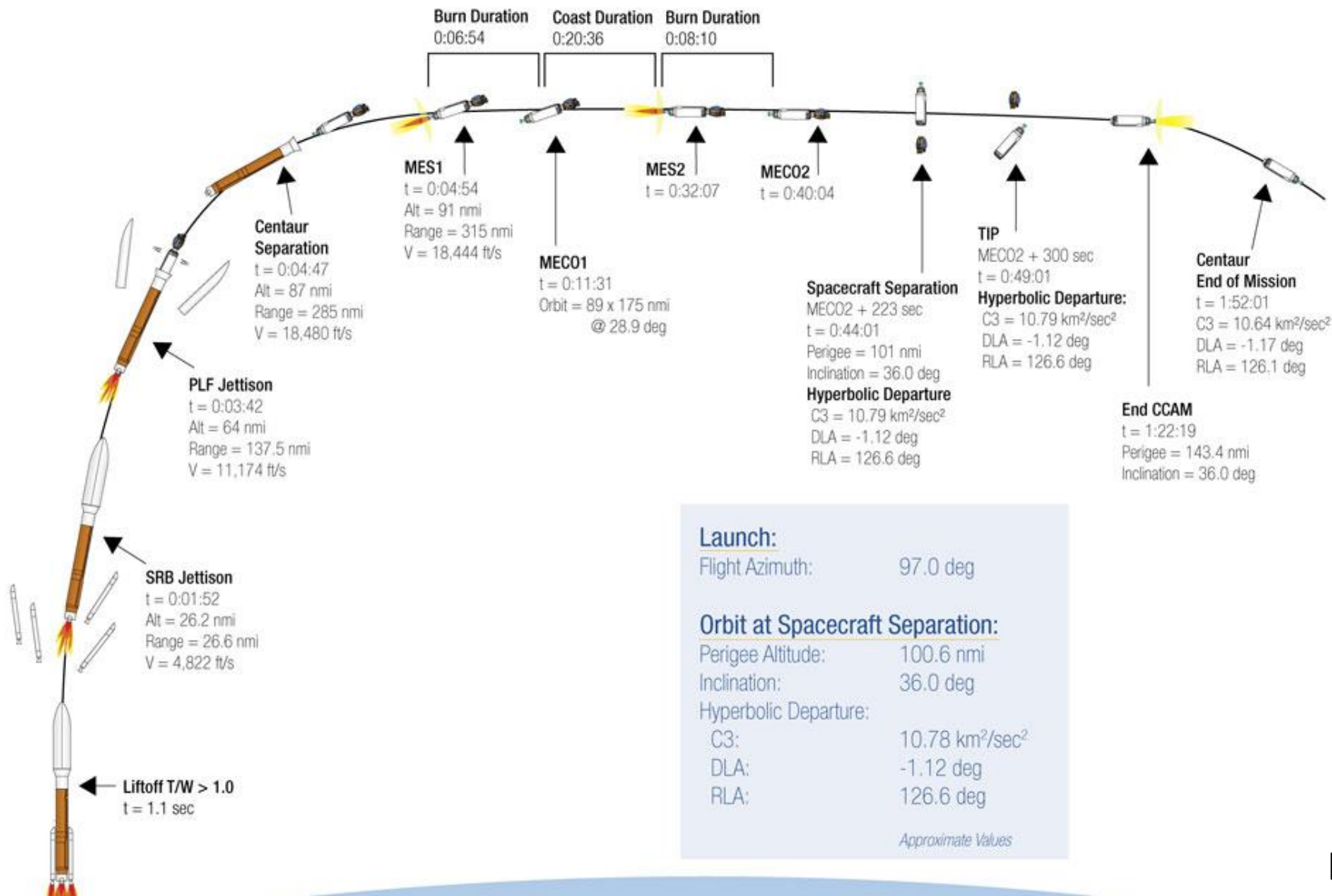


Payload Fairing

- Composite materials
- Protects from
 - Heating
 - Aerodynamic pressure
 - Sound



The Launch Phase



Launch:

Flight Azimuth: 97.0 deg

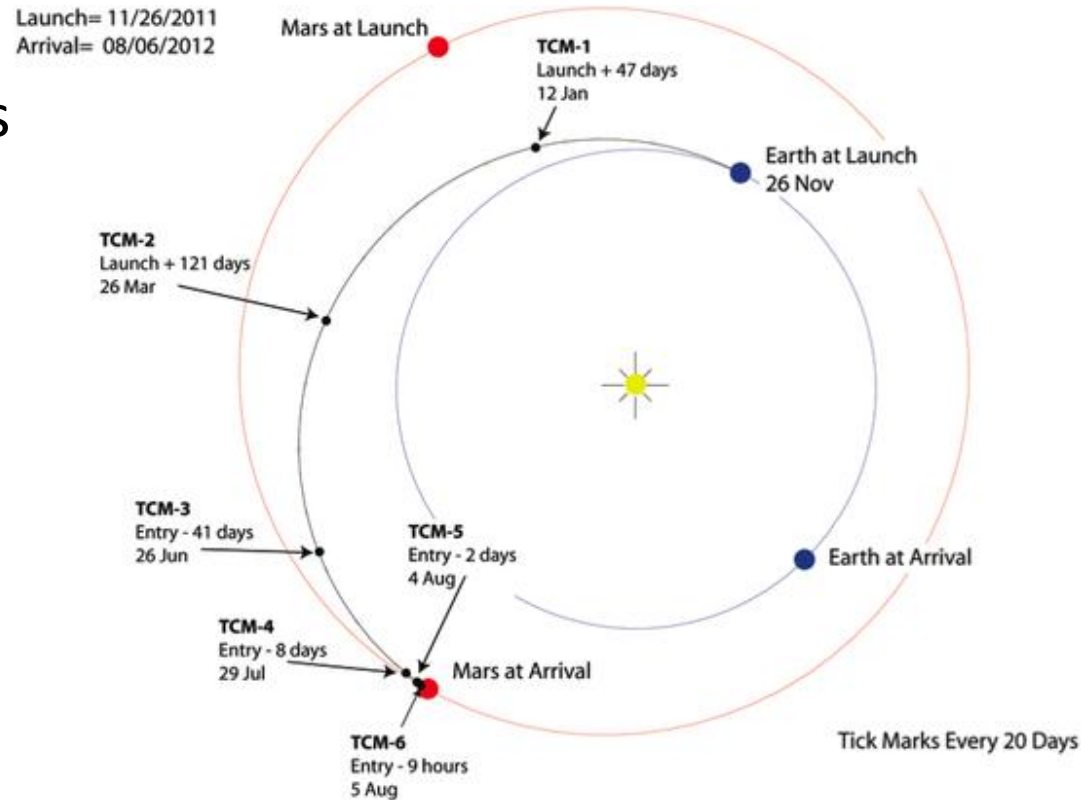
Orbit at Spacecraft Separation:

Perigee Altitude: 100.6 nmi
Inclination: 36.0 deg
Hyperbolic Departure:
C3: 10.78 km²/sec²
DLA: -1.12 deg
RLA: 126.6 deg

Approximate Values

Hohmann Transfer Orbit

- Ellipse connecting two orbits
- Least amount of energy is used
- Increase energy at perihelion increases altitude at aphelion
- Spacecraft must decelerate when it reaches the target planet



Corrections to Orbit

- Perturbations
 - Non-spherical Earth
 - Gravitational effects from sun and moon
 - Pressure from solar radiation
- Non-coplanar orbits
- 5 or 6 trajectory corrections
 - Cruise stage
 - Communication

Curiosity's Descent: 7 Minutes of Terror

- Cruise stage separation
- 13,000 mph
- Peak heating
- Supersonic parachute deploys
- Heat shield separation
- Senses altitude
- Rover separation from backshell
- Powered descent with retrorockets
- Sky crane
- Touchdown
- Flyaway

Curiosity's Descent: 7 Minutes of Terror

- <http://mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=2>

Curiosity's Purpose

- Look for
 - Microbial life
 - Evidence of past life from rocks
- 2 year mission
 - 1 year Mars time

References

Image on title slide:

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Questions?