Jet Propulsion Laboratory
California Institute of Technology

Mars 2020
Entry, Descent, and Landing System Overview

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Cologne, Germany
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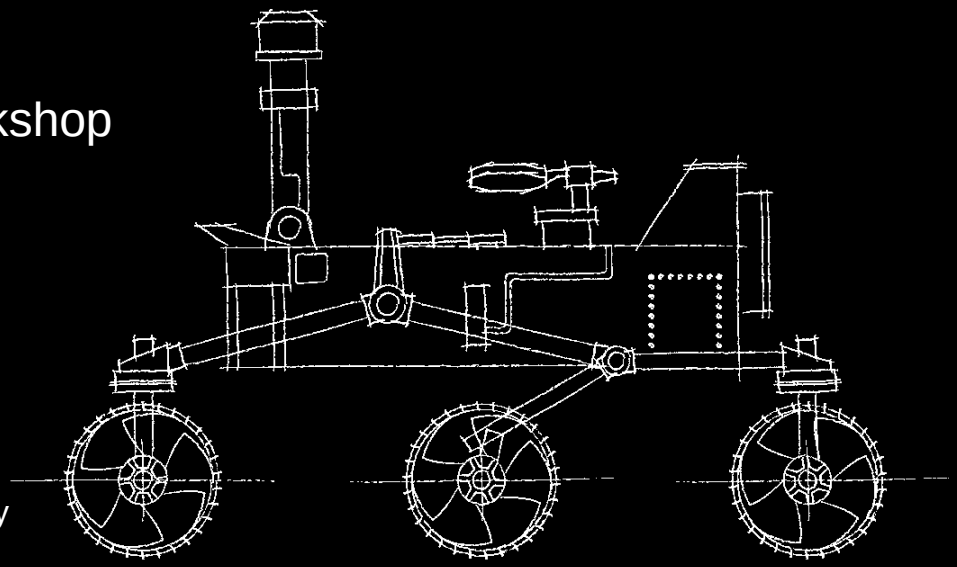
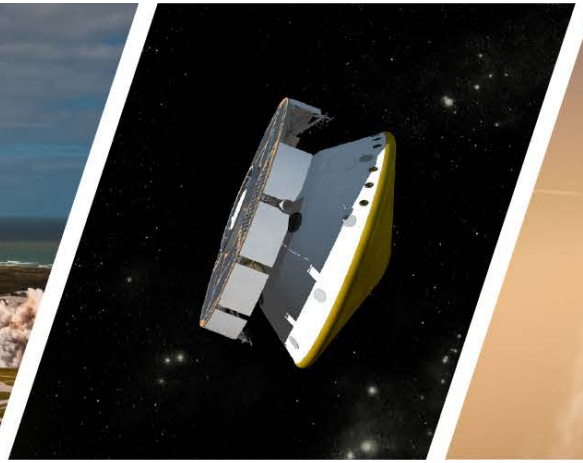


Mars 2020 Project

Mars 2020 Mission Overview



LAUNCH

- Atlas V 541 Class Rocket
- Period: Jul-Aug 2020

CRUISE/APPROACH

- 7.5 month cruise
- Arrive Feb 2021

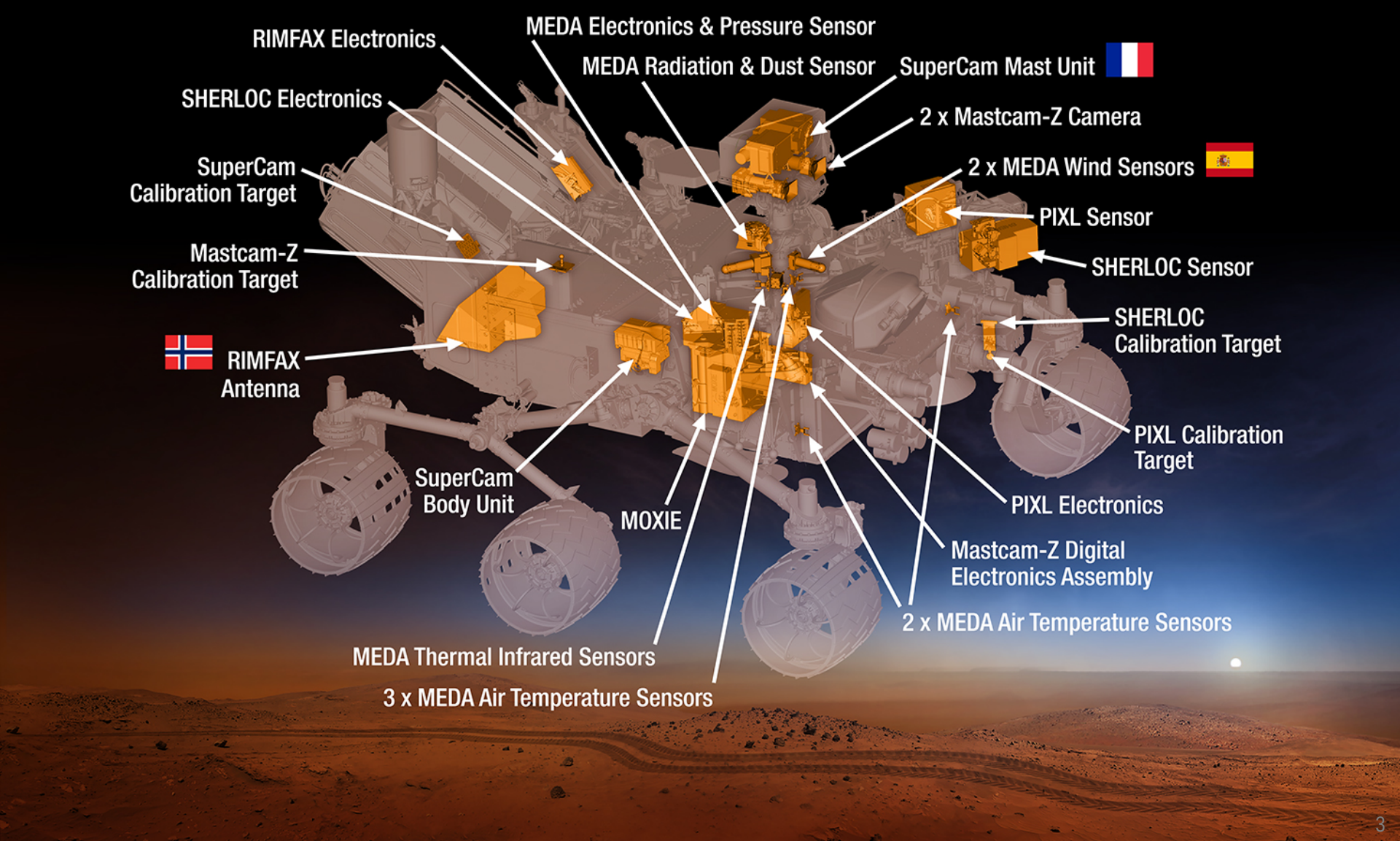
ENTRY, DESCENT & LANDING

- MSL EDL System: guided entry, powered descent, and sky crane
- Augmented by range trigger: 16 x 14 km landing ellipse
- Access to landing sites ±30° latitude, ≤ - 0.5 km elevation
- ~950-1050 kg rover

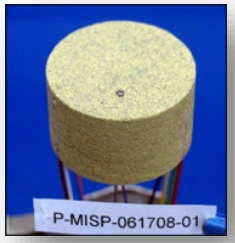
SURFACE MISSION

- Prime mission of at least one Mars year
- 20 km traverse distance capability
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

Mars 2020 Rover

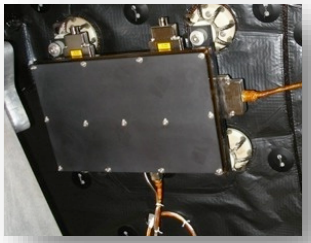


Mars EDL Instrumentation (MEDLI2)

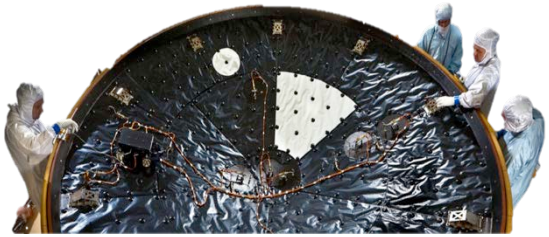


MEDLI Instrumented Sensor Plug (MISP)

Mars Entry Atmospheric Data System (MEADS)



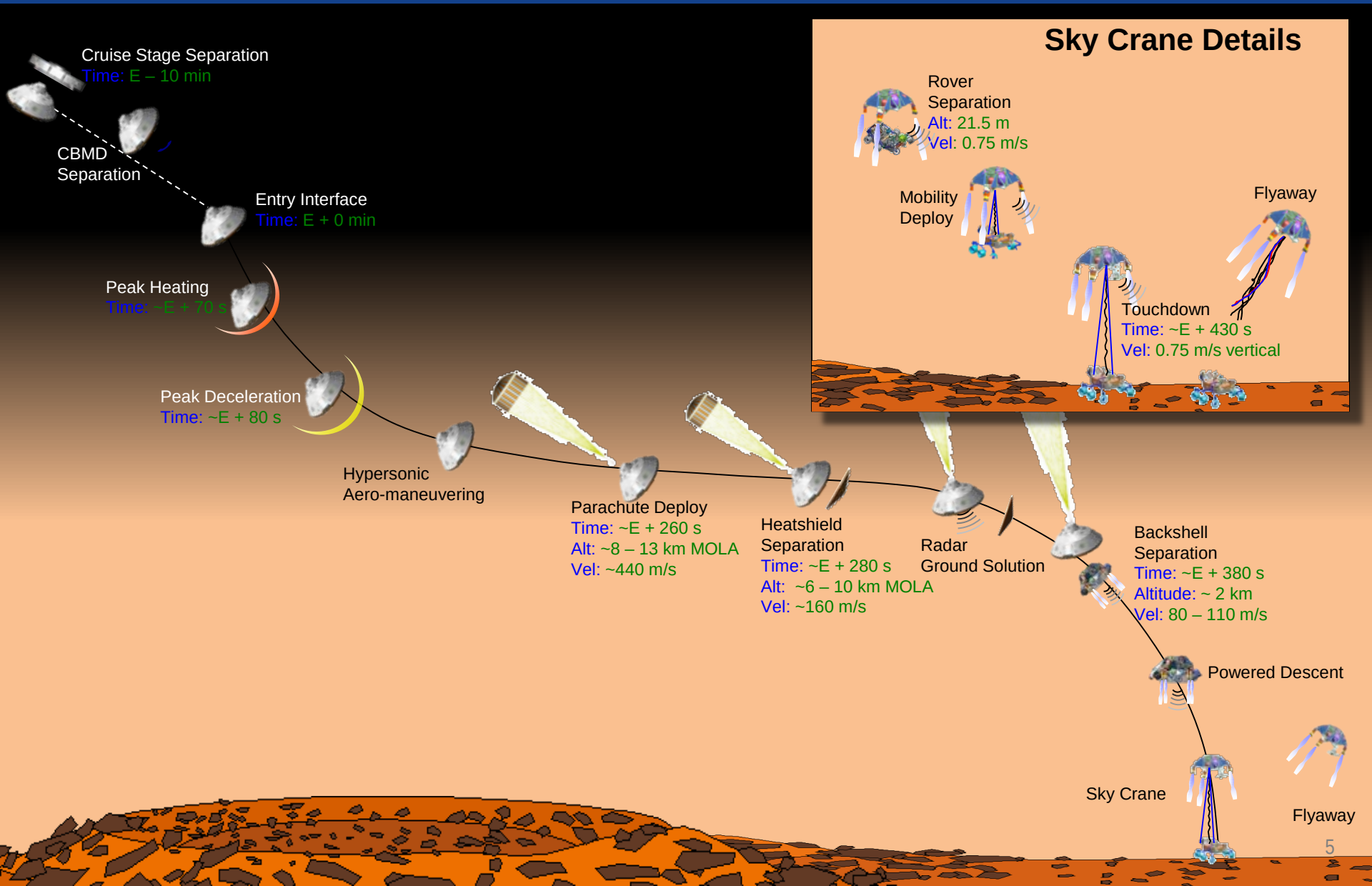
Sensor Support Electronics (SSE)



Item	MSL	Mars 2020
Sensor Support Electronics (SSE) Box	1	1
Heatshield: Pressure Transducers	7	7
Heatshield: Thermal Plugs	7	11
Backshell: Pressure Transducers	**0**	**1**
Backshell: Thermal Plugs	**0**	**9**

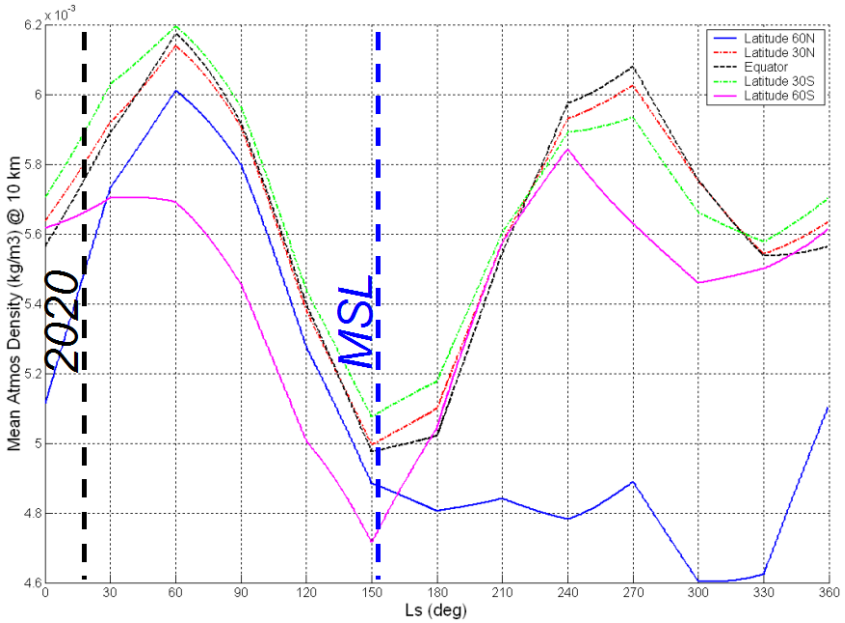
- MEDLI2 (Mars Entry, Descent, and Landing Instrument -2) instrumentation suite for Mars2020 will acquire critical EDL Aerodynamic, Aerothermal, and TPS data
- Builds on success of MEDLI instrument on the heatshield, and extends measurements to the backshell
- Extends heatshield observations to improve understanding of the turbulence and transition footprint and to reduce reconstruction uncertainty
- Targets supersonic aerodynamics for reduction in drag uncertainty
- Aims to improve backshell heating predictions by using direct heat flux sensors

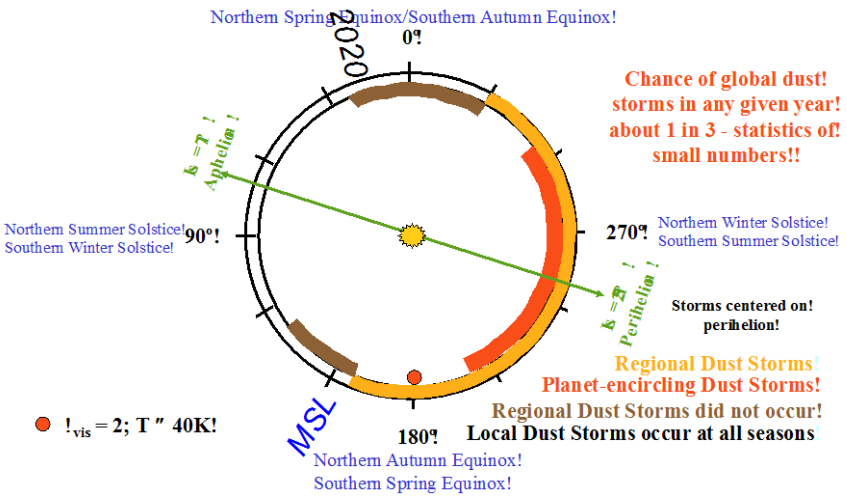
EDL Timeline



2020 Launch Opportunity

- **Pressure cycle very favorable for 2020**
  - Mars orbit eccentricity transfers CO_2 from polar caps to atmosphere
  - Atmosphere significantly more dense compared to MSL opportunity
  - Low risk of dust events
- **More atmospheric density = more stopping power**
- **2020 atmosphere provides significant "no cost" improvements to landing elevation for same landed mass**
- **Alternatively, can trade landing elevation improvement for increase in delivered mass**



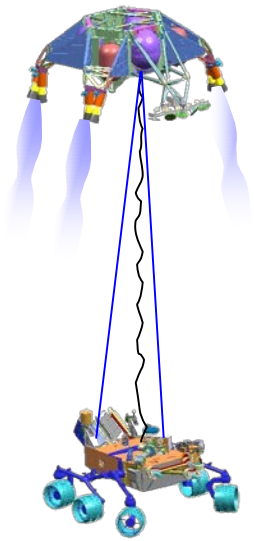


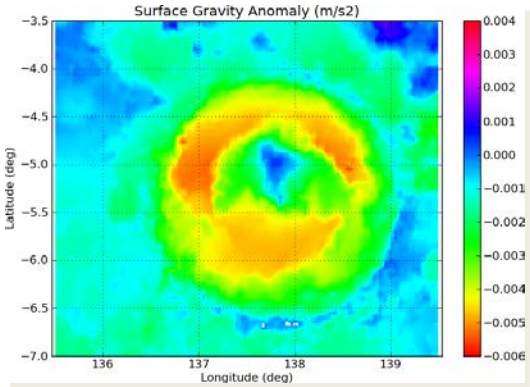
Fixing MSL: Touchdown Velocity

- **Incorrect altitude and velocity estimates during Sky Crane culminated in touchdown conditions outside of predictions**
  - Inaccurate estimation of velocity could result in damage to the rover

- **Root causes**
  - Local gravity differed from onboard gravity estimate
    - Resulted in lower than expected vertical velocity and contamination of horizontal velocity
  - "Sandy radar" – fast-moving dust picked up by radar
    - Misinterpreted as velocity contribution
    - Increased horizontal velocity error, polluted vertical velocity estimation

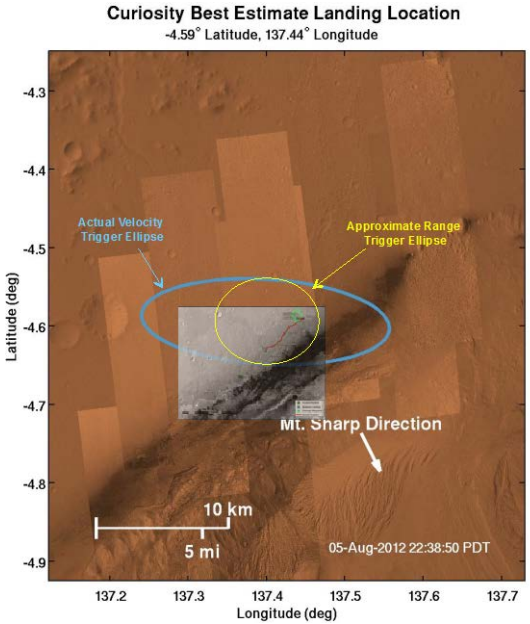
- **Mitigations**
  - Gravity related fixes
    - Developing high fidelity Mars gravity maps
    - Added site-specific gravity parameter
  - Sandy radar fixes
    - Tightened attitude initialization requirement
    - Tightening filtering of suspect TDS measurements
    - Augmenting TDS model for additional sandy radar effects and studying nav filter tuning strategies

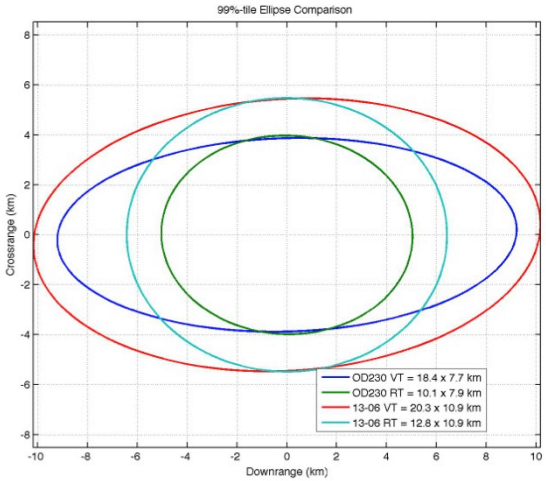




Phase A Baseline Change: Range Trigger

- **Range trigger deploys the parachute based on navigated range instead of navigated velocity**
  - No new hardware is required
  - Simple parachute trigger logic change in EDL Flight Software
  - Already included in working EDL FSW build
- **Using range trigger can significantly shrink the landing ellipse**
  - Conservatively shrinks,
    - From 25 km x 20 km
    - To 16 km x 14 km
  - >50% reduction in ellipse area
  - ~9 km reduction in ellipse length
- **Key benefits:**
  - Makes previously inaccessible landing sites accessible
  - Could save ~1 Earth year of driving
- **Magnitude of the improvement depends on landing site wind uncertainty and site elevation**
- **Range trigger is not a new idea – it's actually a very old idea that we couldn't adopt on MSL because we were chasing altitude performance**

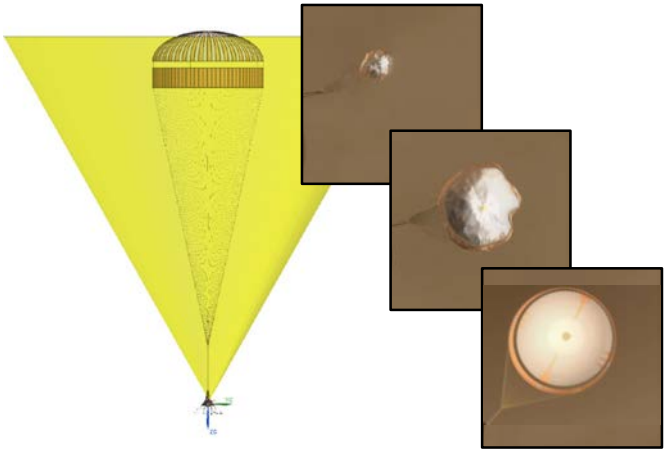




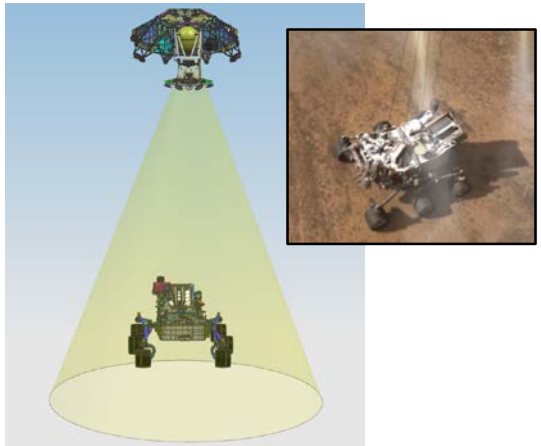
Phase A Baseline Change: EDL Cameras

- **Parachute Up-look Camera**
  - Record deployment, inflation and operational dynamics of the parachute from just before mortar fire until Backshell Separation
  - Camera might be able to capture the following additional events of interest:
    - Launch vehicle separation, Earth recession, Cruise stage separation
- **Descent Stage Down-look Camera**
  - Record rover dynamics and ground interaction with plume from Sky Crane through touchdown
- **Rover Up-look Camera**
  - Record descent stage dynamics from Sky Crane through touchdown
  - Capture fly away event

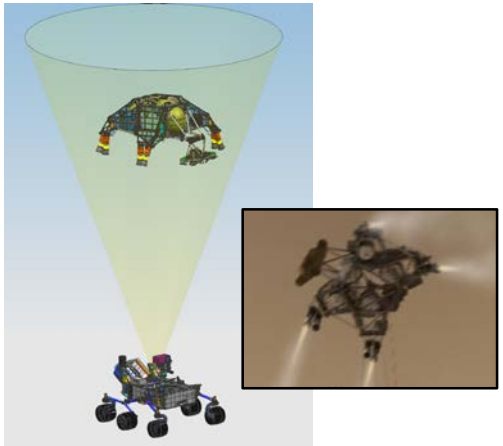
Parachute Up-look



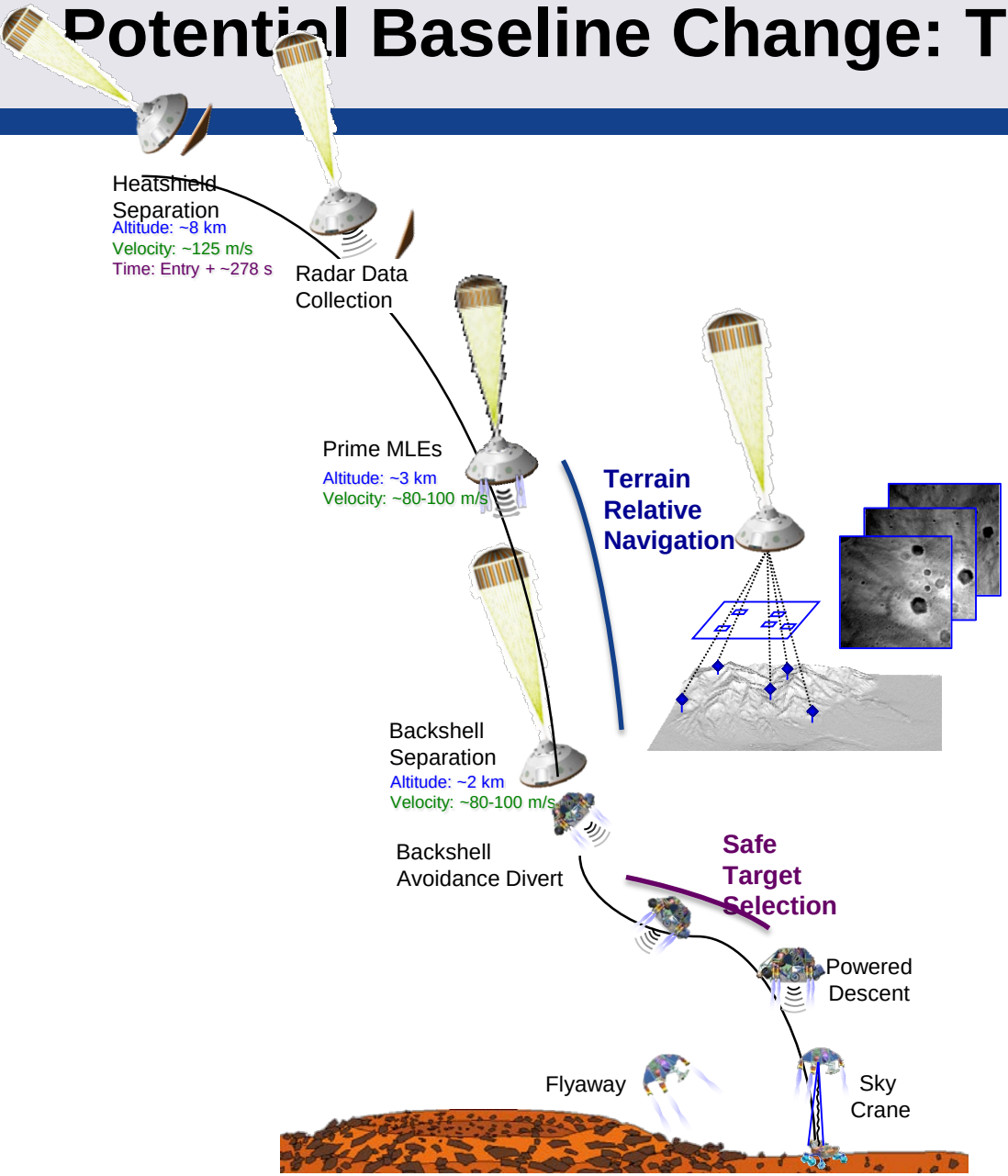
Descent Stage Down-look



Rover Up-look



Potential Baseline Change: TRN



Terrain Relative Navigation

- Takes images during parachute descent and matches them to an onboard map
  - Uses a dedicated computer and camera
  - Yields a position solution
- Performs terrain relative navigation while the spacecraft is priming the descent engines
- Executed by the Lander Vision System (LVS)

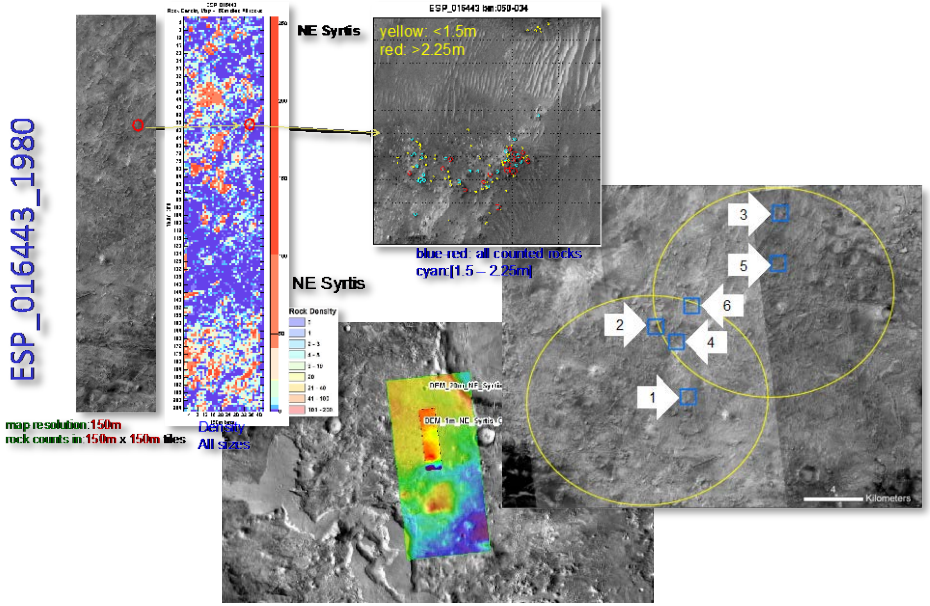
Safe Target Selection

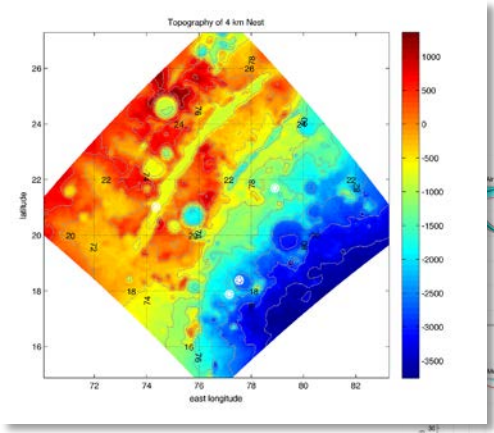
- Uses position solution and list of safe landing locations to select a safe landing target
- Augments original MSL backshell avoidance divert
- Lives within MSL fuel and control constraints
- Not “pinpoint” landing

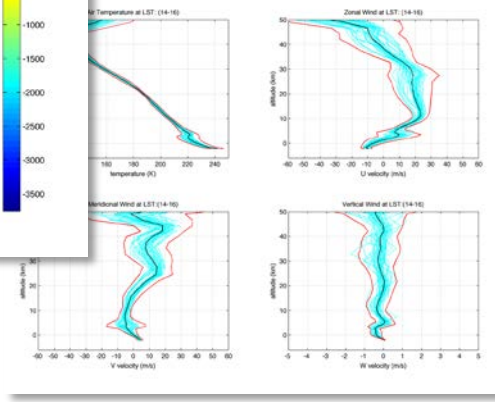
TRN gives Mars 2020 “eyes” to avoid identified landing hazards

Landing Site Selection Progress

- **Landing site selection process for Mars 2020 is well underway**
  - First workshop held in May 2014
  - 2nd workshop scheduled for August 2015
- **Evaluating top sites for landing safety and expected surface productivity**
  - Nominal mesoscale based atmosphere generated
  - Terrain hazard and traverse maps in work
  - Significantly accelerated relative to MSL site selection process
- **Several top sites are significantly rougher than MSL sites**
  - Will likely require TRN for safe landing and to reduce surface traverses







Summary & Conclusions

- **MSL EDL design and heritage remains largely intact as the project heads into PDR season**
  - Issues from MSL have been addressed
  - Selected augmentations have been accepted without threatening the overall architecture
- **2020 is a very favorable launch opportunity**
  - May help offset significant rover mass growth
- **TRN is a major potential EDL augmentation that may be baselined to improve landing site access and surface productivity**