Jet Propulsion Laboratory
California Institute of Technology

Mars 2020 Entry, Descent, and Landing System Overview

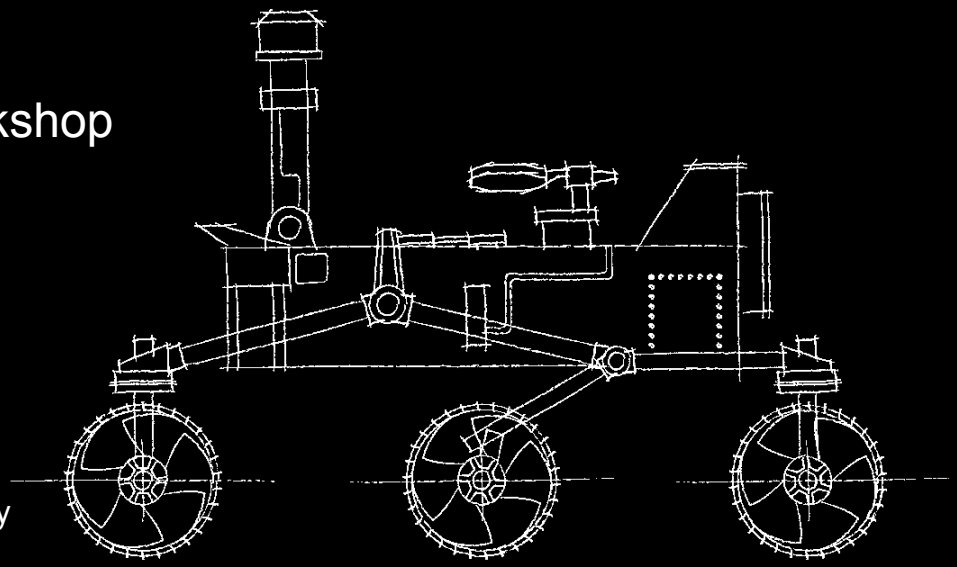
13th International Planetary Probe Workshop

Laurel, Maryland
June 2016

Allen Chen, Paul Brugarolas, Erisa Hines, Andrew Johnson, Richard Otero, Aaron Stehura, Gregorio Villar, David Way

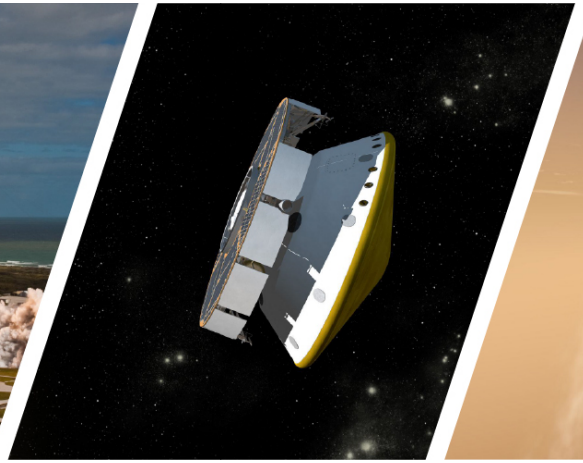
Jet Propulsion Laboratory, California Institute of Technology

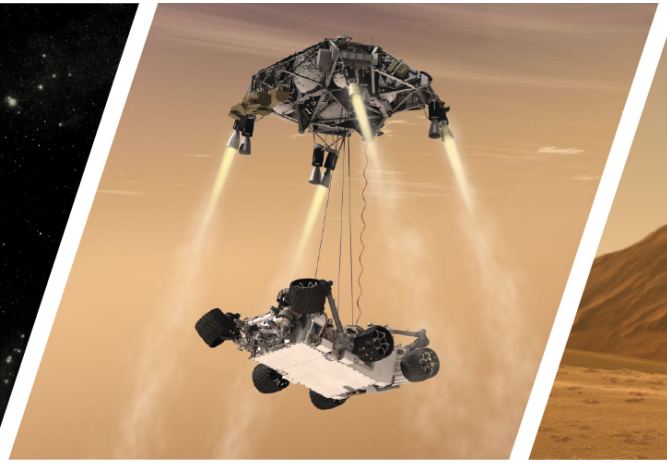
Copyright 2016 California Institute of Technology
U.S. Government sponsorship acknowledged

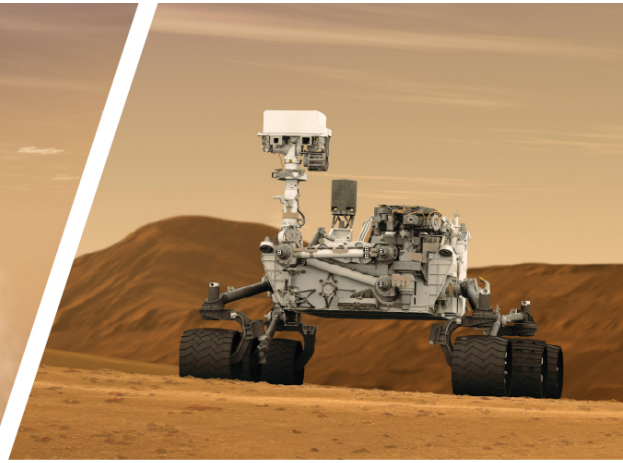


Mars 2020 Project

Mars 2020 Mission Overview







LAUNCH

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

CRUISE/APPROACH

- 7.5 month cruise
- Arrive Feb 2021

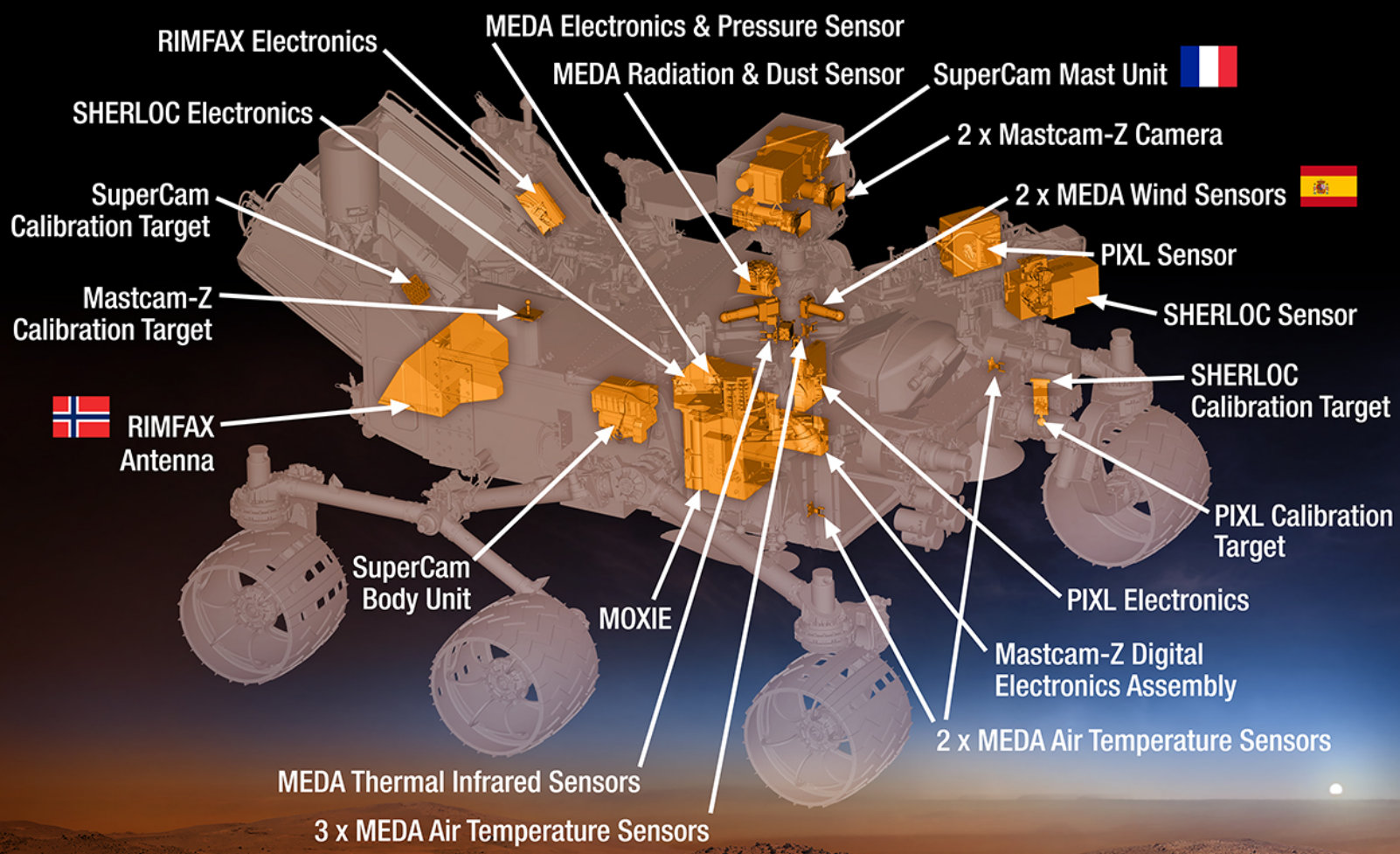
ENTRY, DESCENT & LANDING

- MSL EDL System: guided entry, powered descent, and sky crane
- Augmented by ***range trigger***: 16 x 14 km landing ellipse
- Augmented by ***TRN***: enables safe landing at a greater number of scientifically valuable sites
- Access to landing sites ±30° latitude, ≤ - 0.5 km elevation
- Deliver a 1050 kg rover

SURFACE MISSION

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

Mars 2020 Rover

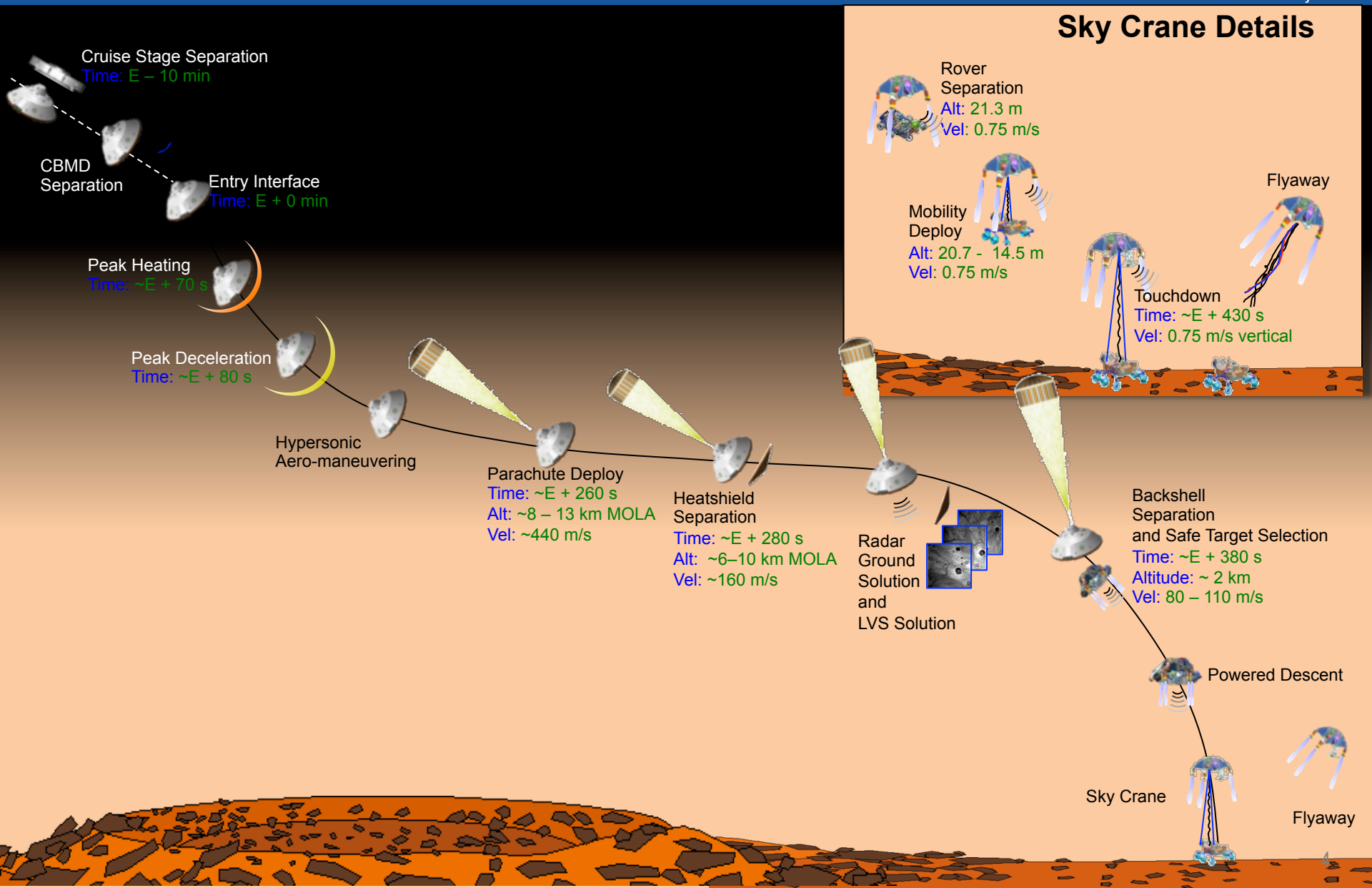


MEDLI2 Instrumentation on the Backshell and Heatshield
EDL Cameras On the Backshell, Descent Stage, and Rover

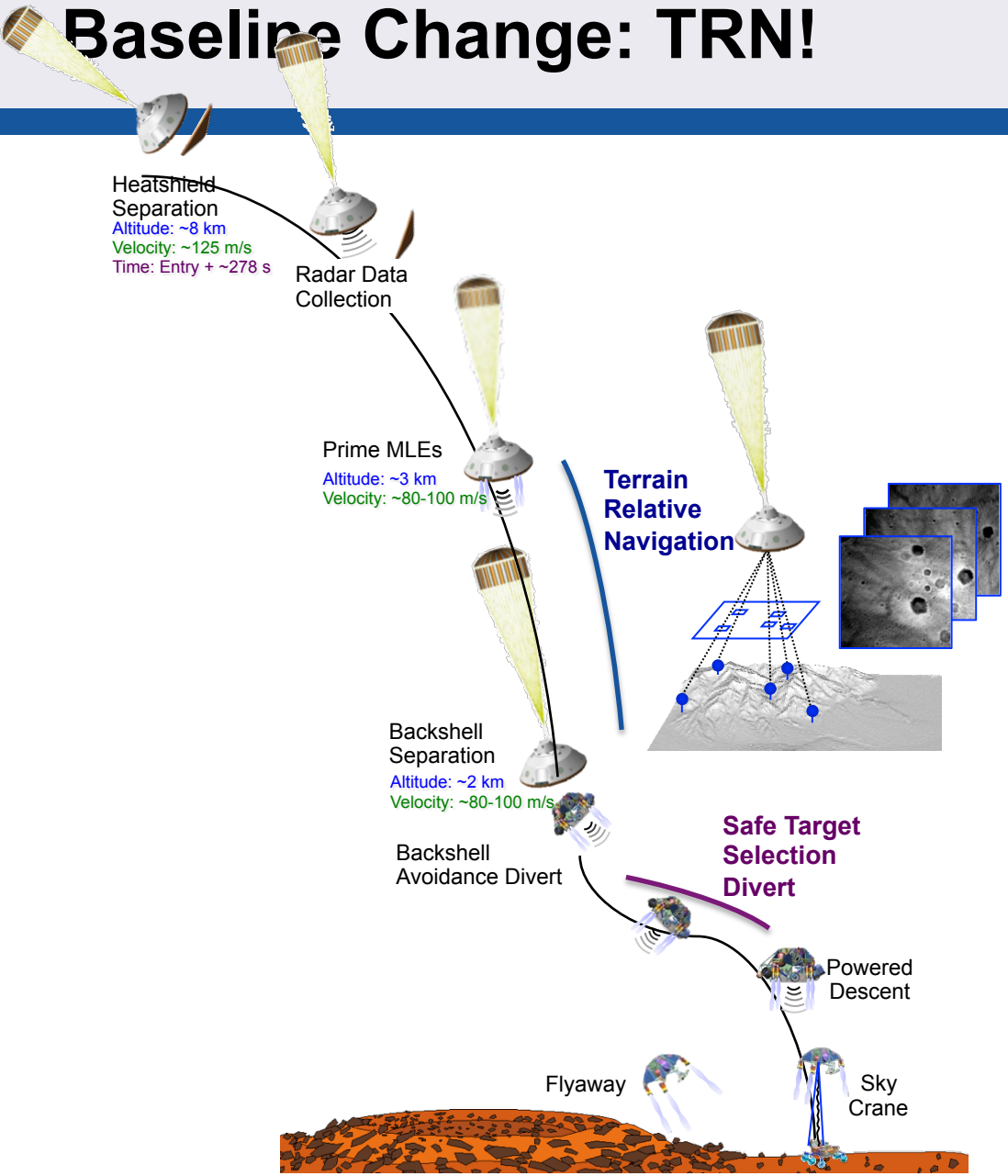
EDL Timeline

Jet Propulsion Laboratory
California Institute of Technology

Mars 2020 Project



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

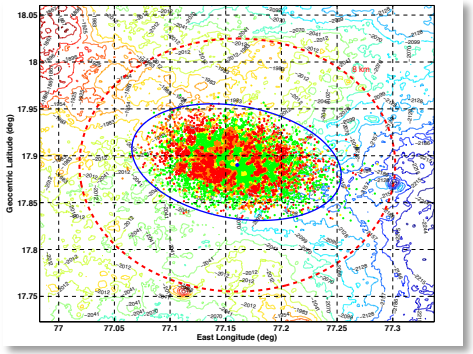
TRN gives Mars 2020 “eyes” to avoid identified landing hazards

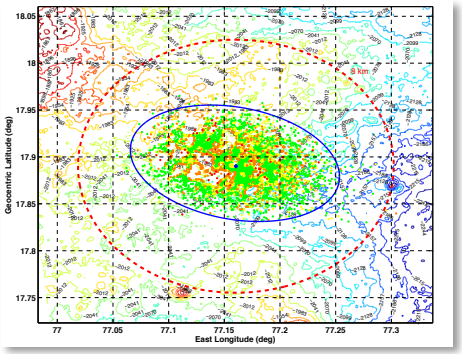
TRN Development Status

- **Preliminary design is complete**

- **LVS development status**
  - Prototype developed and tested in real-time field test (2014) over a wide range of Mars analog terrains and operational conditions
  - Algorithms and software provide 40 m position estimate
  - Vision Compute Element development at PDR level

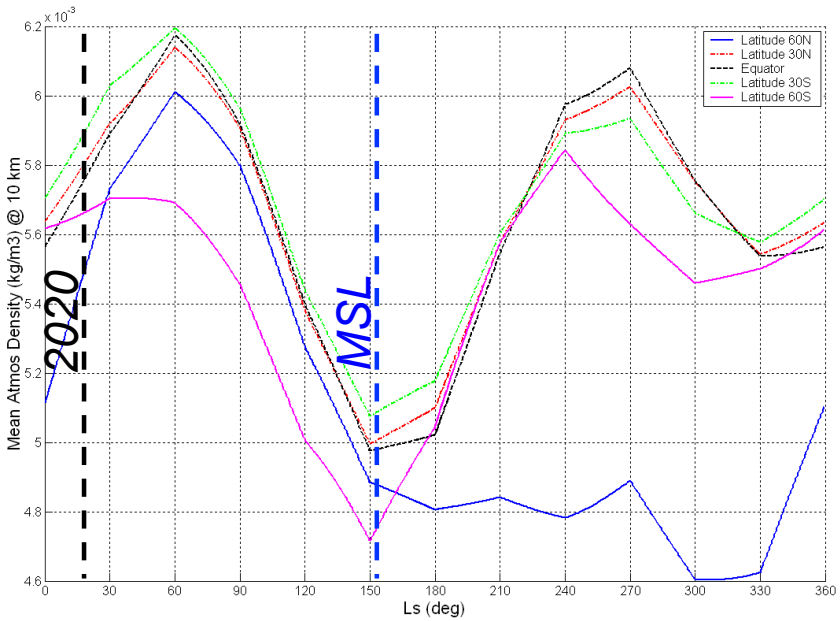
- **Safe Target Selection development status**
  - Prototype developed and integrated with heritage FSW
  - Tested in EDL end to end simulation and testbed environments

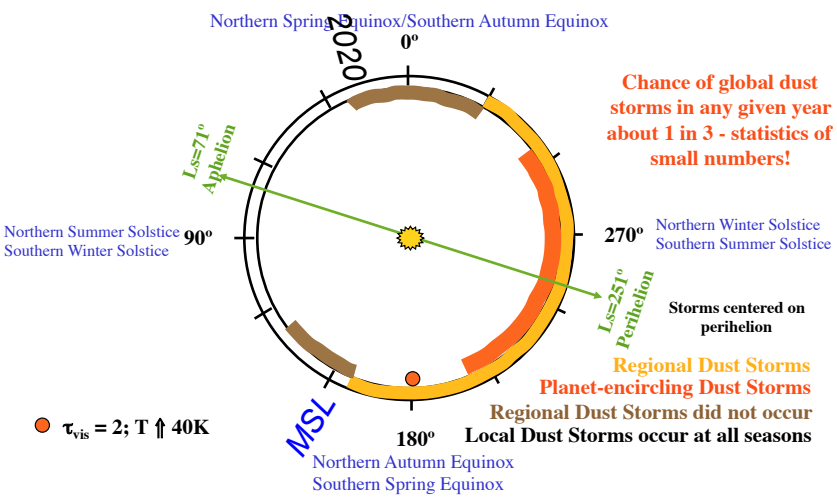




2020 Launch Opportunity

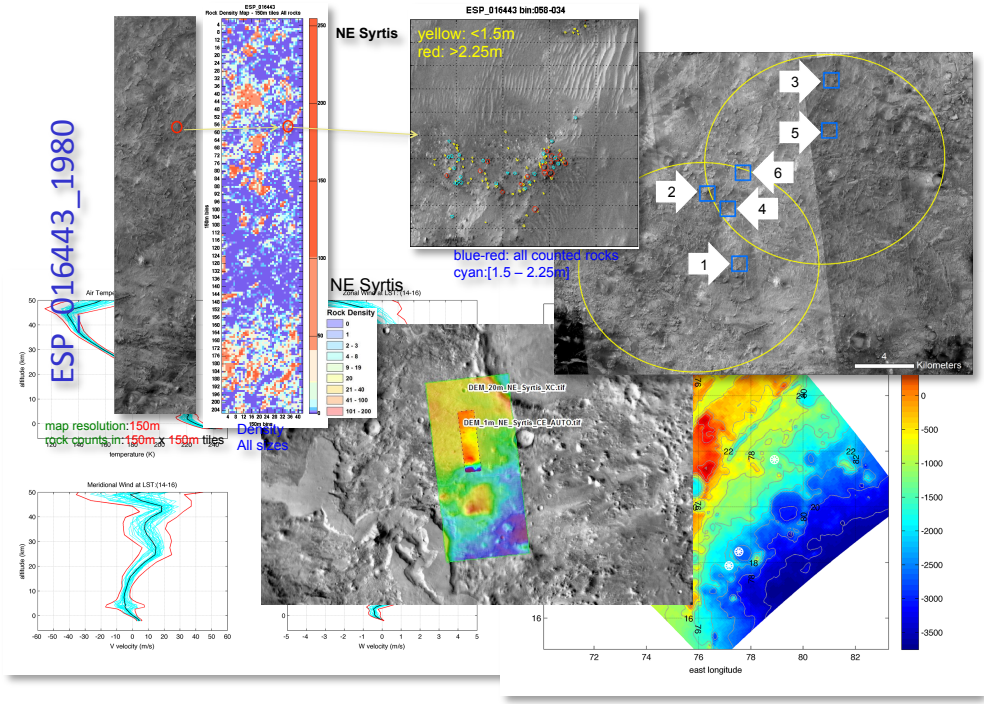
- **Pressure cycle very favorable for 2020**
  - Mars orbit eccentricity transfers CO_2 from polar caps to atmosphere
  - Atmosphere significantly more dense compared to MSL opportunity
  - Low risk of dust events
- **More atmospheric density = more stopping power**
- **2020 atmosphere provides significant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





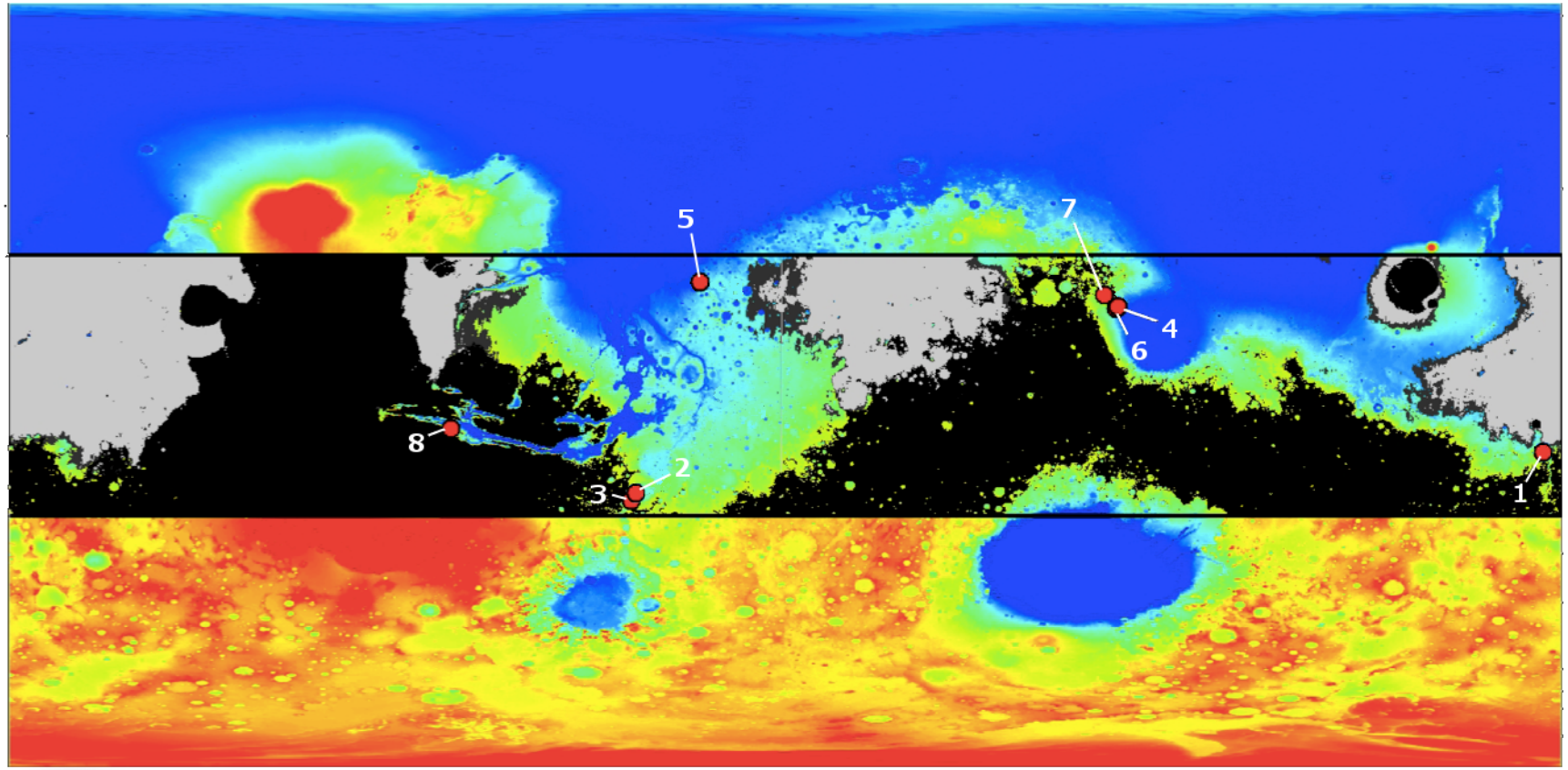
Landing Site Selection Progress

- **Landing site selection process for Mars 2020 is well underway**
  - 2nd workshop held in August 2015
  - 3rd workshop planned for January 2017
- **Down-selected to eight candidate landing sites**
  - Principally driven by scientific objectives
- **Continuing to evaluate top sites for landing safety and expected surface productivity**
  - Site specific atmosphere and terrain products developed
  - Developing tailored surface operations scenarios for each site
  - Significantly accelerated relative to MSL site selection process
- **Majority of sites require TRN for safe landing**



Site	w/o TRN	w/ TRN	Comments
Columbia Hills (Gusev)			Can likely land near Columbia Hills with or without TRN
Eberswalde			Near complete terrain data products available; likely requires TRN; potentially difficult traversability
Holden (TRN target)			Data product coverage is excellent; Southern latitude may be a surface productivity and longevity concern
Jezero		+3.75%	Requires TRN; traverse difficulty may impact surface performance
Mawrth		+1.93%	Near complete terrain data products; requires TRN; etched slopes will impact surface productivity
NE Syrtis		+1.75%	Requires TRN; surface situation good
Nili Fossae			Data product coverage is good; TRN not required; surface situation good. High site elevation.
SW Melas		+1.22%	Safe with TRN; surface looks good as long as ellipse shrinks somewhat

Candidate Landing Sites



(alphabetical order)

1- Columbia Hills (Gusev)
2- Eberswalde
3- Holden
4- Jezero
5- Mawrth
6- NE Syrtis
7- Nili Fossae
8- SW Melas

Elevation above MOLA Geoid (m)

High: 4000 Low: -5000

Black elevation mask > 0.5 km

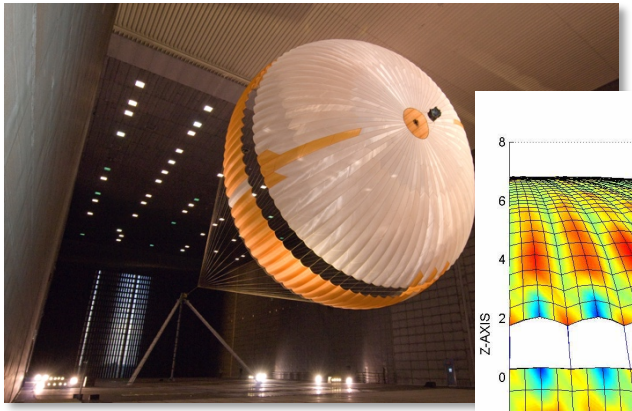
Thermal Inertia masks:

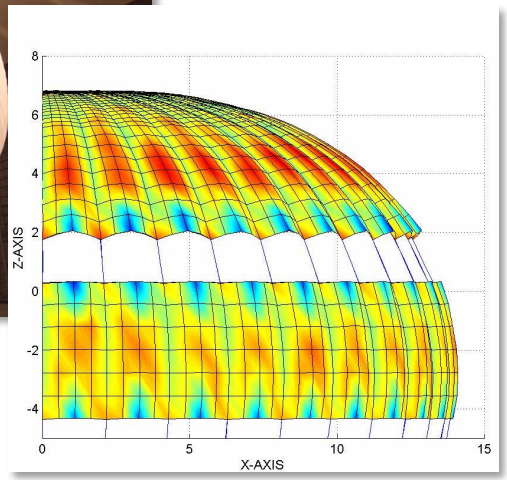
< 150 = Dark Gray

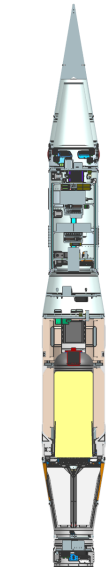
< 100 = Light Gray

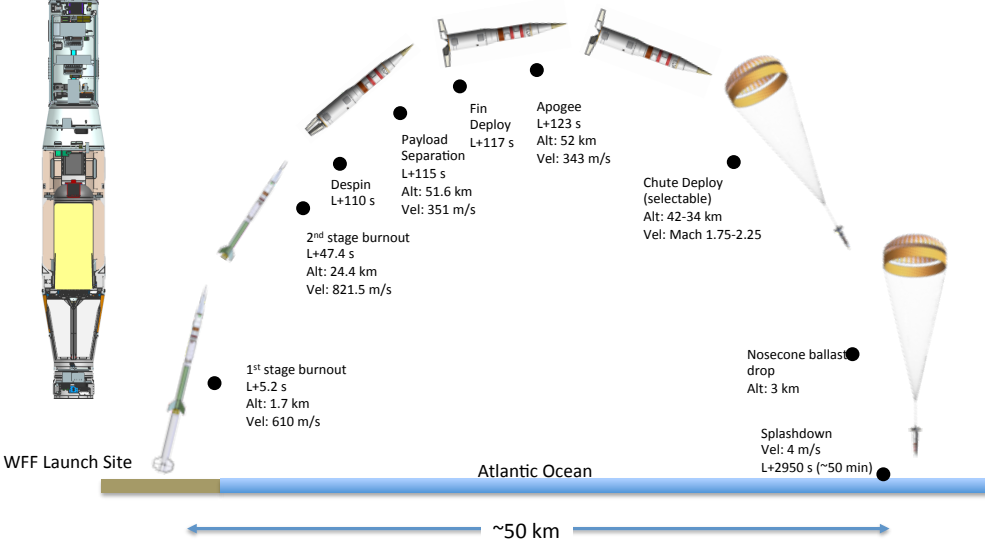
Parachute Status

- **LDSD parachute test results have heightened awareness of risk regarding parachute inflation**
- **Investigating a potential supersonic test program to address inflation related risks**
  - Studying sounding rocket based test campaign
  - Evaluating test opportunities for Summer 2017
- **Developing both MSL build to print and strengthened parachute designs in parallel**









Programmatic Status

- **Successfully passed CEDL system, TRN, and Project PDRs**

- **Key upcoming milestones**
  - Parachute Go-Forward Plan Review 2 — September 2016
  - TRN CDR — October 2016
  - CEDL CDR — Early November 2016
  - Project CDR — November 2016
  - MEDLI2 PDR — December 2016
  - Landing Site Workshop #3 — January 2017

Launch: July 17 – August 5, 2020
Landing: February 18, 2021

Summary

- **MSL EDL design and heritage remains largely intact as the project heads into CDR season**
  - Continuing to maintain our head start from MSL
  - Working to address LDSD-related parachute risk
- **Landing site science and engineering evaluation rapidly maturing**
- **TRN incorporated into the baseline**
  - Major EDL augmentation that will improve landing site access and surface productivity