



Mars 2020 EDL Update

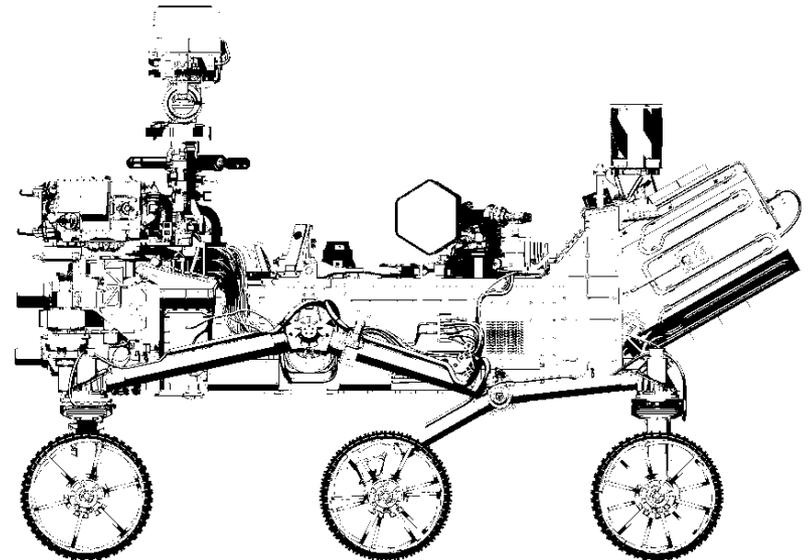
14th International Planetary Probe Workshop
The Hague, Netherlands

June 2017

Allen Chen
Jet Propulsion Laboratory, California Institute of Technology

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U.S. Government sponsorship acknowledged





Mars 2020 Mission Overview

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LAUNCH

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

CRUISE/APPROACH

- ~7 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 $\pm 30^\circ$ latitude, ≤ -0.5 km elevation

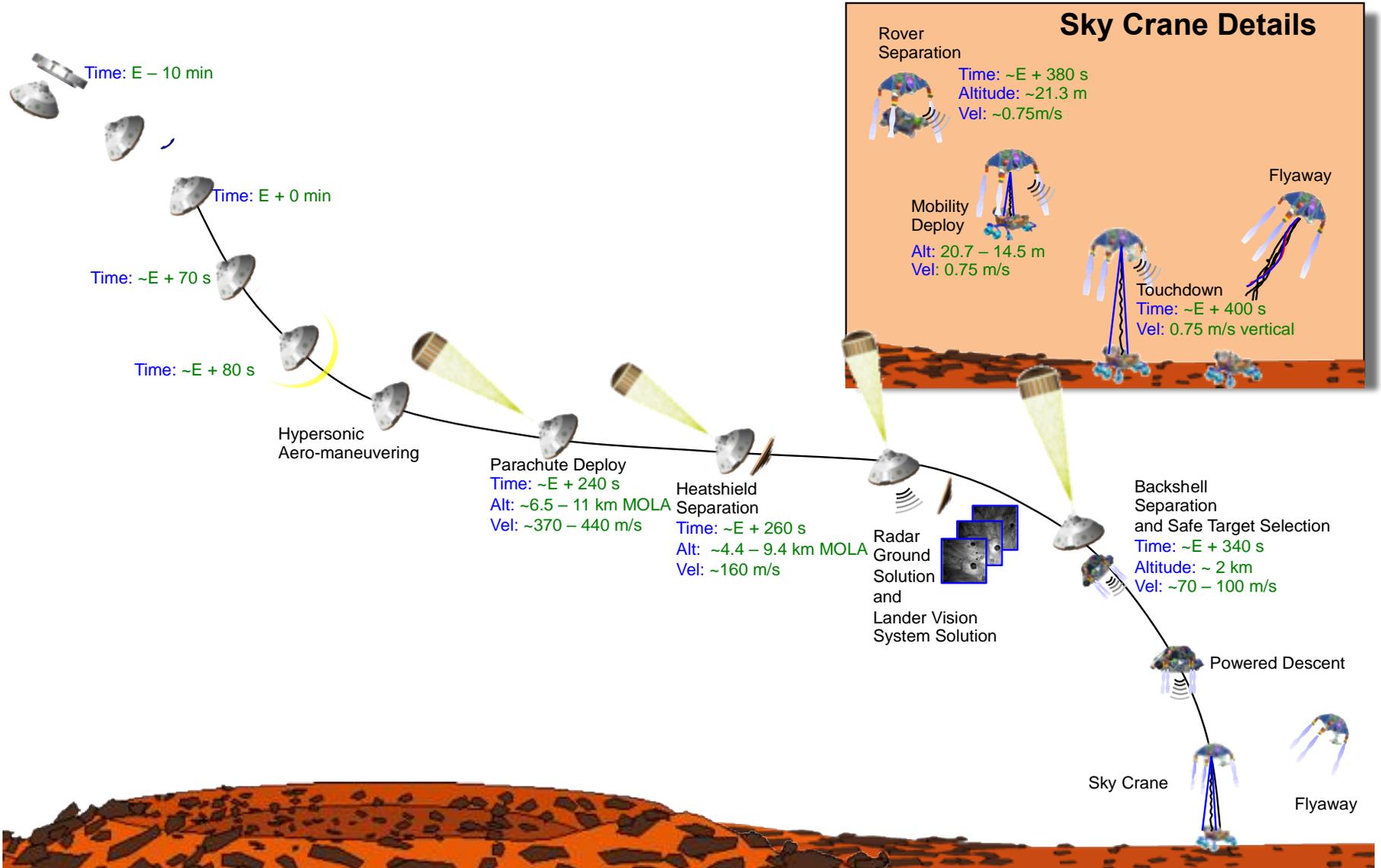
SURFACE MISSION

- Prime mission of 1.5 Mars years
- 20 km traverse distance capability
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars



EDL Timeline

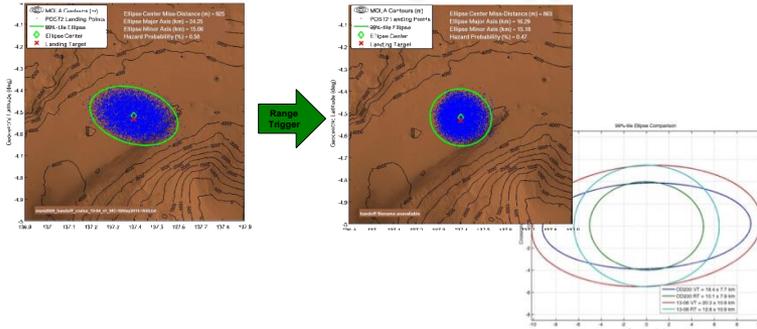
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New Capabilities for Mars 2020

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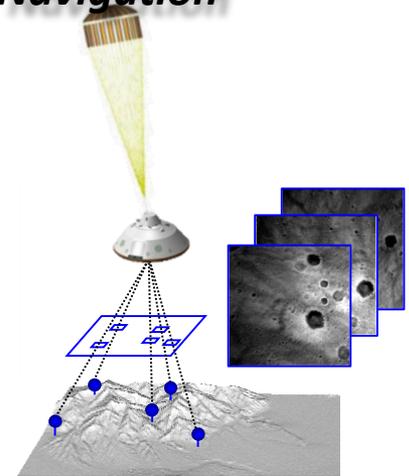
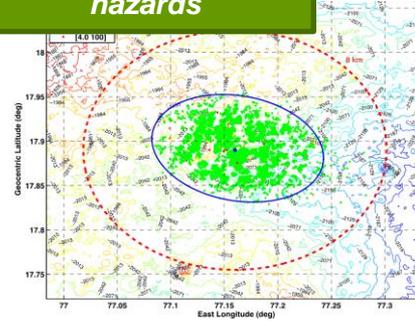
Range Trigger



Range trigger shrinks the landing ellipse area by 40%

Terrain Relative Navigation

TRN gives Mars 2020 "eyes" to avoid identified landing hazards

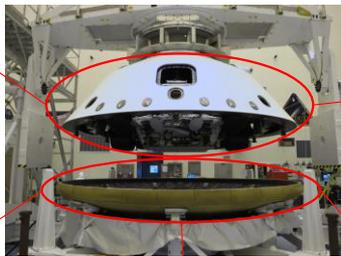


MEDLI2

MISP (BS)
6 Sensor Plugs (7 T/Cs)
(SLA - Heritage) & 3 Heat Flux Sensors
(2 total & 1 radiative - New)



MISP (HS)
11 Sensor Plugs
(17 T/Cs)
(PICA - Heritage)



SSE
Data Acquisition & Signal Conditioning System
(Modified Heritage); & all intra-instrument harnesses



MEADS (BS)
One Pressure Transducer on the Backshell (COTS)



MEADS (HS)
1 PT for Hypersonic regime (MEDLI Spare)

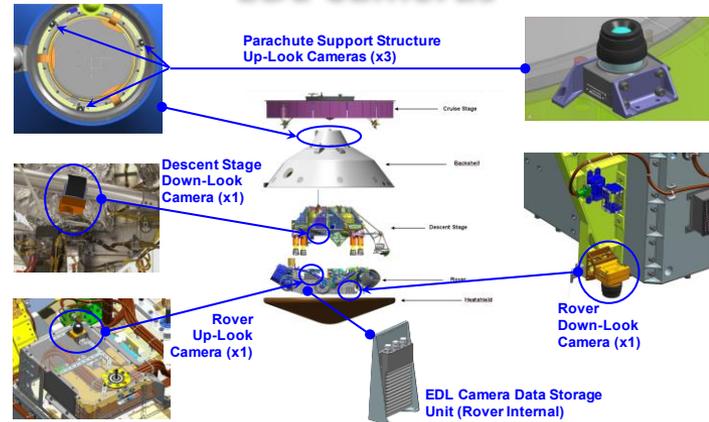


6 PTs for Supersonic Regime (New)



Building upon MEDLI with new backshell observations and supersonic pressure measurements

EDL Cameras



High resolution, high frame rate parachute, descent stage downlook, and rover up and downlook cameras



Since Last Year...

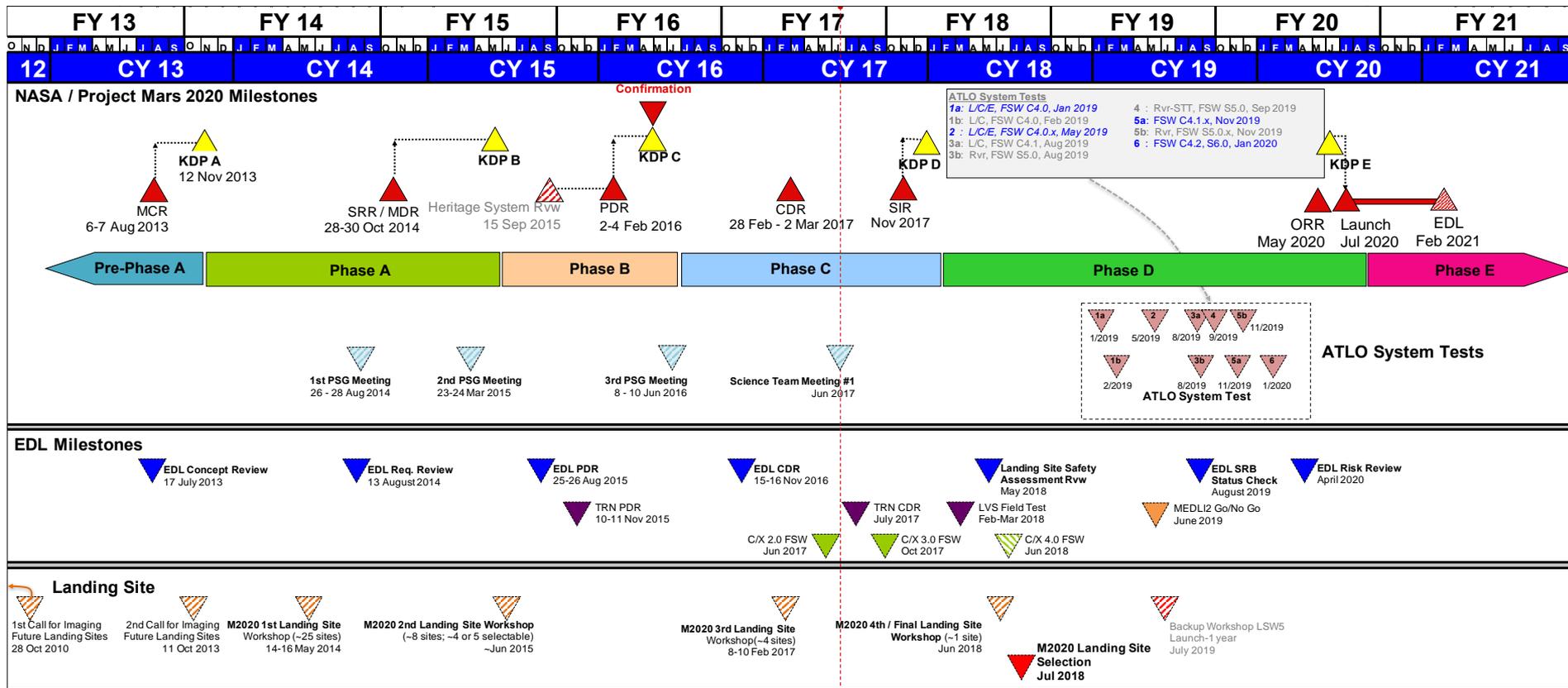
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- Successfully passing through CDR season
- Down-selected to three landing sites
- Embarked on parachute risk reduction efforts



High Level Schedule

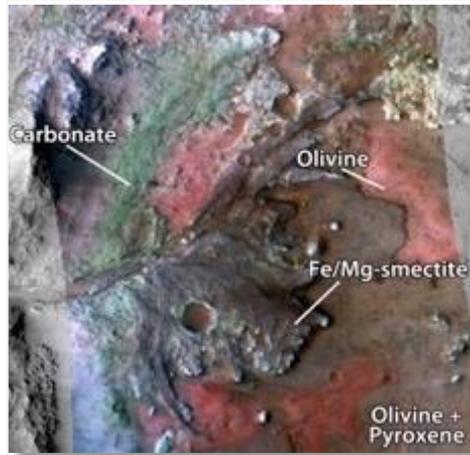
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- EDL CDR completed successfully in November
- Conducted landing safety assessments in support of Landing Site Workshop 3 in February
- Baseline EDL FSW capability available in the fall of 2017 for testing

Three Landing Sites Remain

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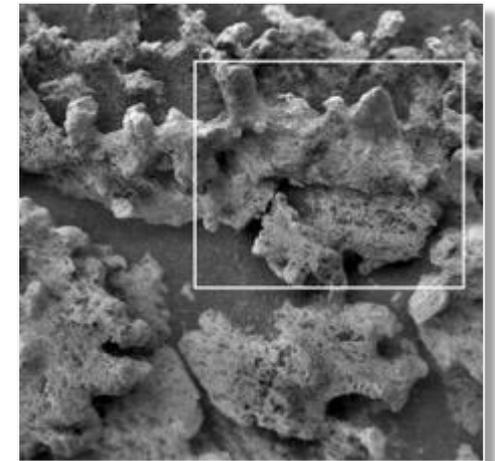
JEZERO

- Deltaic/lacustrine deposition with possible igneous unit and hydrous alteration
- Mineralogic diversity including clays and carbonates
- Shallow water carbonates?



NE SYRTIS

- Extremely ancient igneous, hydrothermal, and sedimentary environments
- High mineralogic diversity with phyllosilicates, sulfates, carbonates, olivine
- Possible serpentinization and subsurface habitability



COLUMBIA HILLS

- Carbonate, sulfate, and silica-rich outcrops of possible hydrothermal origin. Hesperian volcanics.
- Potential biosignatures identified
- Previously explored by MER

Landing Safety

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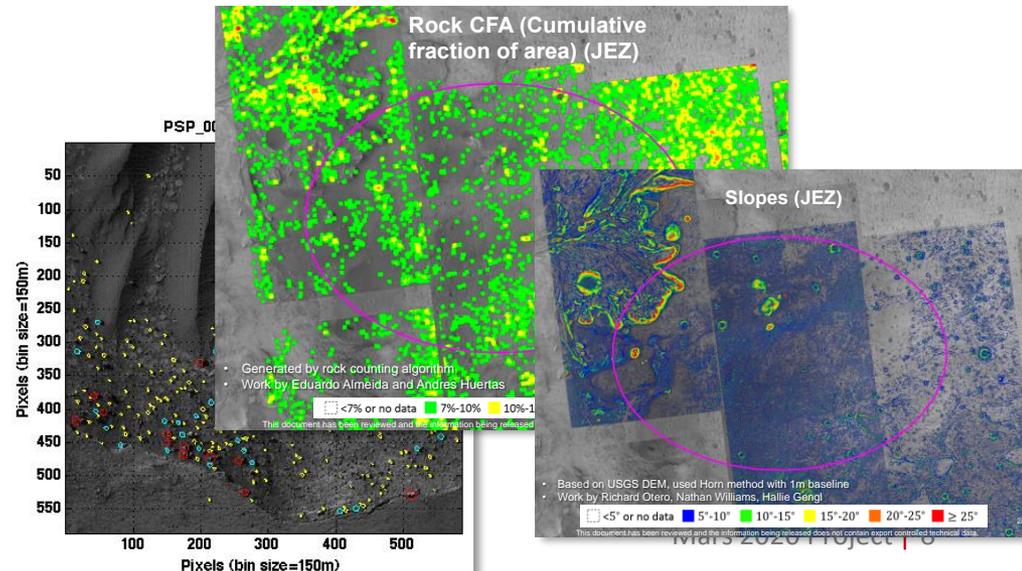
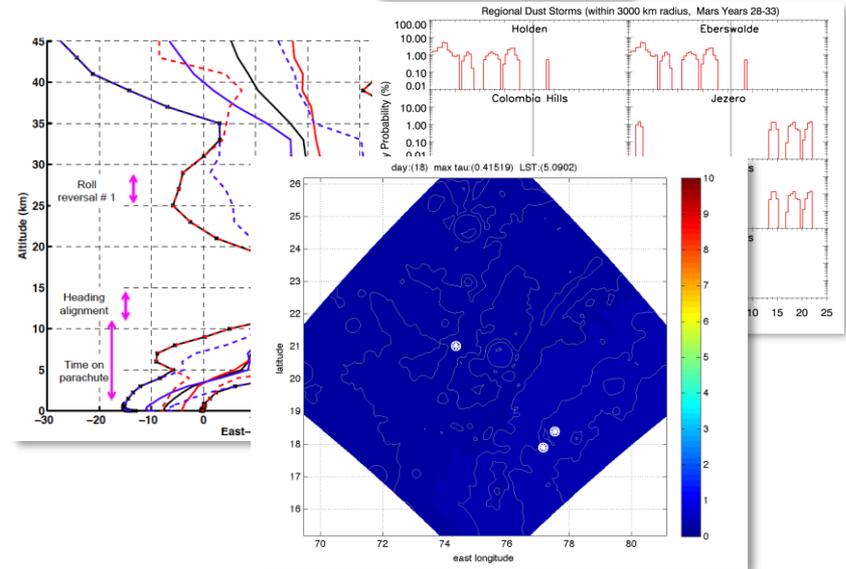
* No Global Dust Storm observed for Mars 2020 EDL Season *

Credit: Cantor

- When combined with range trigger, TRN gives the system the ability to reach Jezero and NE Syrtis

- Atmosphere and terrain characterization efforts have matured and are on par with the maturity MSL had at final site selection

- All three remaining candidate landing sites can be reached with acceptable risk





Parachute Overview

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- The Low Density Supersonic Decelerators program revealed shortcomings in the perceived conservatism of our parachute analysis and test methods and in our understanding of supersonic parachute inflations

- The Mars 2020 project is responding by:
 - Developing a strengthened parachute design in parallel to the “build to print” design from MSL

 - Performing supersonic parachute risk reduction testing (dubbed ASPIRE)

- Both parachute designs are undergoing subsonic wind tunnel testing; supersonic risk reduction testing begins in the fall

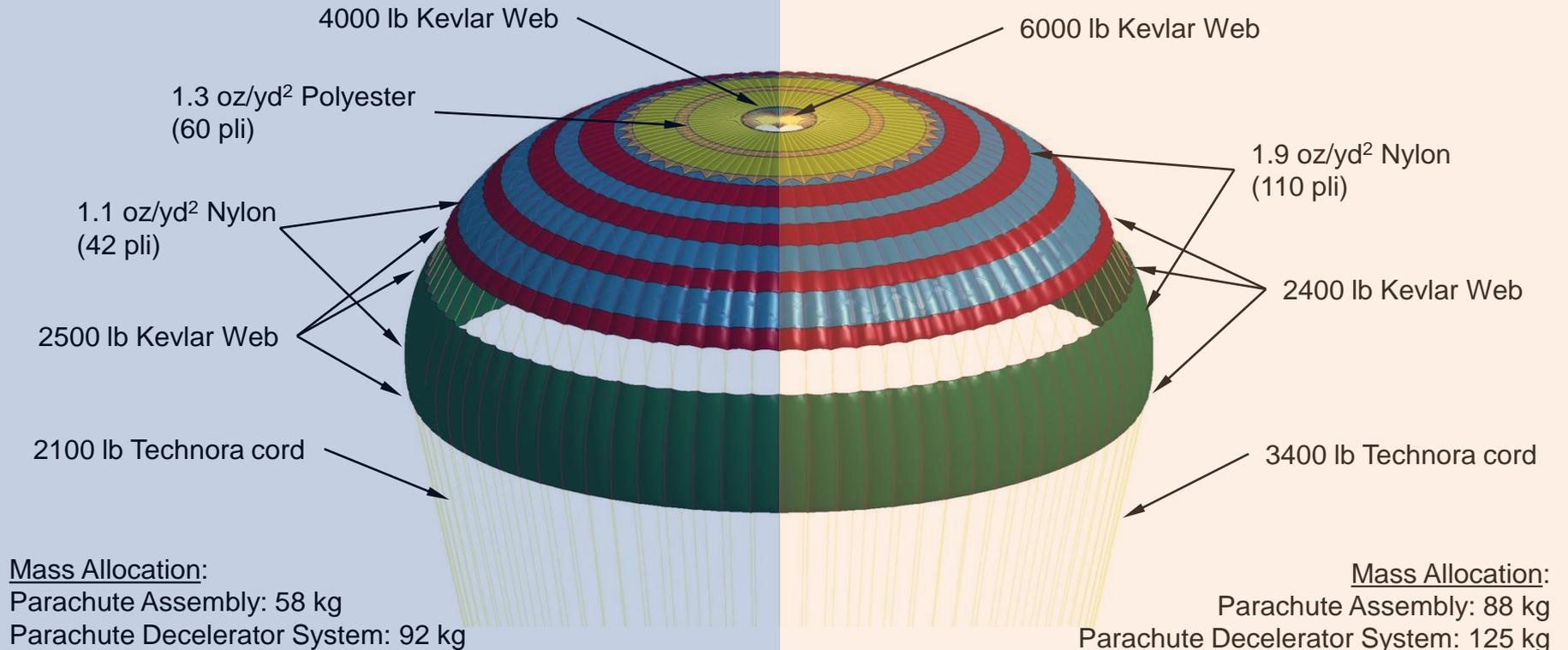
- Additionally, Mars 2020 is also investigating the impact of planetary protection heating on parachute material strength

Canopy Comparison

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M2020 Built-to-Print

M2020 Strengthened

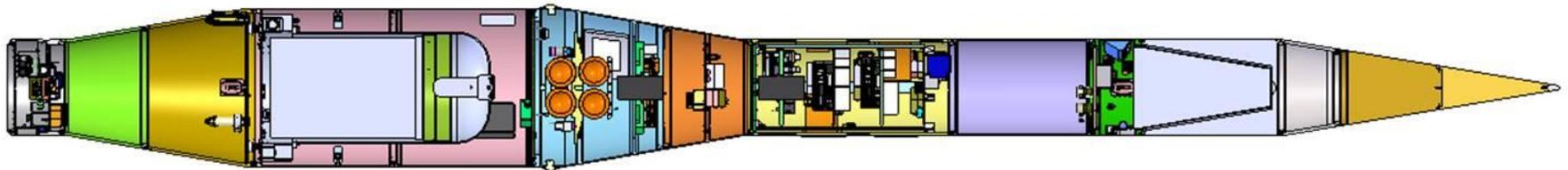


- Both have same number of gores, fabric orientation, continuous line construction, vent constraint method, and confluence fitting
- Strengthened parachute pack will be larger and have higher pack density (but within Mars heritage values)
- Stiffness increases with increased material strength, but strain (compliance) are similar between the two parachutes due to increased mass

ASPIRE Overview

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Advanced Supersonic Parachute Inflation Research and Experiments



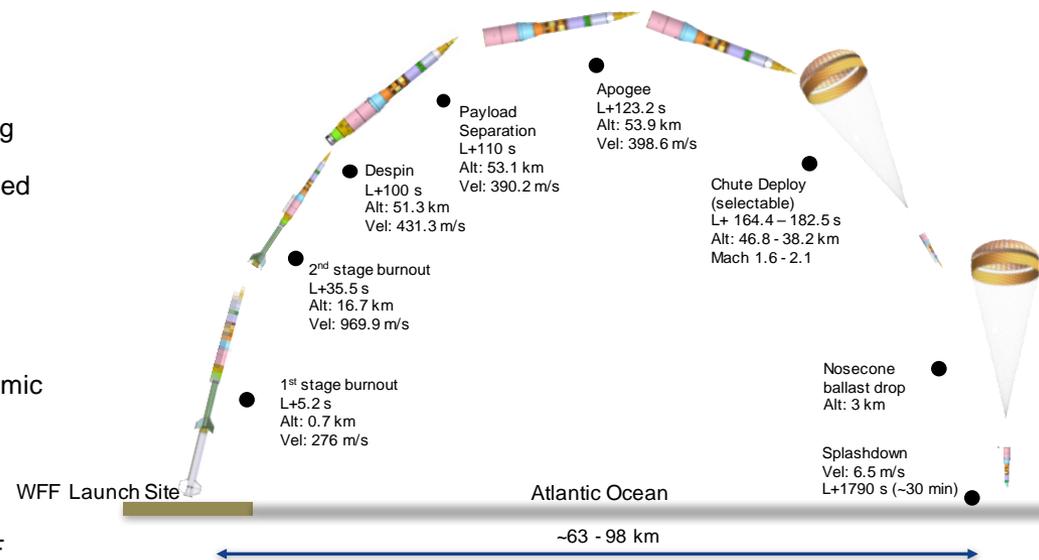
adapter parachute / mortar / foam ACS avionics foam ballast

Test architecture:

- Terrier-Black Brant (Black Brant IX) sounding rocket launched out of WFF with water recovery of payload section and parachute
- ~ 1200 kg payload with 28.5" diameter payload fairing
- Instrumentation includes IMU, load pins, 3x high-speed high-resolution cameras, 3x situational cameras

Test Conditions:

- Targeting Mach ranges between 1.6 to 2.0 with dynamic pressure ranging from 250 Pa to 1250 Pa
- Targeting enables parachute inflation loads between 25,000 and 90,000 lbf
- As close as possible to infinite mass condition; TAYF exceptions vetted through review board



Test architecture will provide relevant supersonic inflation data



Parachute Strength Reduction Due to Heating

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- Mars 2020 has discovered that certain parachute broadcloth materials lose substantial strength after long duration planetary protection bake-out

- Broadcloths that meet the same Parachute Industry Association standards may behave differently depending on exposure time at high temperatures

- Mars 2020 has identified options to address this issue:
 - Use parachute materials that are insensitive to required heating
 - Investigate bake-out options that avoid strength degradation



Summary

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- Mars 2020 EDL development remains on track
- Down-selected to three highly scientifically desirable landing sites that are safely accessible using range trigger and TRN
- Parachute risk reduction efforts in progress...stay tuned