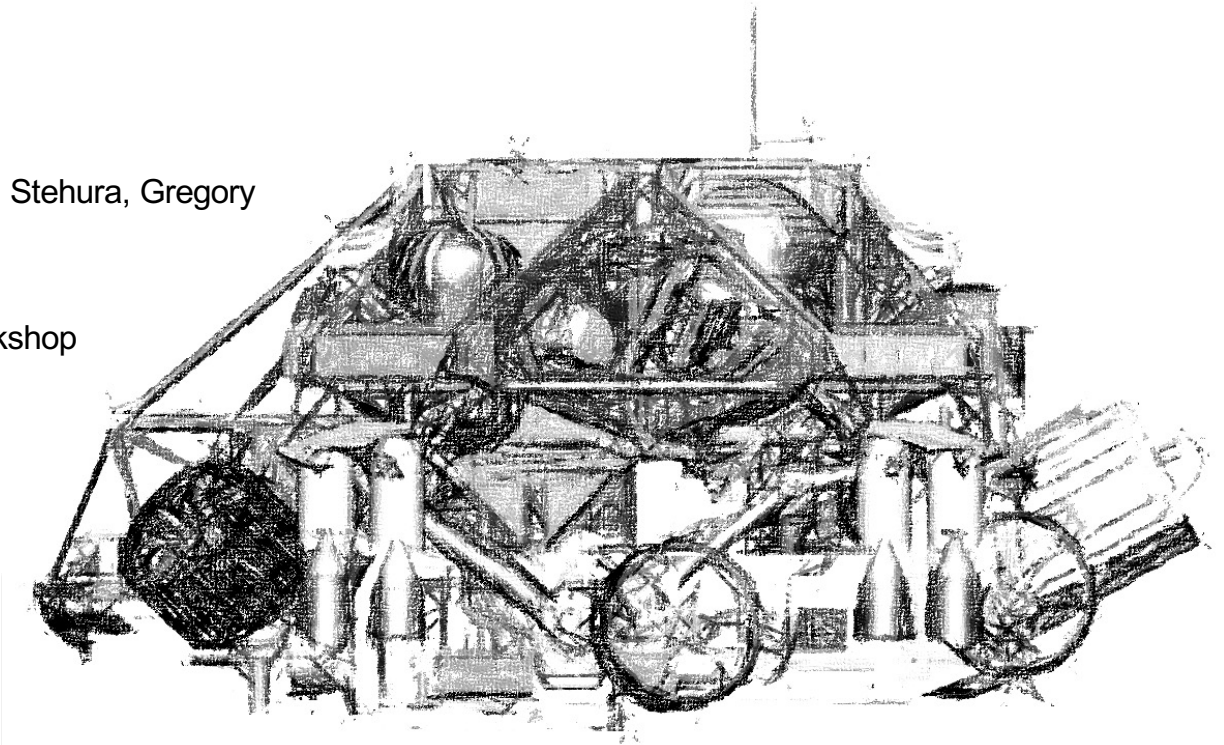# Flight Systems Verification & Validation

Mars 2020 Entry, Descent, and Landing

Cj Giovingo

Allen Chen, Mallory Lefland, Aaron Stehura, Gregory Villar
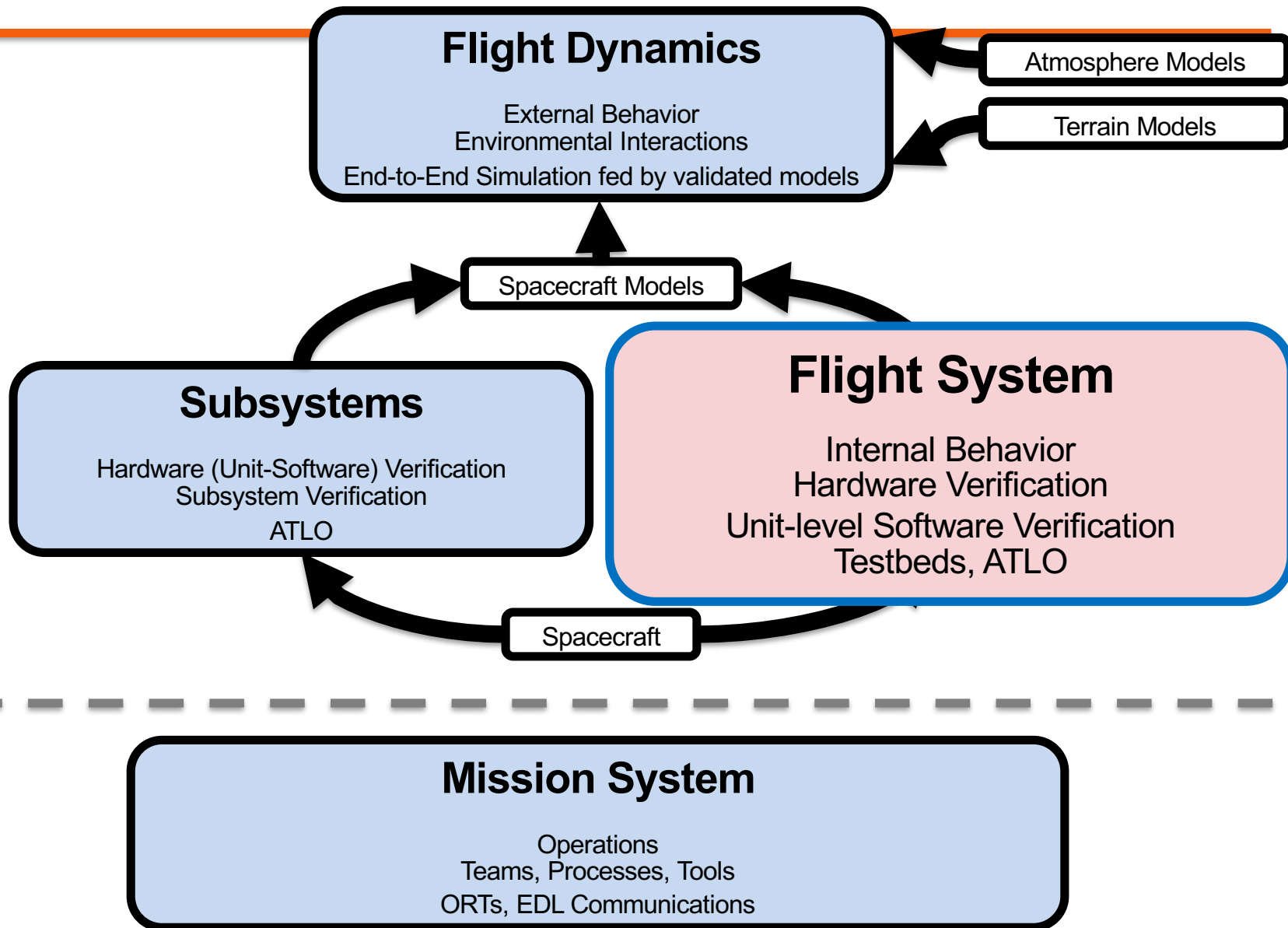
International Planetary Probe Workshop

June 12, 2018

Flight System V&V

- **Based on the heritage MSL V&V program but with some added challenges**

  - ☐ Smaller team to accomplish the testing

  - ☐ Must complete our V&V before Launch so as not to interfere with Surface behavior testing

    - In addition, we must share our testbed venues with the Surface team to help support the new functions under development

  - ☐ New EDL technology which adds complexities and unknowns to our heritage test program

- **To mitigate those challenges**

  - ☐ Decomposed the system into behavioral functions with dedicated owners to drive the planning and testing

  - ☐ Integrated the test plans across the team to create an efficient test campaign within the time and resources we have
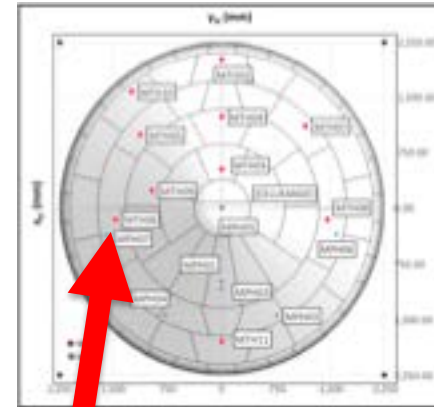
Actuators & MEDLI2

MLE

RCS Thruster

Actuators

EDL propulsive actuators, specifically the Descent Reaction Control System (DRCS) and Mars Lander Engines (MLE) systems.

Heatshield

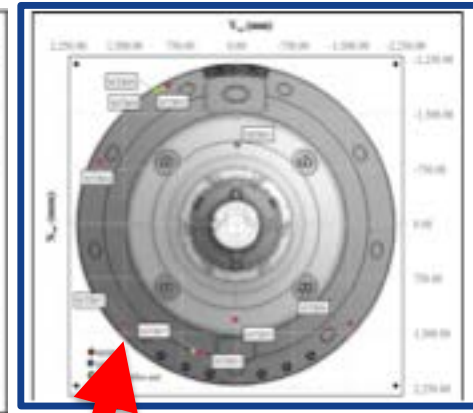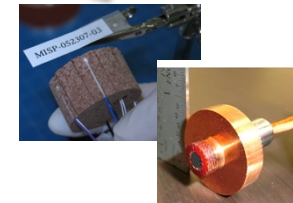**Backshell**

Sensor Plugs

MEDLI2 (Mars EDL Instrumentation 2) *Instrument suite on the heatshield and backshell built upon the heritage MSL MEDLI suite. Analyzes aerothermal, thermal protection, and aerodynamic characteristics of the Entry Vehicle during entry and descent into Mars.*

EDL Cameras

New camera suite that captures imagery of key EDL events to aid in reconstruction activities, inform future EDL engineering design activities, and support public outreach activities.

Parachute Support Structure Up-look
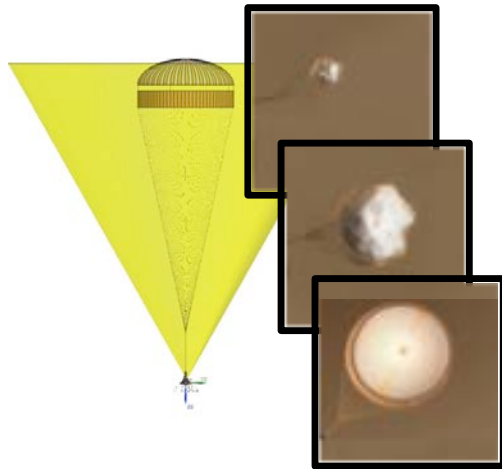
Descent Stage Down-look

Rover Up-look

Rover Down-look
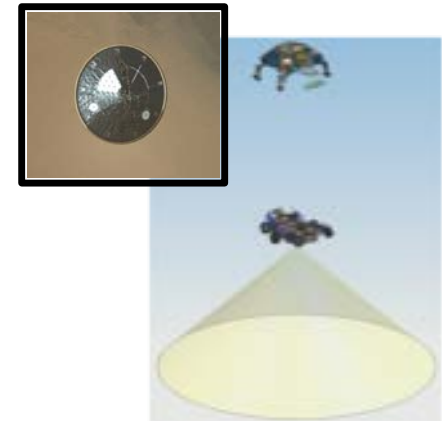
Guidance, Navigation, and Control (GNC) Sensors

Sensors that provide overall position & rate information throughout EDL, specifically the Terminal Descent Sensor (TDS) and the Descent Stage Inertial Measurement Units (DIMU).

New for Mars 2020, the Terrain Relative Navigation (TRN) with Lander Vision System (LVS), a smart sensor subsystem that provides real-time map-relative position, velocity, and attitude estimates

DIMU

TDS

LVS

Surface mission performance based on communication paths shown in red.

CRUISE

EDL UHF to all orbiters TLM: 8 kbps

SURFACE
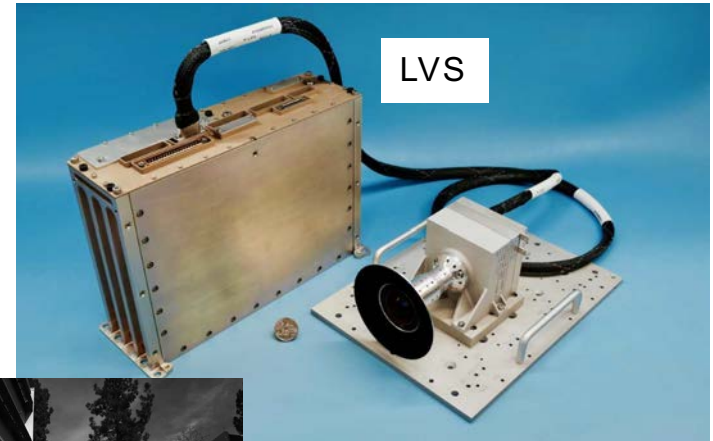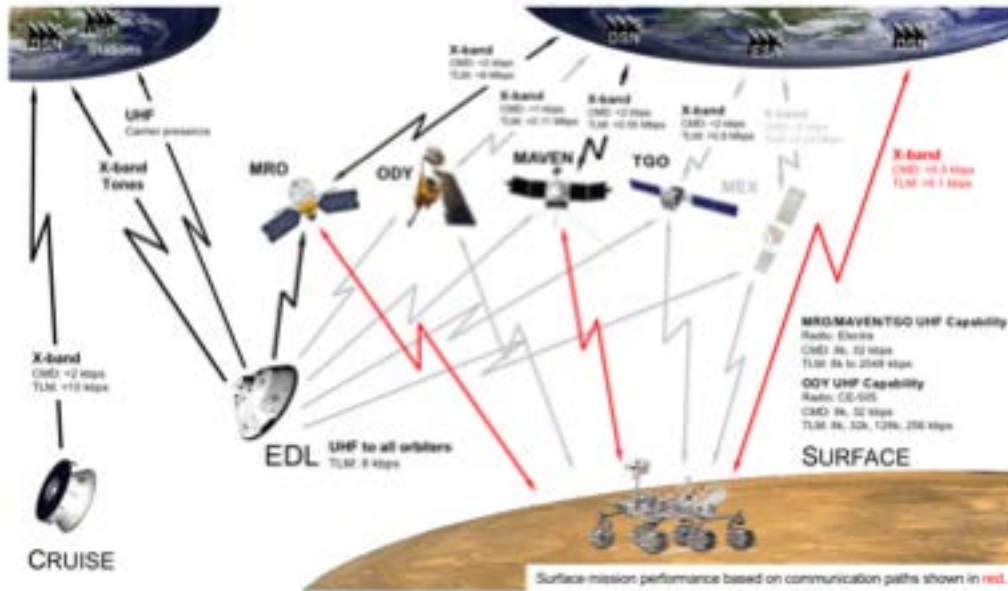
Events and Control

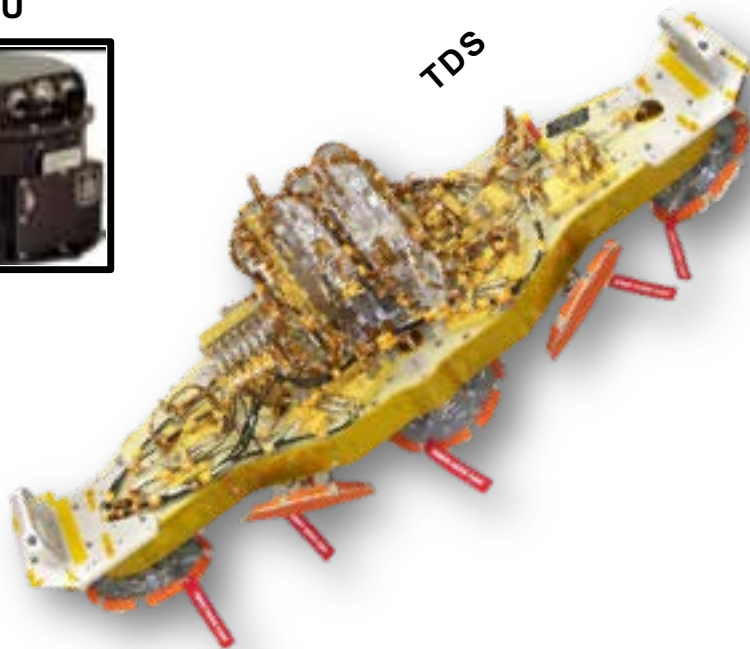*Primary flight software behavior that automates EDL activities using the Timeline, a set of actions or events grouped through on-board timers or GNC calculated triggers.*
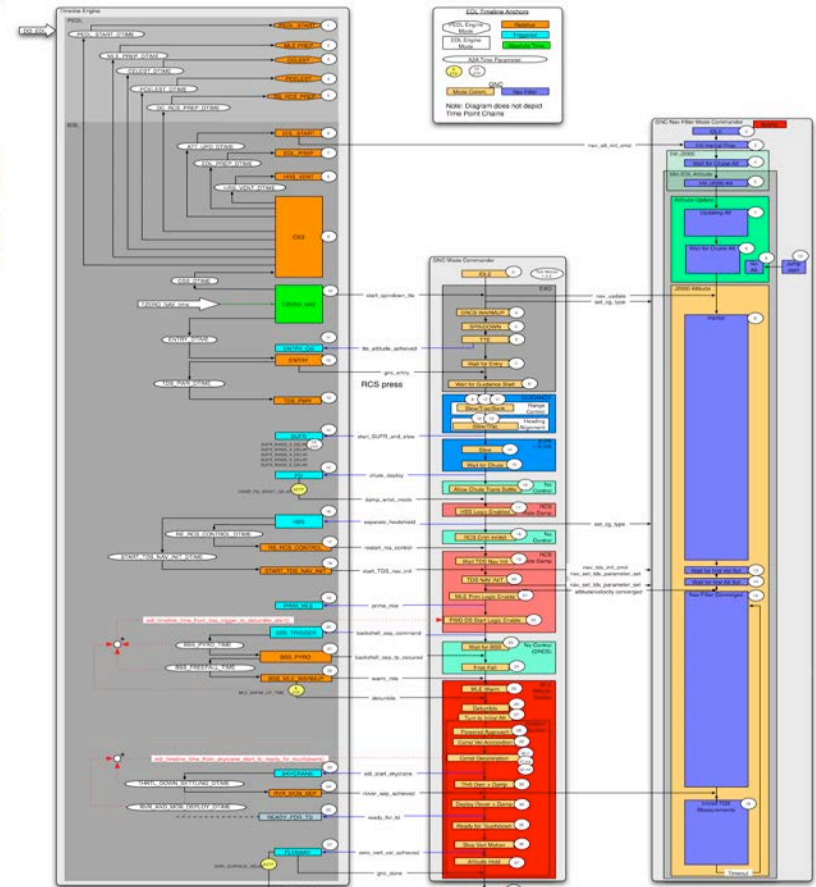
Communications

Provides telemetry to assess the state of the system during EDL, immediately following touchdown, and a recorded data set to provide detailed reconstruction following successful landing on Mars.

Greco, Brugarolas, Serrichio, SanMartin
Jan 2012, v30

Second Chance (SECC) Flight Software
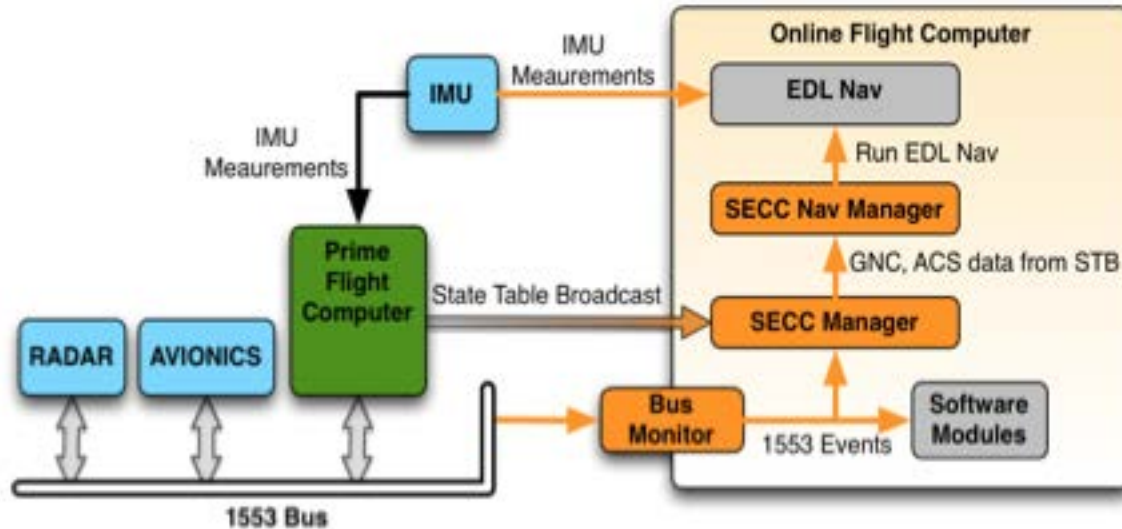
Back up flight software designed for use only during EDL. Takes control and lands the rover in the event of an

unexpected reset on the primary flight software or computer.

Integrated EDL Timeline V&V

L3 EDL FS Verification Activity Groups

Actuators	Cameras	Communications
Events and Control	GNC Sensors	MEDLI2

Remaining Lower Level Testing

Test Case (1)
Test Case (2)
Test Case (3)

Test Case (1)
Test Case (2)
Test Case (3)

Test Case (1)
Test Case (2)
Test Case (3)

Test Case (1)
Test Case (2)
Test Case (3)

...

Second Chance Test

Dual-String Computers, cause a computer fault during Parachute Deploy and confirm the backup software takes over and lands.

EDL FSW Test

In a hardware test venue, run EDL Main test with all non-critical devices marked sick. Should still land nominally.

Stress & Robustness Test

In a software venue, make devices talk during flyaway and confirm it doesn't impact flight software.

EDL FSW Test (1)
Test Case (1)
Test Case (2)
Test Case (2)

EDL FSW Test (2)
Test Case (1)
Test Case (3)
Test Case (1)

EDL FSW Test (3)
Test Case (2)
Test Case (1)
Test Case (2)

EDL FSW Test (4)
Test Case (2)
Test Case (1)
Test Case (3)

...

Stress & Robustness Test (1)
Test Case (11)
Test Case (12)
Test Case (15)

...

Second Chance FSW Test (1)
Test Case (5)
Test Case (6)
Test Case (2)

Second Chance FSW Test (2)
Test Case (8)
Test Case (4)

...

Roadmap to Launch

- **To Date**

  ☐ Inherited the Software and Engineering Hardware Test Venues from MSL

  ☐ Updated inherited EDL post-processing scripts which were developed late on MSL

  ☐ Conducted development testing on our initial flight software builds

- **Upcoming**

  ☐ Primary V&V campaign has begun and will be complete by December 2018

  ☐ System level tests with flight hardware will begin January 2019 and continue through the end of the year

  ☐ Stress and Robustness testing will begin in 2019 and continue until Launch

  ☐ Launch in July 2020

  ☐ Landing in February 2021