

# Thermal Design of the Sample Handling Assembly in the Sampling and Caching Subsystem on the Mars 2020 Rover

ICES-2019-28



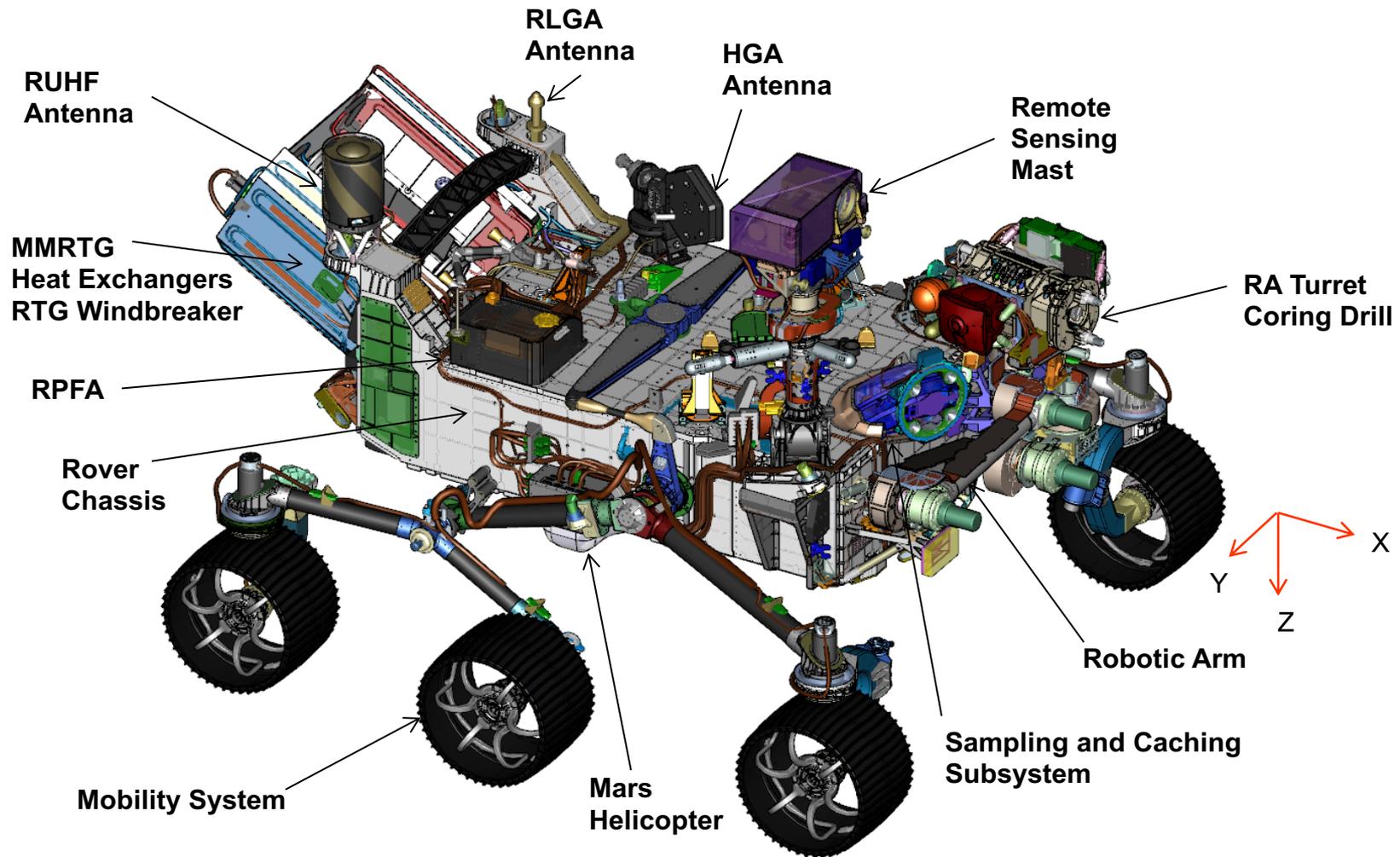
**Mars 2020 Rover gets its  
wheels! Photo Credit:  
NASA/JPL-Caltech**

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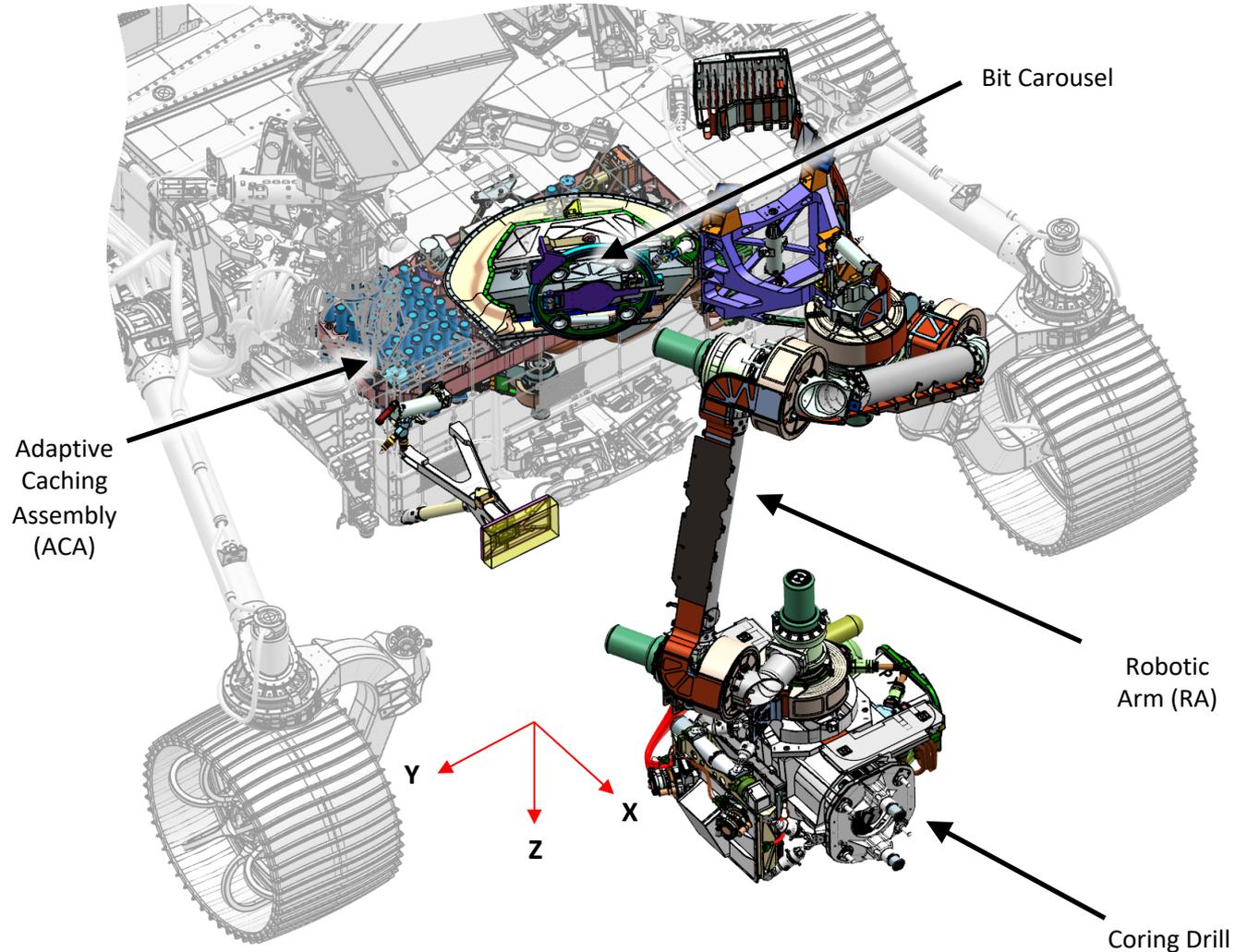


International Conference on Environmental Systems,  
Boston, MA 2019

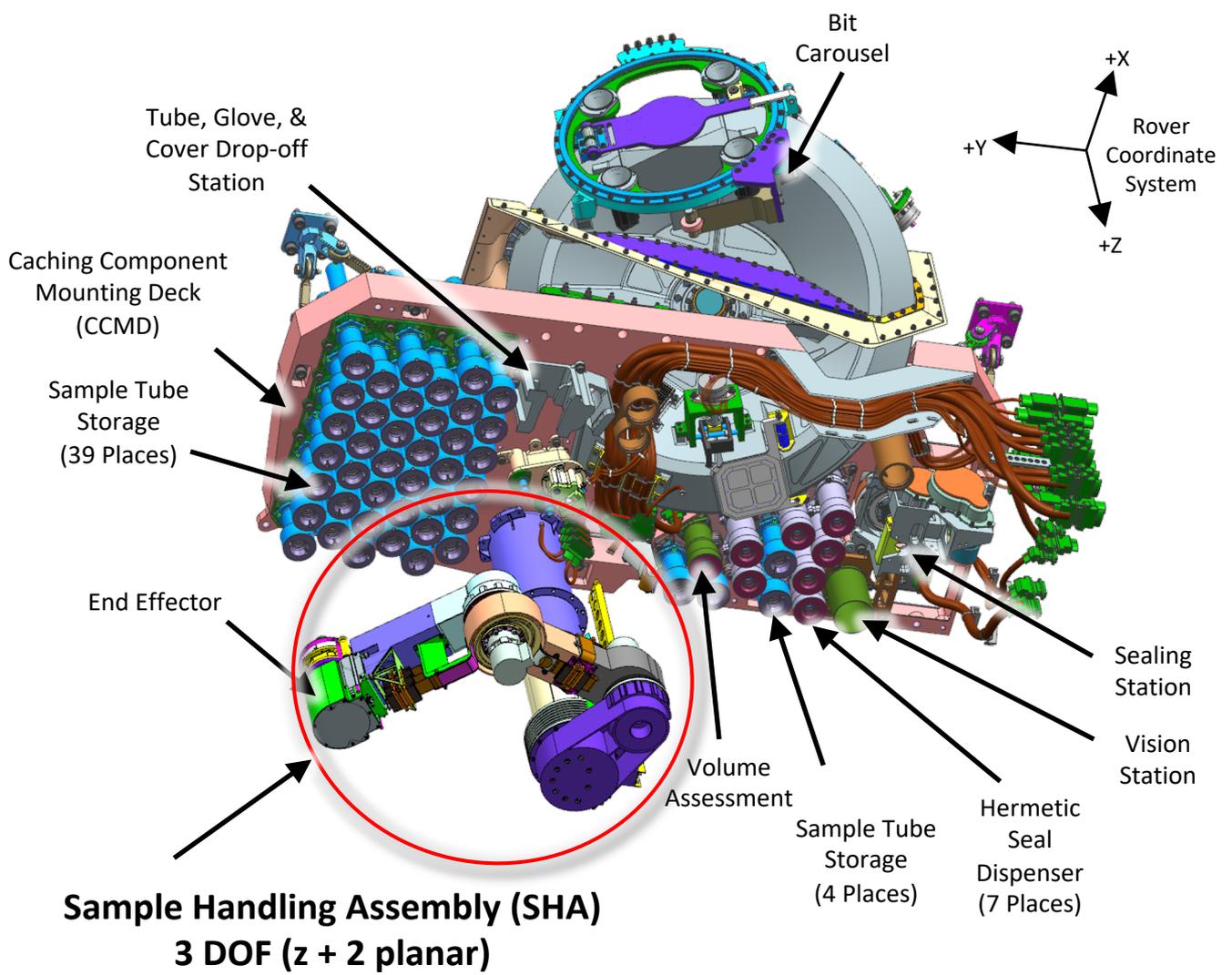
# Mars 2020 Rover Overview



# Sample Caching Subsystem (SCS) Elements



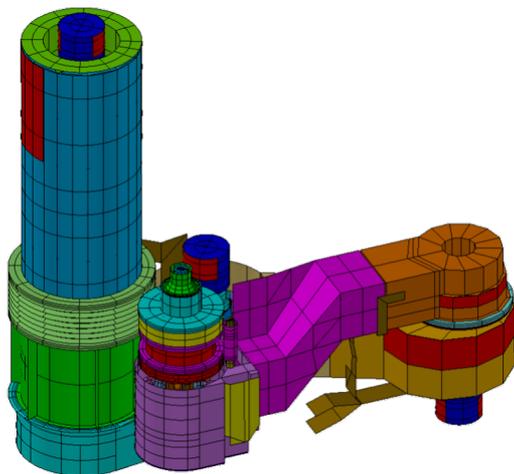
# Adaptive Caching Assembly (ACA) Elements



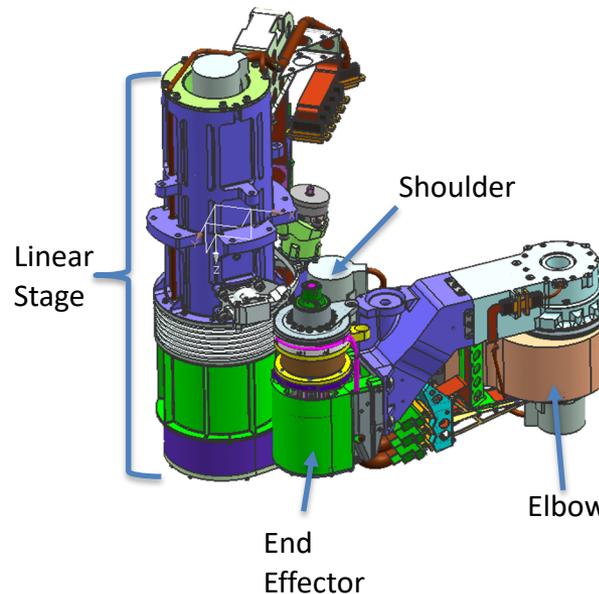
# Temperature Requirements

| SHA & End Effector Hardware                                 | Temperature, °C         |     |                |     |
|---|-------------------------|-----|----------------|-----|
|   | Allowable Flight Limits |     |                |     |
|   | Operational             |     | Nonoperational |     |
|   | min                     | max | min            | max |
| SHA Linear Stage Mechanism (Slider, Lead Screw, Bearing)    | -55                     | 50  | -128           | 50  |
| SHA Linear Actuator (Motor and Gearbox)                     | -55                     | 50  | -128           | 50  |
| SHA Shoulder Actuator (Motor, Gearbox, and Output Assembly) | -55                     | 50  | -128           | 50  |
| SHA Elbow Actuator (Motor, Gearbox, and Output Assembly)    | -55                     | 50  | -128           | 50  |
| SHA End Effector Tube Gripper Actuator (Motor and Gearbox)  | -55                     | 50  | -128           | 50  |
| SHA End Effector Gripper Mechanism                          | -25                     | 50  | -128           | 50  |
| SHA End Effector Force/Torque Sensor                        | -90                     | 50  | -128           | 50  |
| SHA Flex & Round-wire Harness - across rotating joints      | -95                     | 50  | -128           | 50  |

- Non-operational values driven by environmental temperatures
- Operational values driven by lubricant viscosity
  - Heat-to-use



SHA Thermal Model

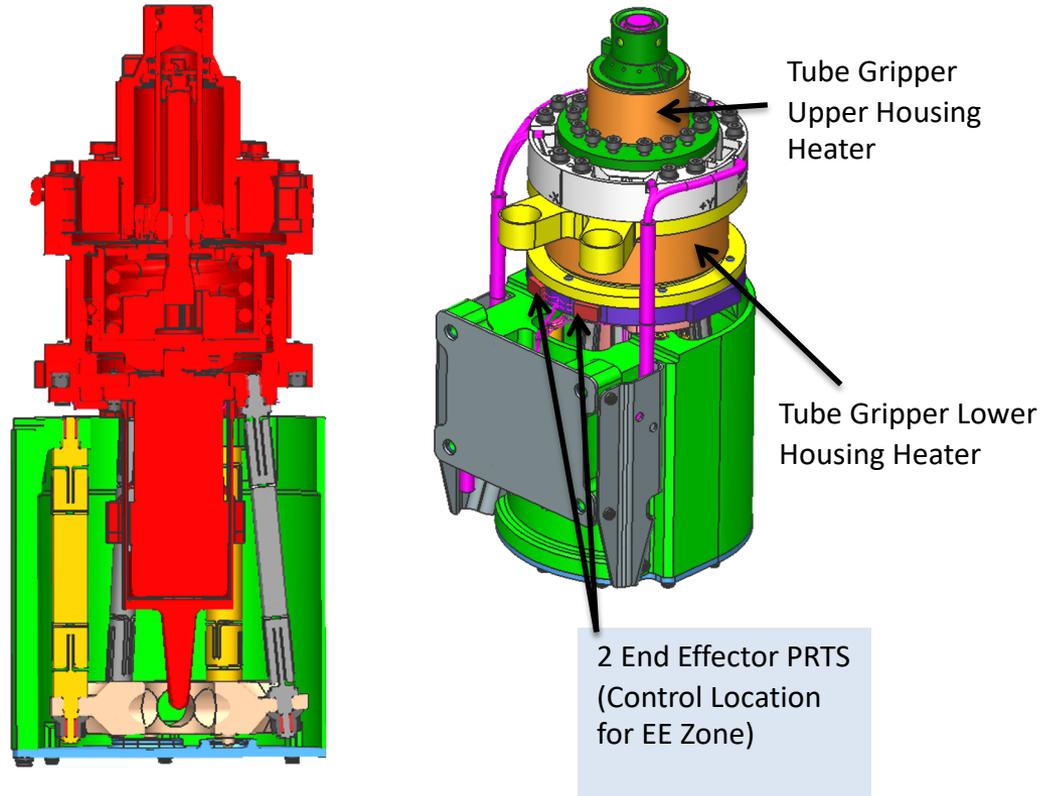


SHA CAD Model



# Thermal Hardware Overview

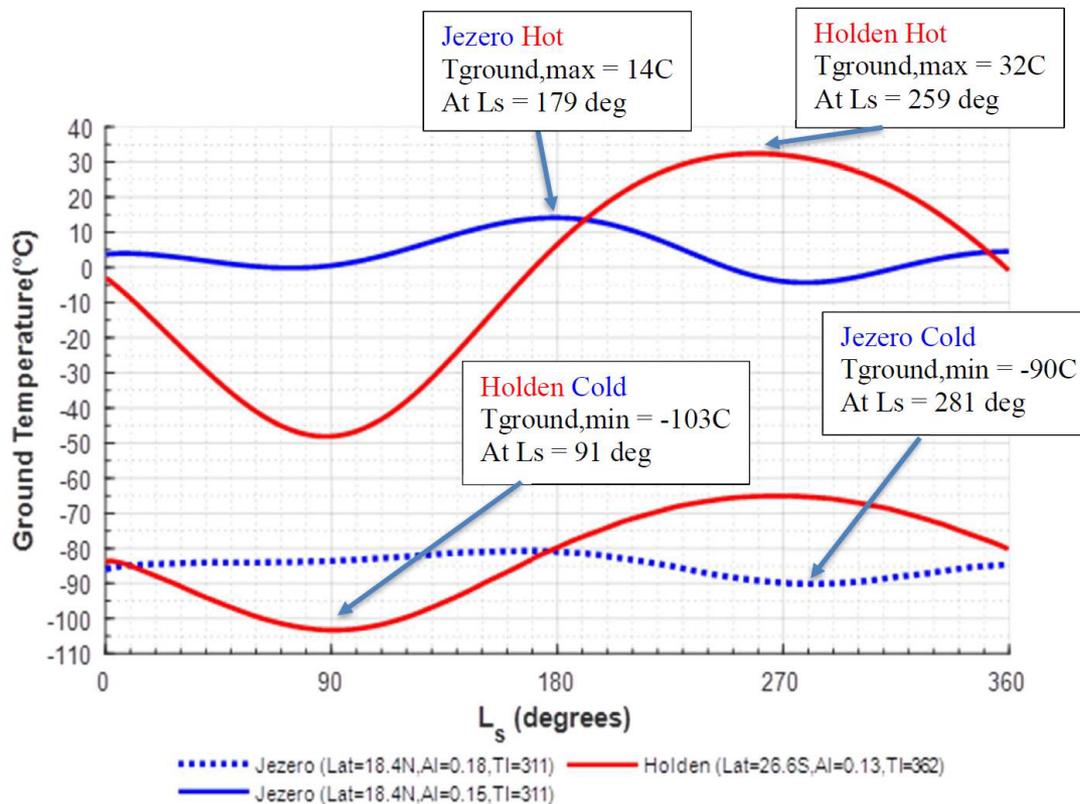
- Thermal hardware applications:
  - Heater control
  - Fault Protection
  - Information
- Single string heaters with switch redundancy and redundant PRTs
  - Flex cable trace limitations led to acceptable of single string heaters
- Complete SHA thermal hardware locations shown in paper
  - 18 Heaters (88 W)
  - 14 PRTs



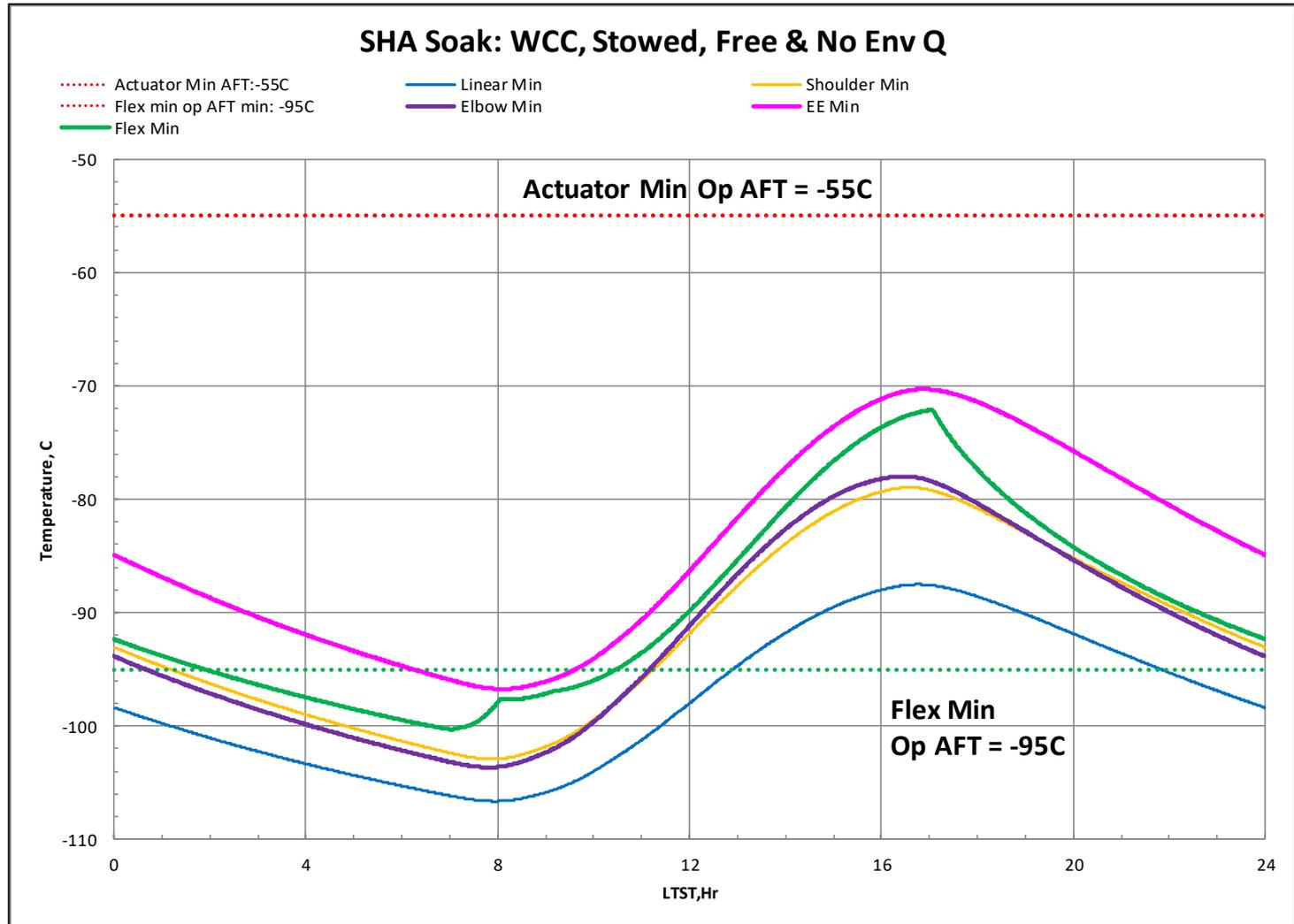
End Effector Thermal Hardware Locations

# Thermal Environment Overview

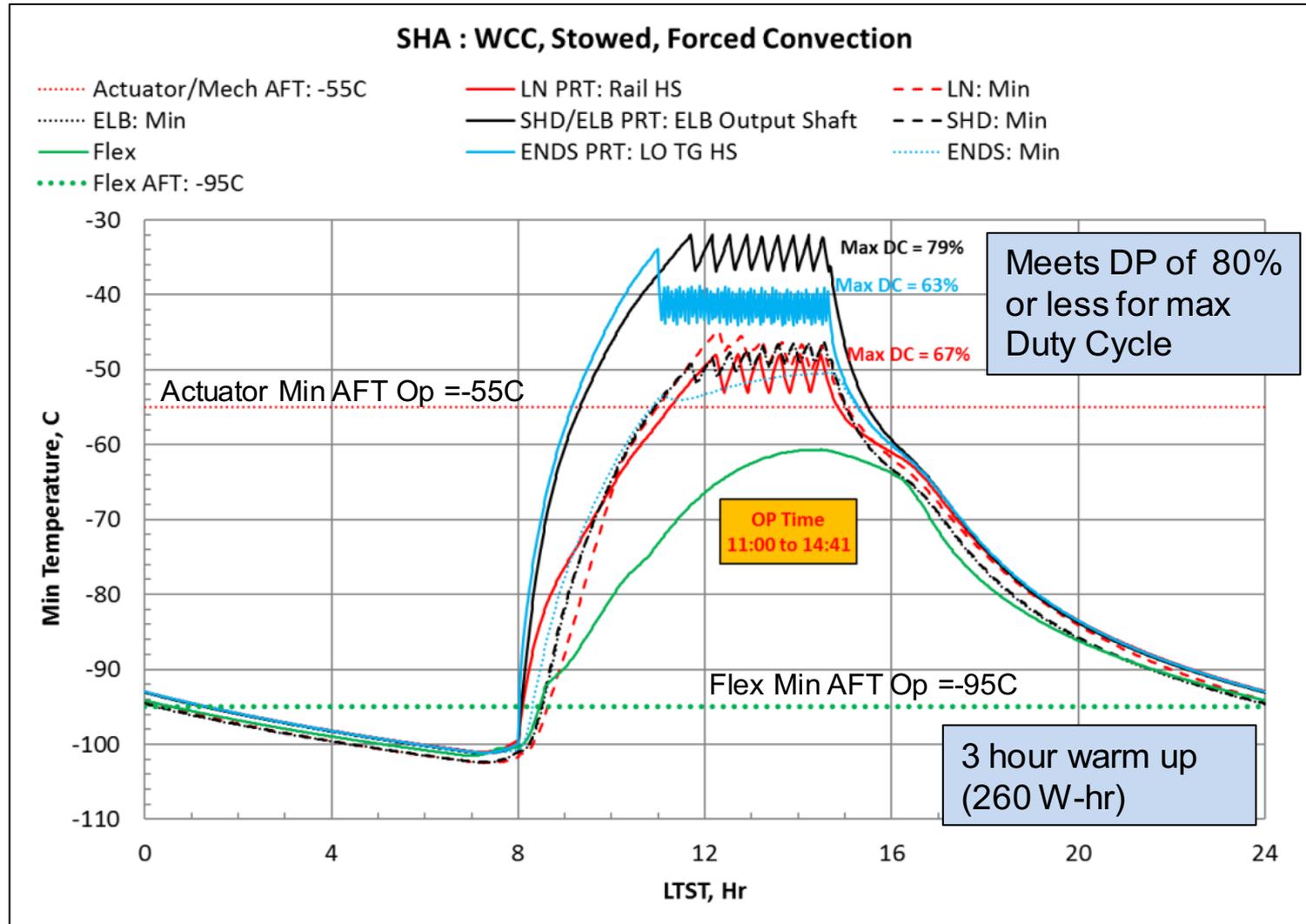
- Paper focuses on temperature predictions at Holden Crater (26.4° S), the worst case thermal potential landing site for the initial thermal design
  - Jezero Crater (18.5° N) selected as the final landing site



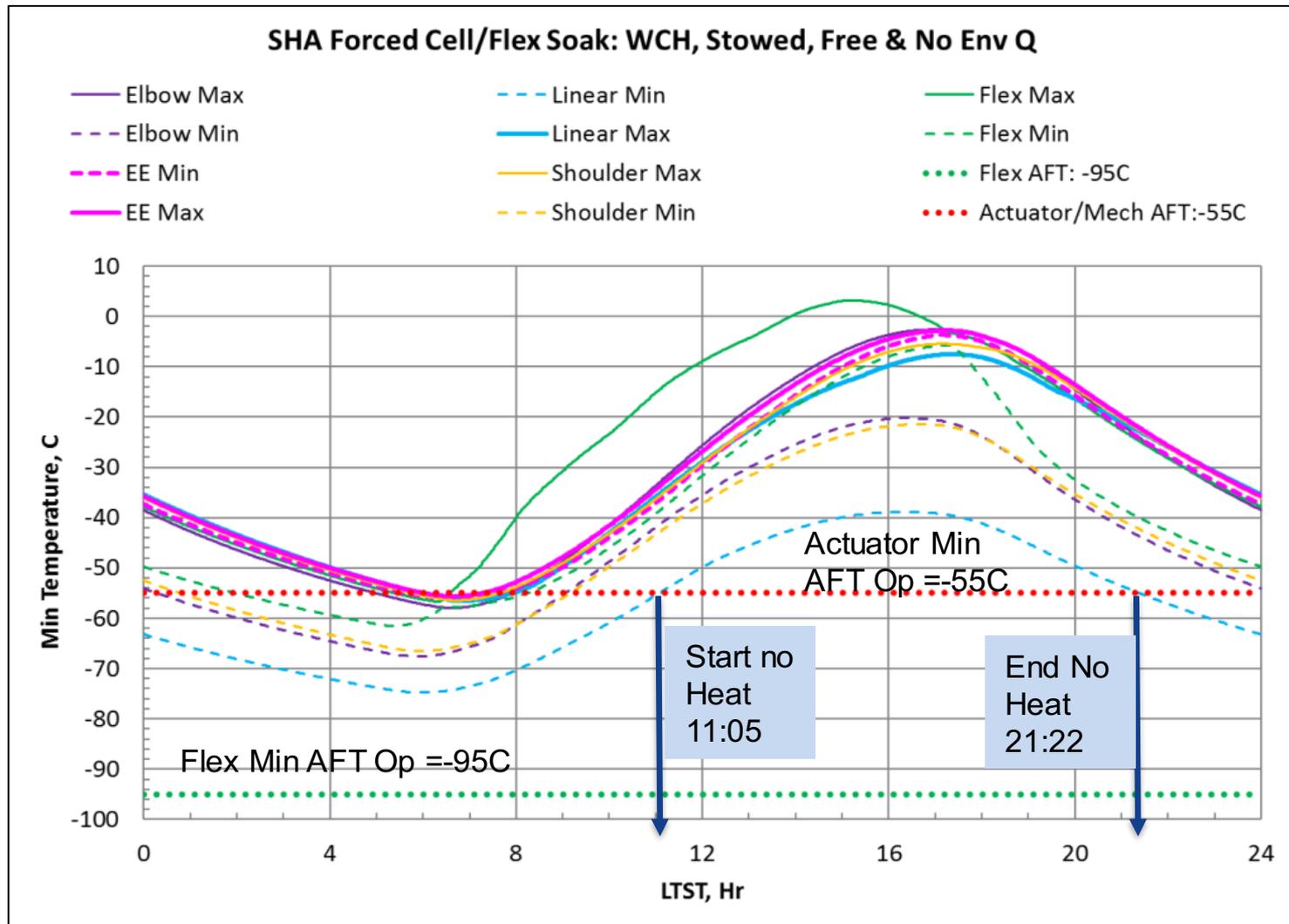
# Cold Soak Predictions



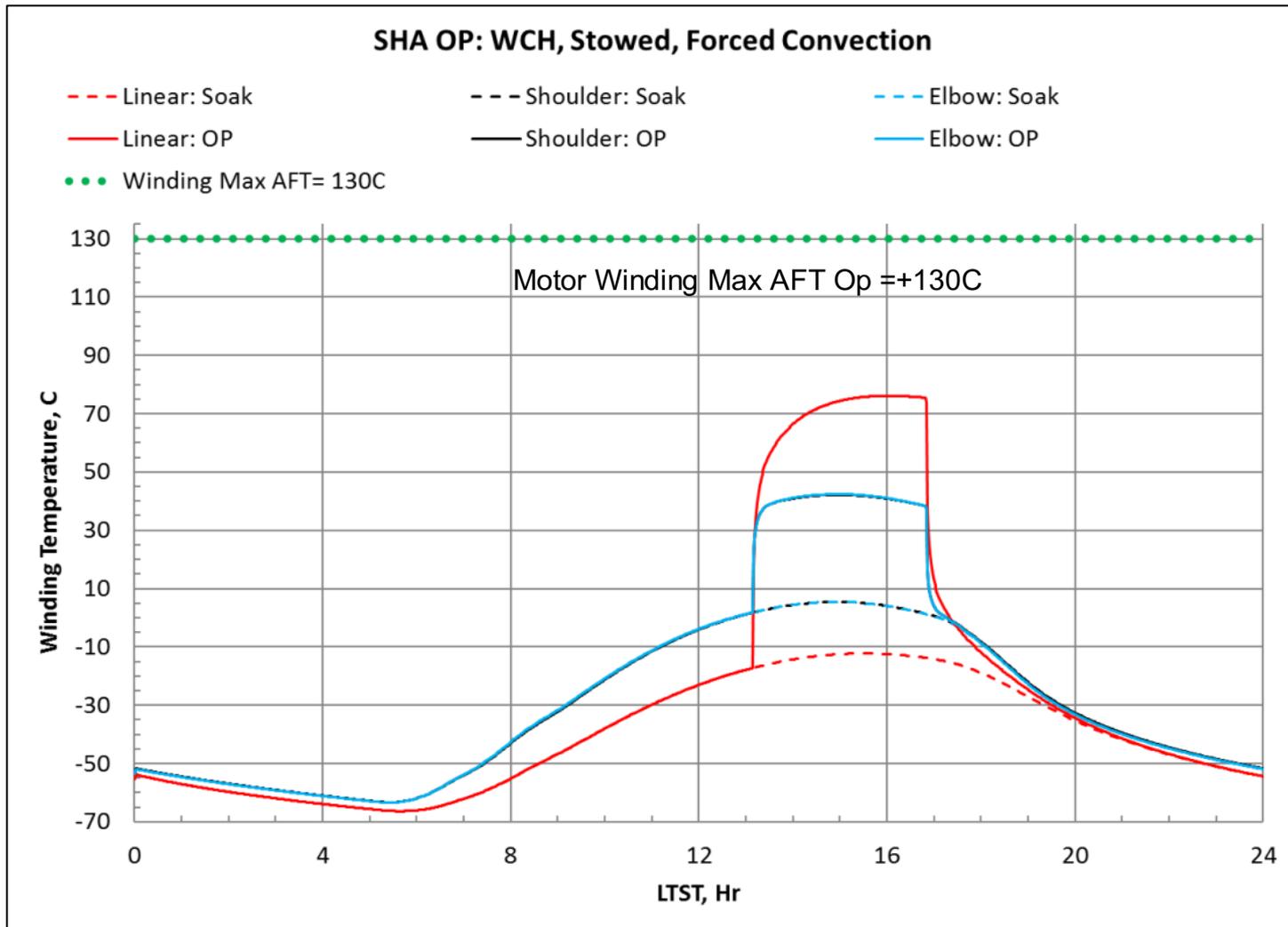
# Cold Predictions with Heater Control



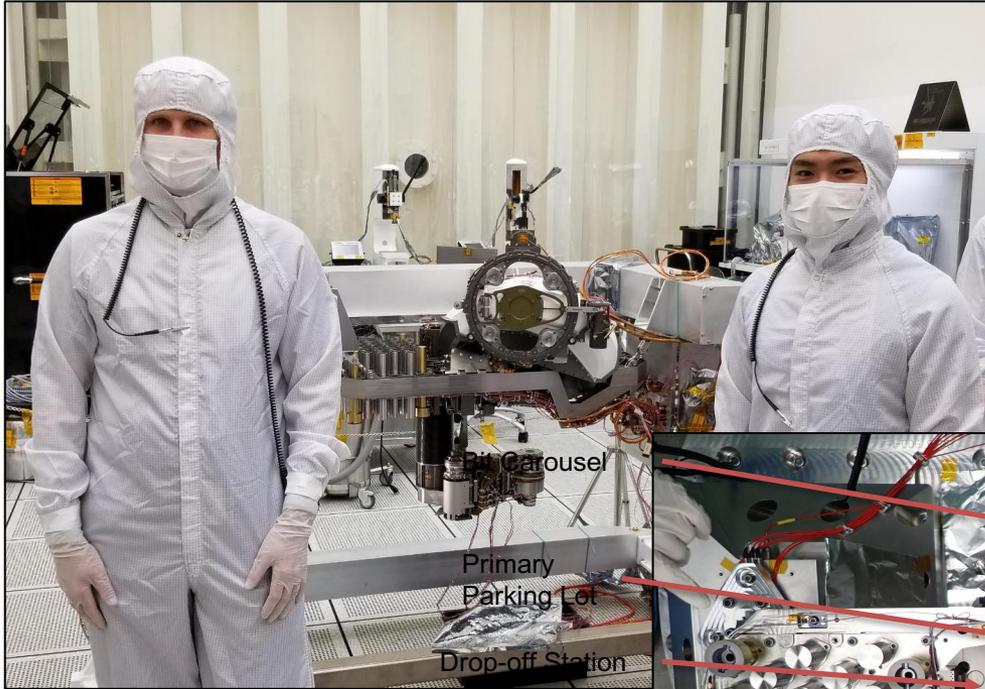
# Hot Soak Predictions



# Hot Operation Predictions



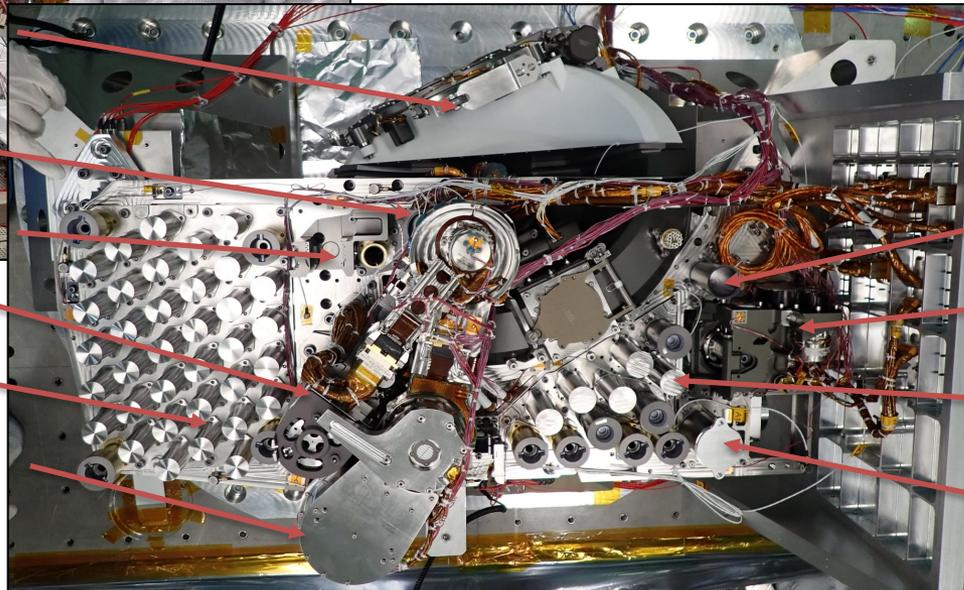
# Recent Build Images



**Thermal Engineers Jason Kempenaar and Takuro Daimaru with the Assembled Hardware**

Pit Carousel  
Primary Parking Lot  
Drop-off Station

End Effector  
STSA (AFM)  
Sample Handling Arm



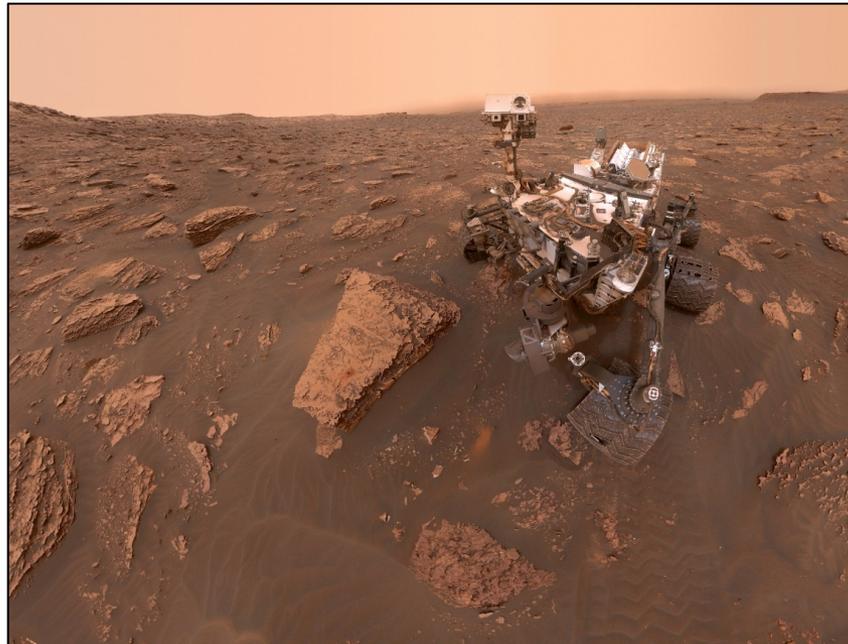
Spare Parking Lot  
Sealing Station  
DVT (AFM)  
Vision Station (mass model)

**Hardware Closeup prior to TVAC**



# Conclusions

- A robust thermal design provides the capability to adapt during the mission
- As the Jezero Crater landing site is more benign than Holden Crater, the thermal design will perform even better (with larger margins) during Mars 2020 surface operations.



**Curiosity Selfie in Sol 2082 Dust Storm – Gale Crater**

# Acknowledgements

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