



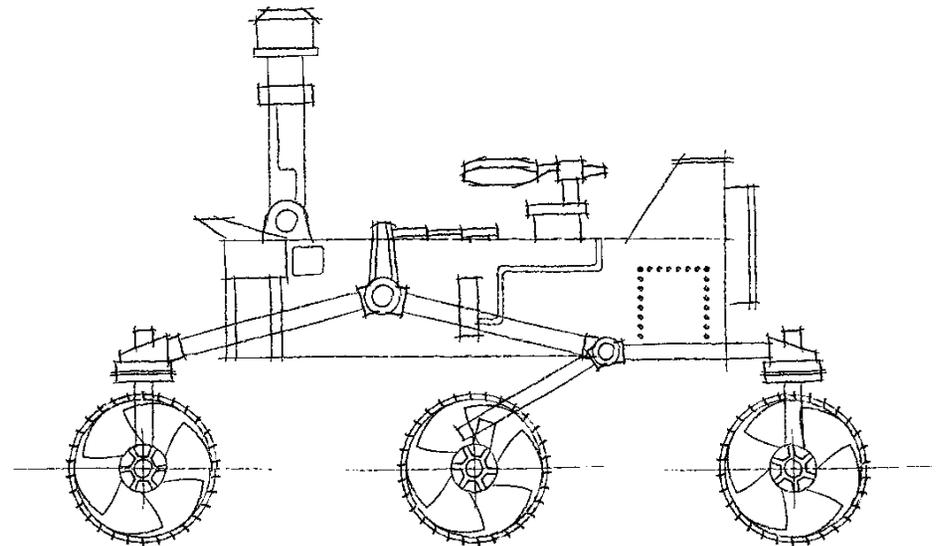
45th International Conference on
Environmental Systems



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Preliminary Surface Thermal Design of the Mars 2020 Rover

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Mars 2020 Project

Hilton Bellevue, Bellevue, WA

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Mission Timeline



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MISSION TIMELINE



LAUNCH

- Atlas V
- Period: Jul/Aug 2020

CRUISE/APPROACH

- 7-month cruise
- Arrive Feb. 19, 2021
- No changes from MSL (equivalent checkout capability, etc.)

ENTRY, DESCENT & LANDING

- MSL EDL system: guided entry and powered descent/Sky Crane
- 25 x 20 km landing ellipse*
- Access to landing sites $\pm 30^\circ$ latitude, ≤ 0 km elevation*
- ~950 kg rover
- Technology enhancements under consideration

SURFACE MISSION

- Prime mission is one Mars year (669 days)
- Latitude-independent and long-lived power source
- Ability to drive out of landing ellipse
- Direct (uplink/downlink) and relayed (downlink) communication
- Fast CPU and large data storage

* EDL in work

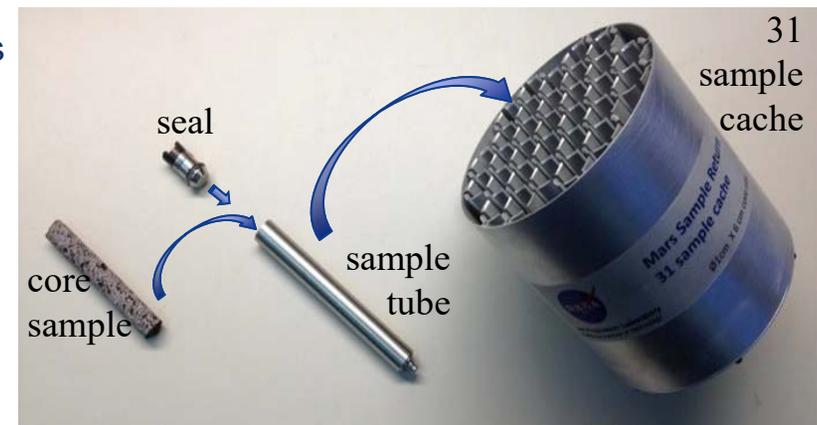
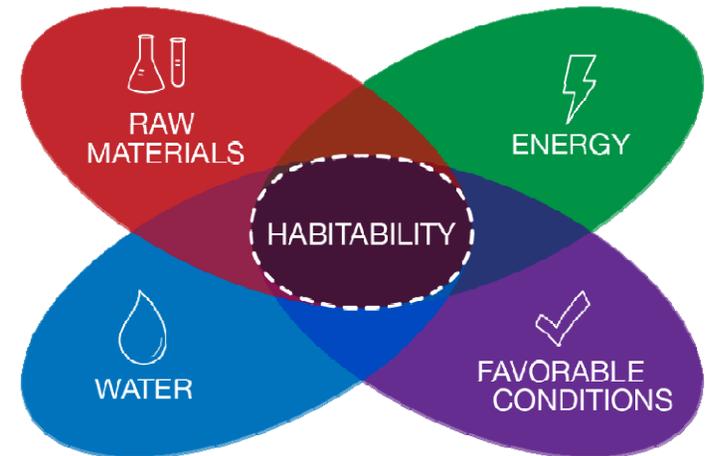
M2020 Science Objectives



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- **Examine Geological Record & Assess Habitability**
 - Today's Martian climate is challenging for life, but it wasn't always
 - Mars has abundant evidence for ancient water
- **Search for Potential Evidence of Past Life**
 - The Mars 2020 rover would begin a search for signs of past life on Mars and enable the possible future return of the most promising samples to Earth
- **Capture rock & regolith samples for possible future return to Earth**
 - Mars 2020 would enable an enormous leap in Mars science by capturing compelling rock and soil samples in tubes for later analysis using the full power of the world's laboratory capabilities
- **Prepare for Human Exploration**
 - carry instruments to test technologies related to the eventual human exploration of Mars



M2020 Science Instruments



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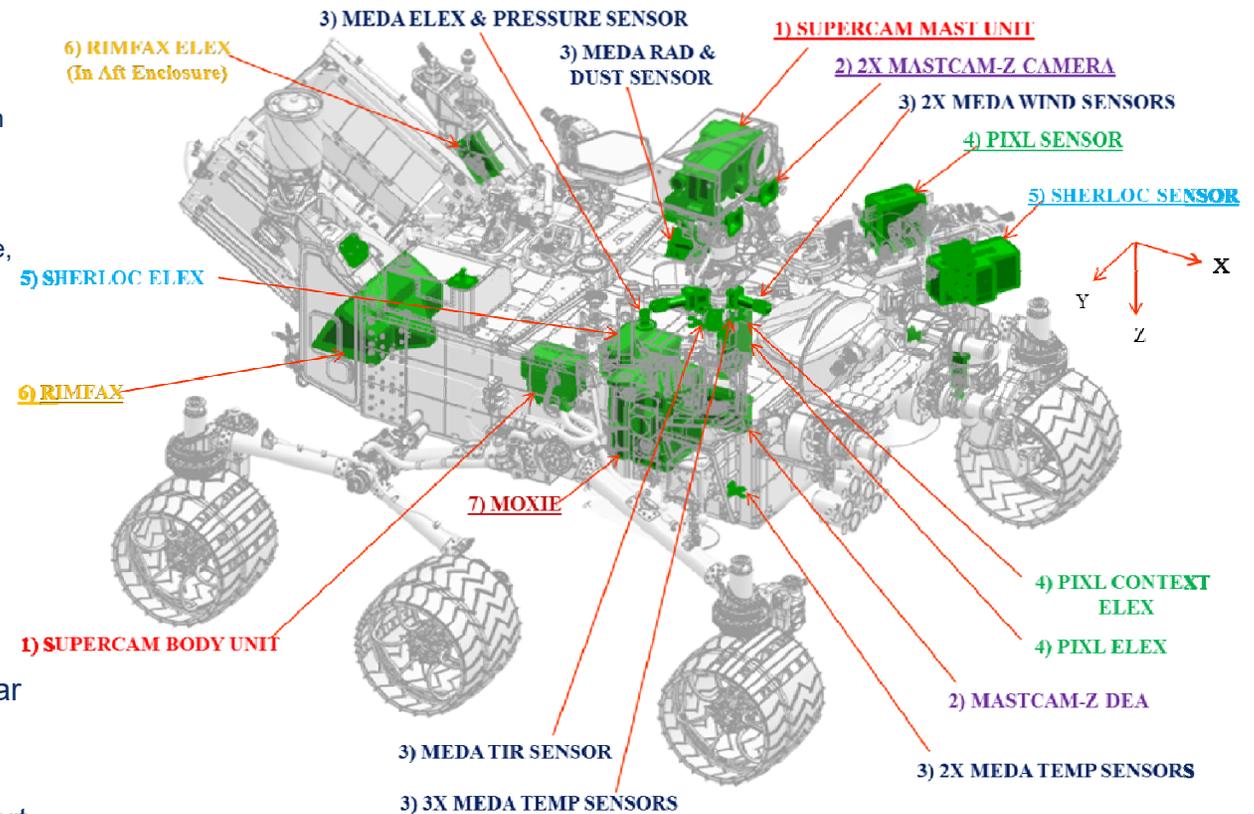
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Enhanced MSL instruments

- **SuperCam** - Like ChemCam
 - LIBS instrument with Raman spec.
- **Mastcam-Z** - Like MastCam
 - Visible imager with zoom function
- **MEDA** - Like REMS
 - Weather Station with temperature, humidity, wind, & dust sensors

New Instruments

- **PIXL** - X-ray fluorescence spectrometer - mineralogy
- **SHERLOC** - UV Raman spectrometer - organics
- **RIMFAX** - ground penetrating radar - subsurface geologic structure
- **MOXIE** - ISRU tech demo - convert CO₂ to O₂ - support future human mission to Mars



M2020 Rover Similar to MSL



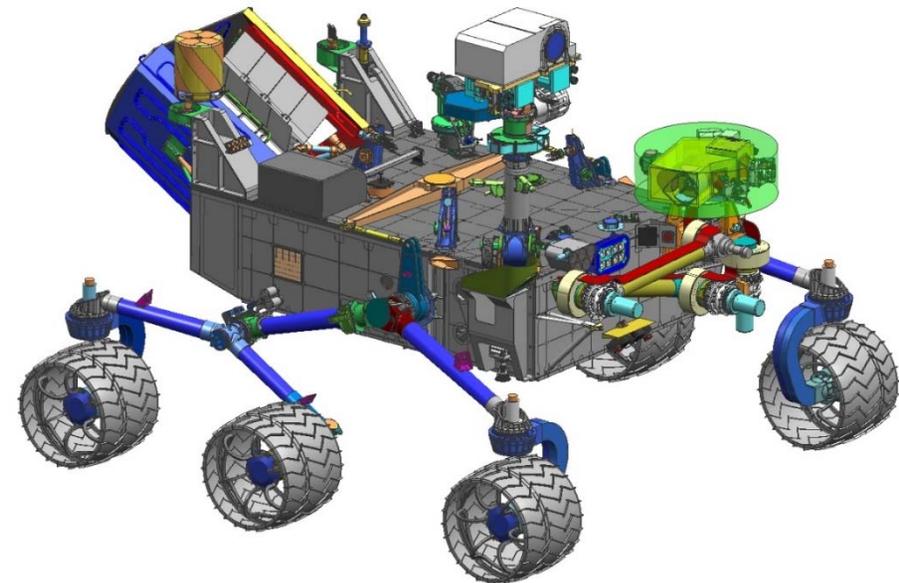
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- Same Launch & EDL system
 - Same mass (~950 kg) & volume constraints (fit in aeroshell)
- Same RTG Power system
 - Same power (~110 W at BOL) and energy constraints
- Same Avionics & Telecom System



M2020 Rover



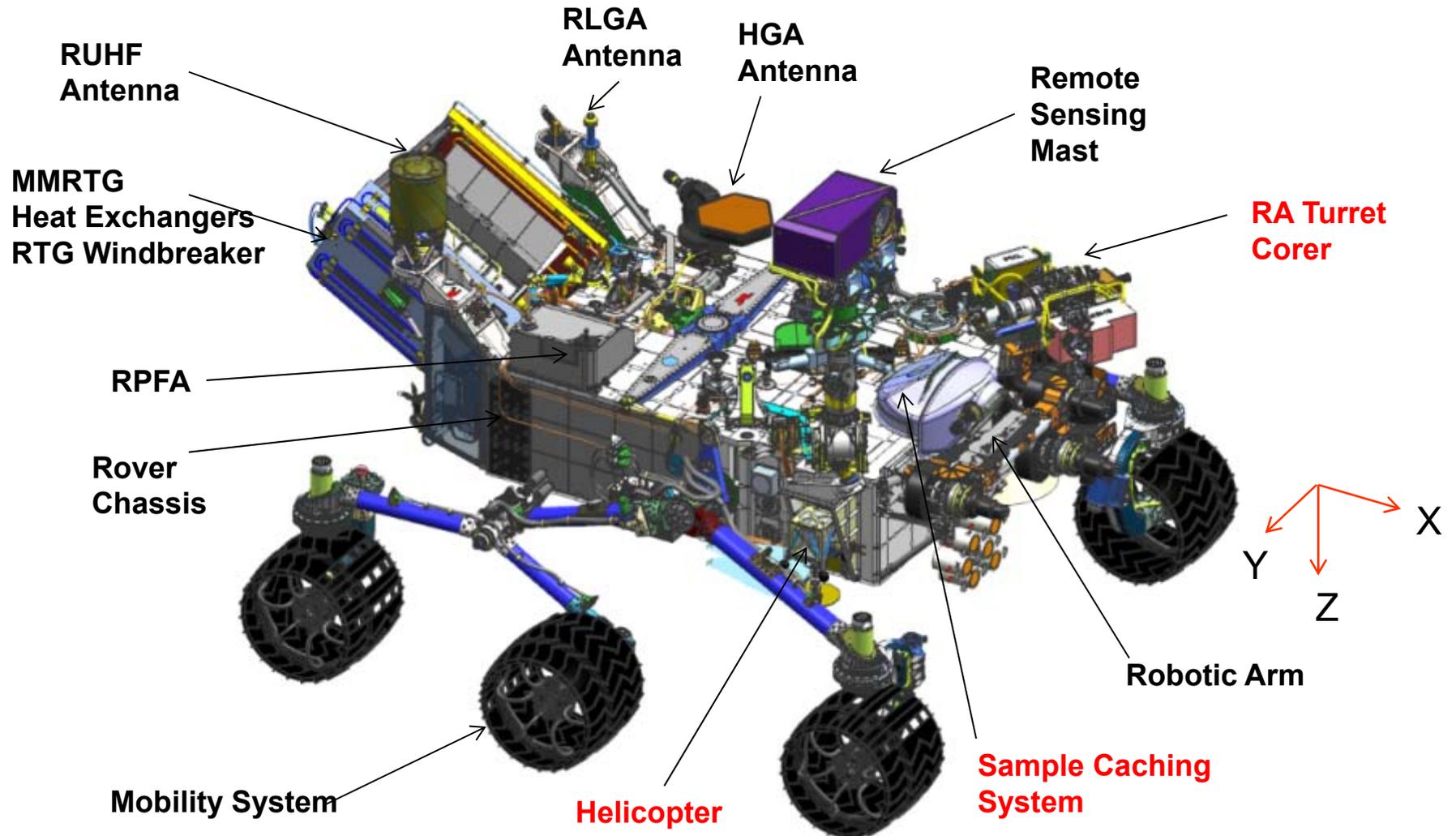
MSL Rover - Curiosity

M2020 Rover - Overview



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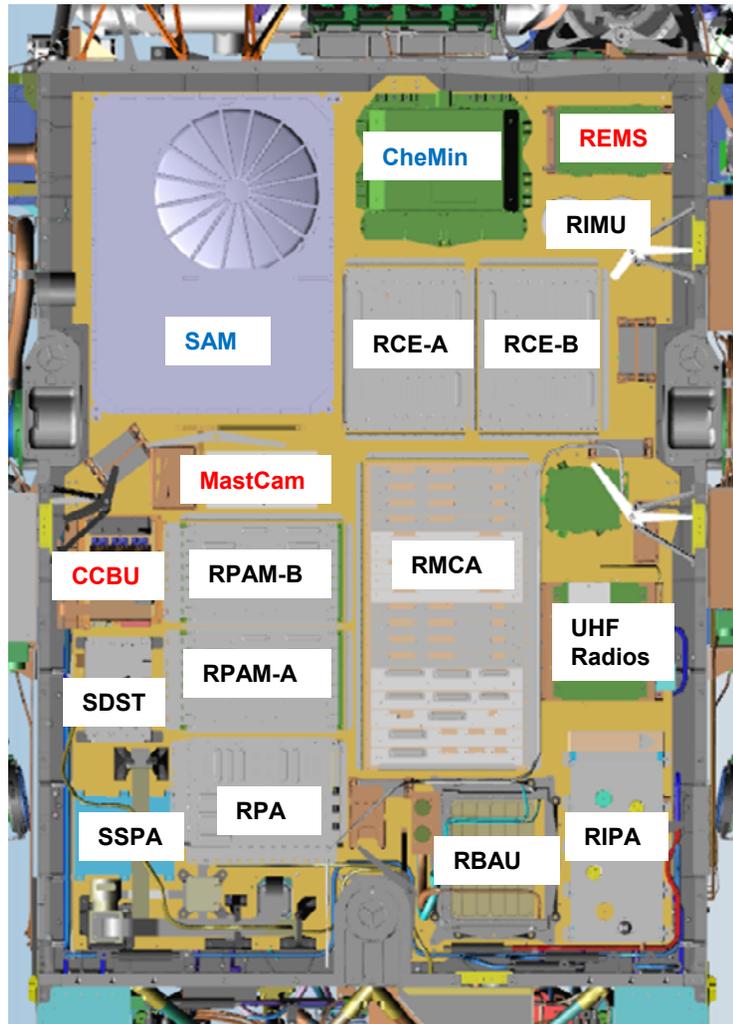
RAMP Layout - MSL vs M2020



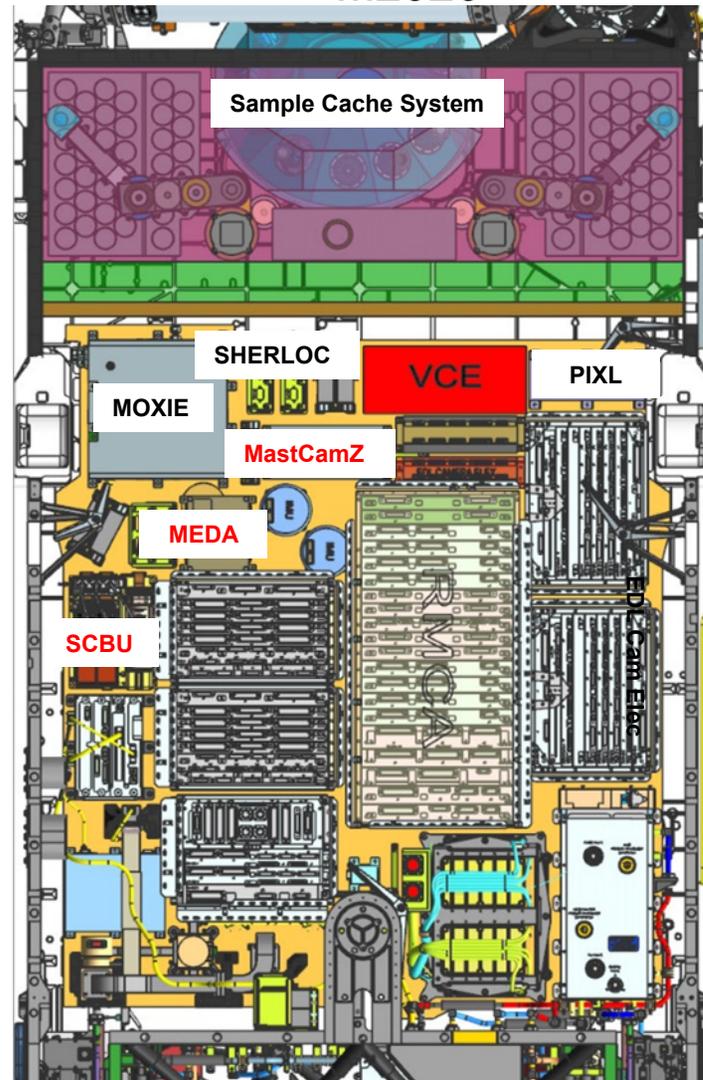
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MSL



M2020



- Chassis extended 50 mm in front and 69 mm in rear
- UHF Radios, RIMFAX & Helicopter Electronics to Aft Towers

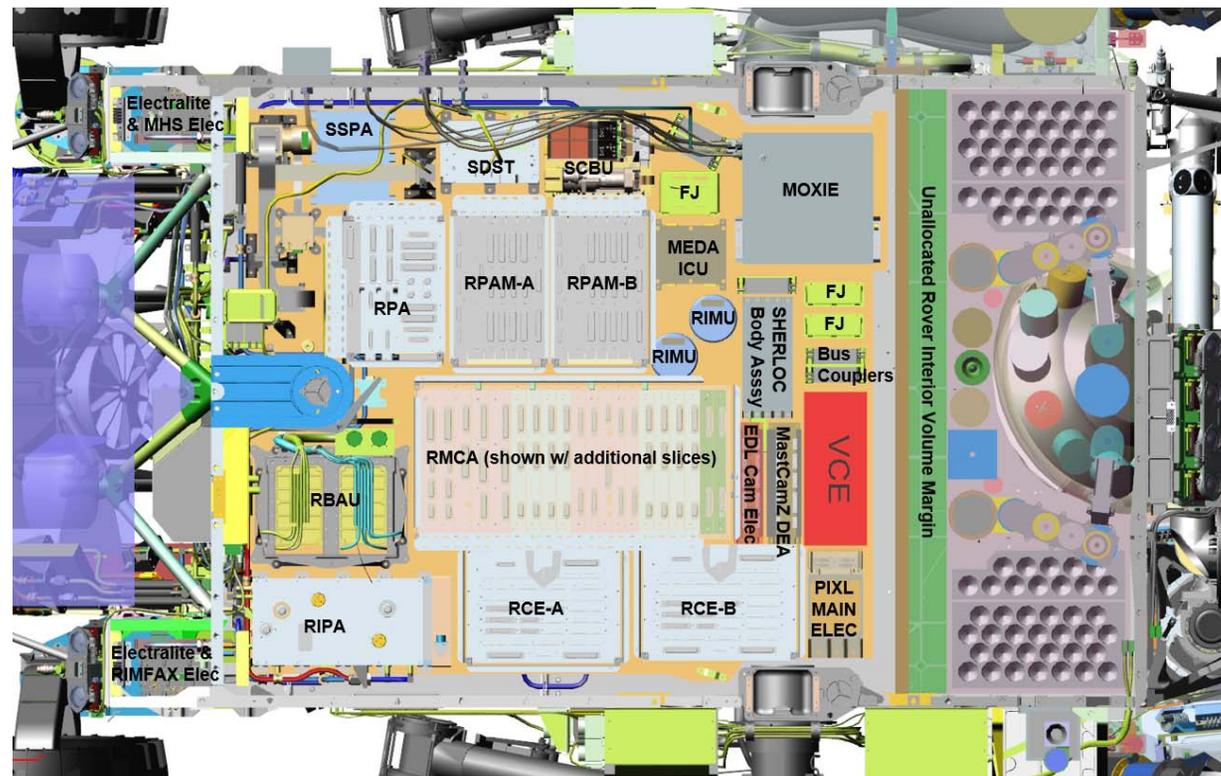
M2020 RAMP Thermal Control



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- Sensitive electronics with AFT range of -40C to +50C
- Boxes thermally coupled to Rover Avionics Mounting Panel (RAMP)
- RAMP temps controlled by Heat Rejection System (HRS) fluid loop
 - Delivers heat from MMRTG to keep RAMP warm at night
 - Rejects heat from radiator surfaces to keep RAMP cool during day

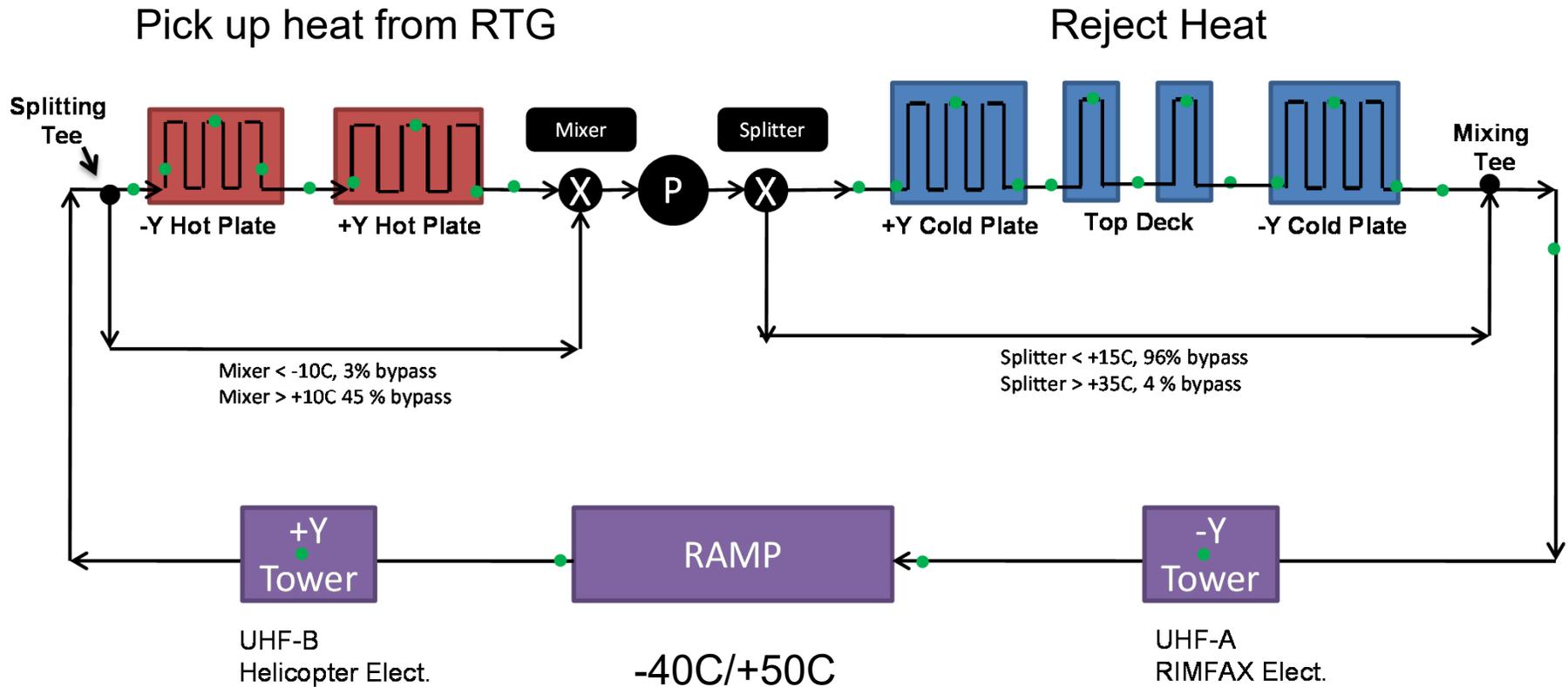


M2020 HRS System Schematic



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M2020 External Thermal Control



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- Most hardware items survive external environment with no survival heaters
 - Survival heaters consume energy
 - Non-op Allowable Flight Temperature (AFT) limits = -128C to +50C
 - Notable exceptions are SuperCam Mast Unit, SHERLOC & PIXL
- External actuators and cameras equipped with warm-up heaters
 - 3 science cameras & 14 engineering cameras
 - 37 electric motor driven actuators (includes SCS)
 - Must be warmed above op AFT limits (-55C to -40C) prior to use



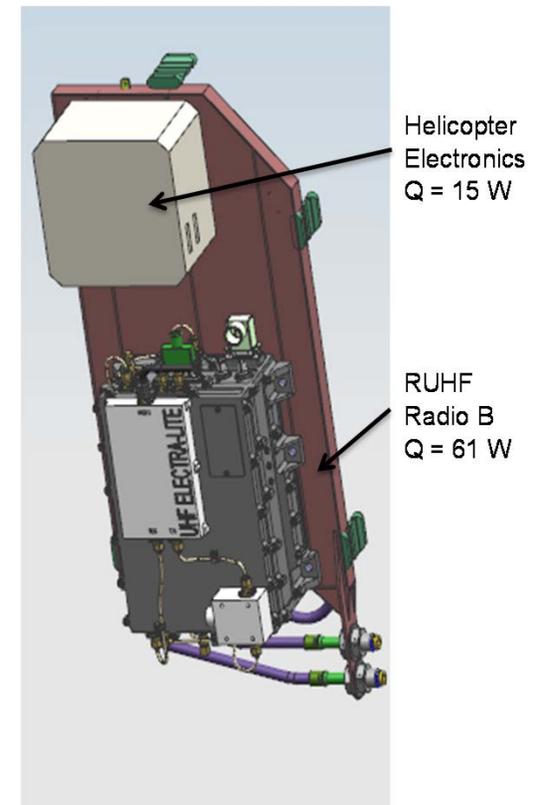
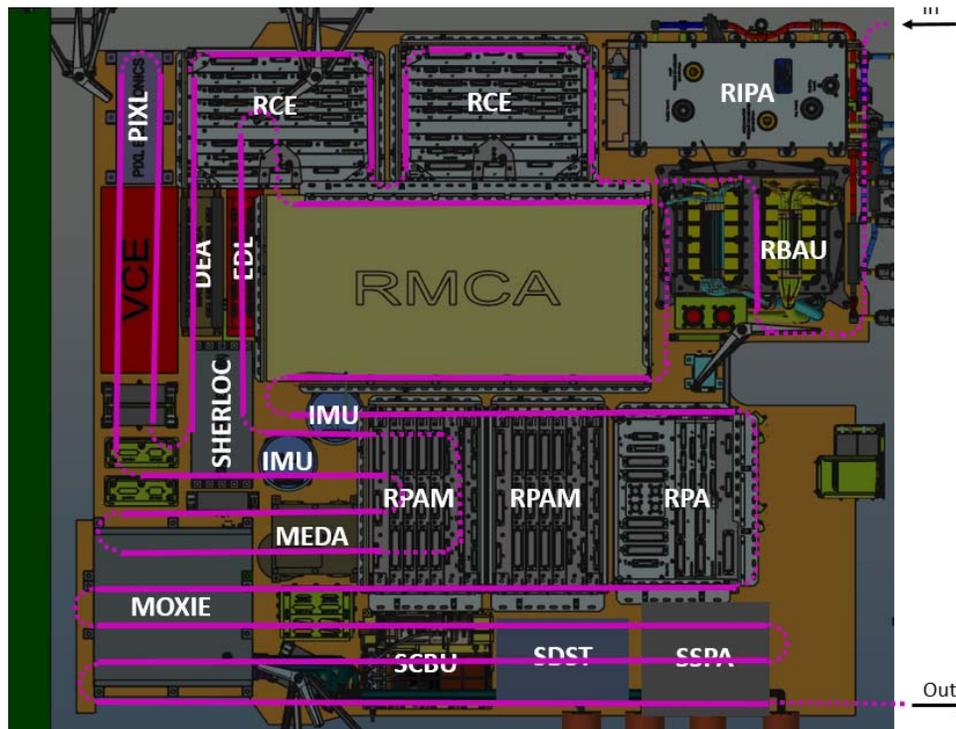
Thermal Design Mods for M2020



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- RAMP is highly volume and footprint area constrained
 - SCS takes large volume at front of the rover
 - Accommodate existing avionics & new science
 - Re-route HRS tubing
 - UHF radios to mini-RAMPs in rear towers



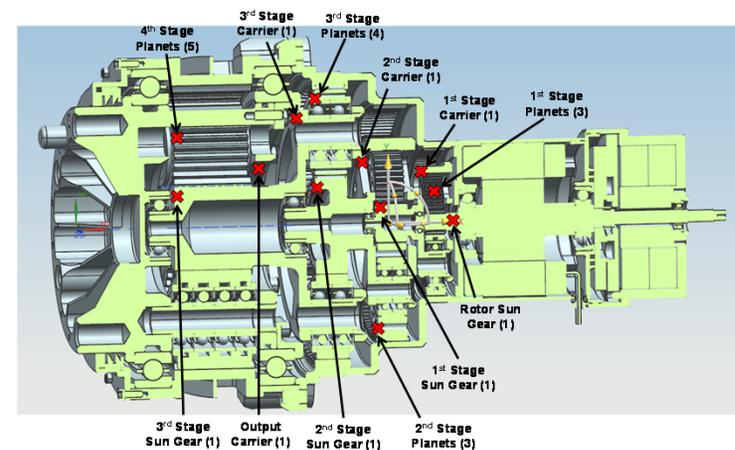
Proposed Thermal Changes for Increased Operability



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- M2020 required to drive long distances and collect samples more efficiently than MSL
 - Warm up actuators faster – additional heaters
 - Uses more energy
 - Spend less time waiting; more time doing science & driving
 - Test of actuator with internally mounted thermocouples
 - Better characterize internal heat paths
 - Requalification of actuators to colder temperatures
 - Larger “no-heat” operational windows
 - Lower heat energy needed to get to op temperature
 - Increased rover autonomy – “event-driven” ops
 - Put PRT inside output gearbox
 - Allow rover to determine when actuator is at op temp





- M2020 rover thermal design is highly leveraged from MSL
 - Internal thermal control architecture
 - HRS controlled – needs new tubing layout for M2020
 - Flexible architecture – allows iterative placement of boxes to come up with volume & area efficient configuration
 - External thermal control architecture
 - Utilize similar survival heater & warmup heater strategy
 - Implement thermal changes for increased operability
- MSL thermal design architecture was flexible enough to accommodate M2020 Science Payload and Sample Caching System with a reasonable number of design modifications

BACKUP



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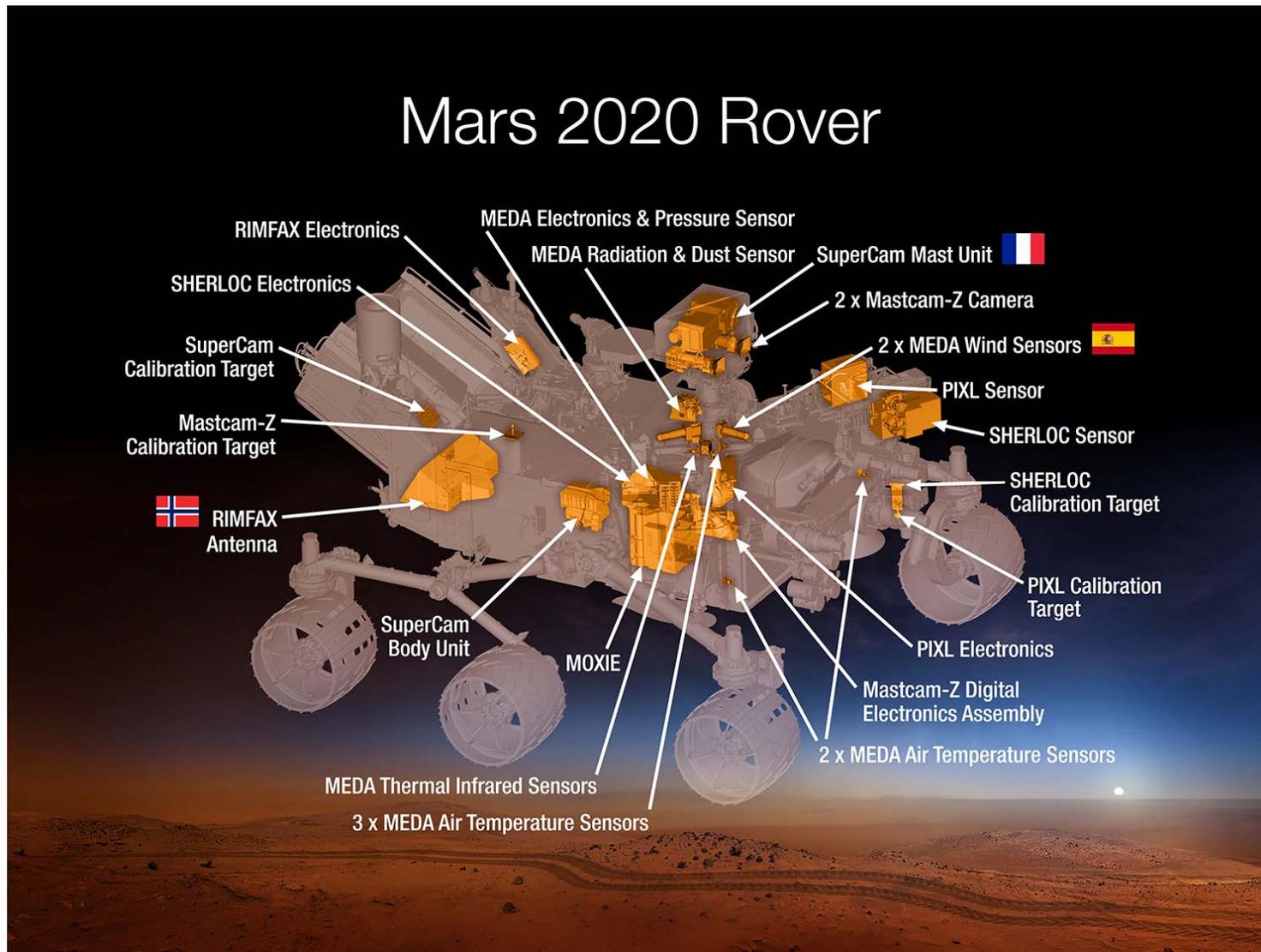
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M2020 Science Instruments



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ROVER-Thermal



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