KISS Revolutionizing Access to the Martian Surface

Advances in Robotics and Mobility

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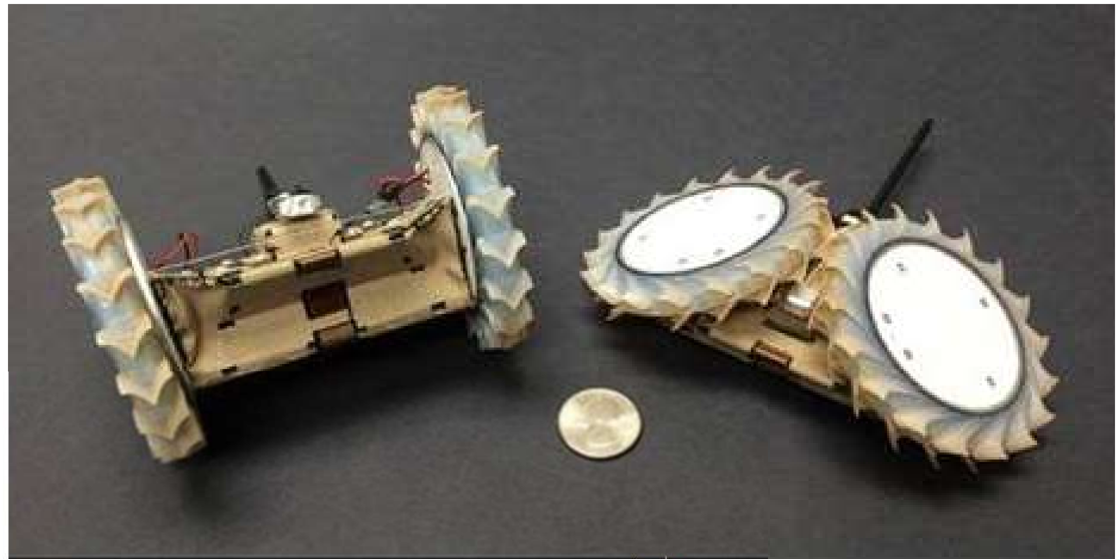
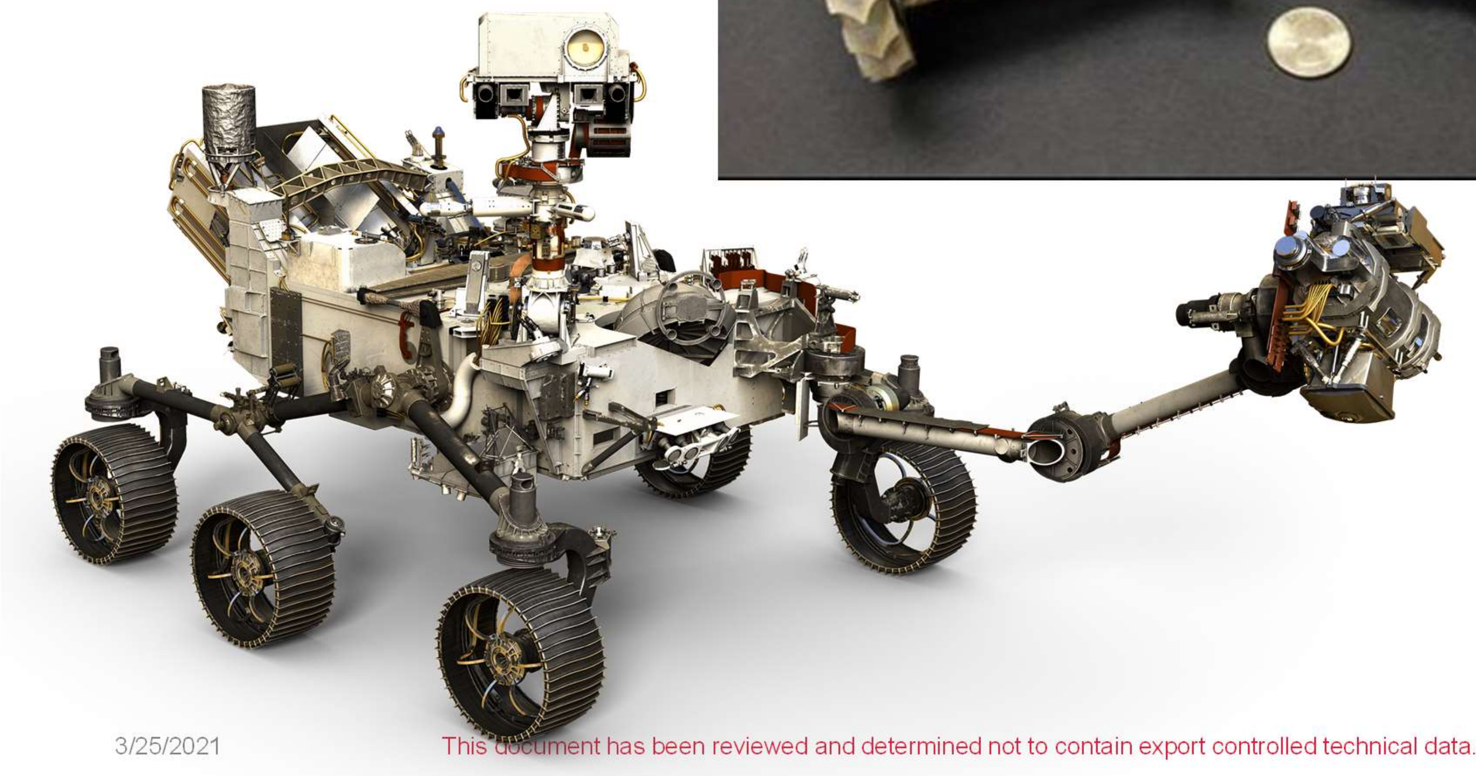
Advances in Robotics and Mobility

- What are we talking about when we say “robotic mobility system”?
- What advances in technology can affect access to the Martian surface?
- What advances in philosophy can affect access to the Martian surface?
- What might it look like if we apply those advances?

Advances in Robotics and Mobility





First, a System Breakdown

And it all matters

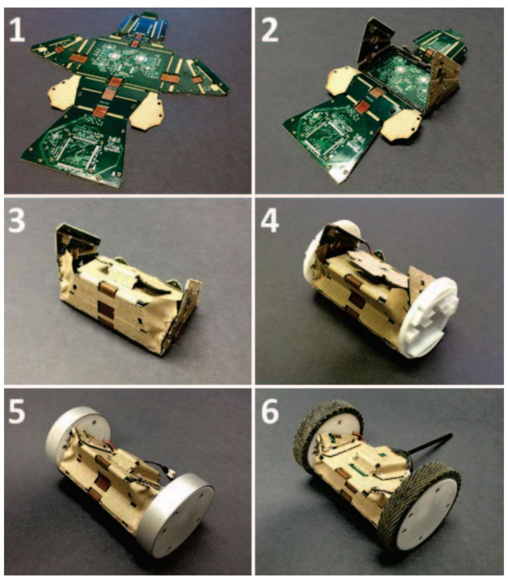
- Mechanical/Structure
- Mobility
- Instrument Pointing / Instrument Placement / Sampling
- Power
- Thermal
- Actuation Drive and Control
- Compute and Data
- Telecom
- Localization Algorithms
- Perception Algorithms
- Flight Software
- Mission Science and Engineering Planning (ground ops)

Key* areas of tech advancement (1/2)

And things that give us hope for them

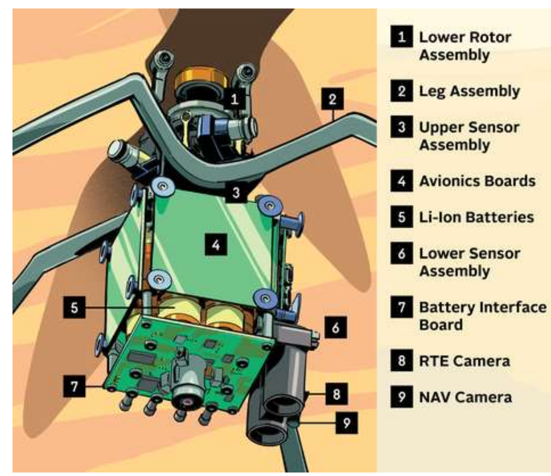
Advanced Materials and Manufacturing for part number reduction and improved performance

(Bulk Metallic Glass gears and additively manufactured housing of Perseverance Drill)



Hybrid Structures for part number reduction

(PUFFER single board structure and electronics)



Commercial Components for improved cost and performance

(Mars Helicopter electronics and sensors)

* Definitely not exhaustive

Key* areas of tech advancement (2/2)

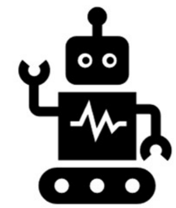
And things that give us hope for them

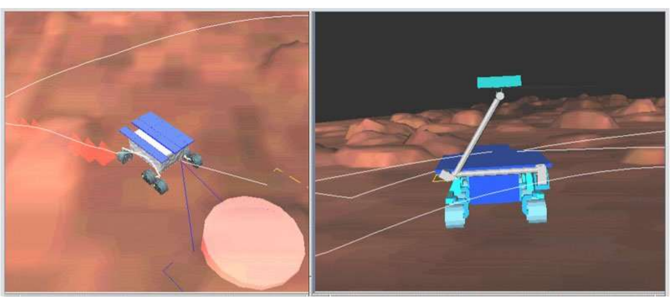

Interoception, the sensing and perception of self-state, for reduction of design margins

(Advanced state of charge for battery systems, Force Sensing for robotic arms)

Sensing and Onboard Autonomy for increased operational tempo, lower operational risk, and optimized communication strategy

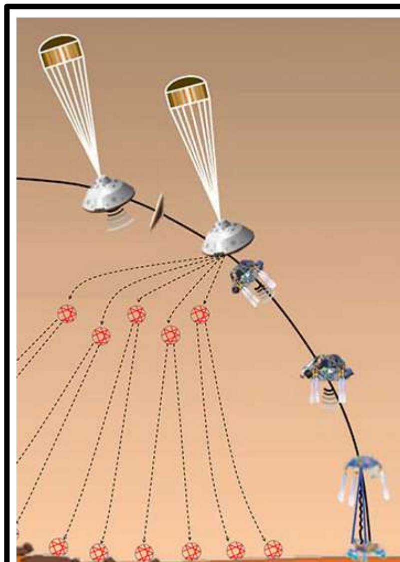
(Perseverance Fast Traverse, Machine Learning for hazard identification, engineering and science data curation)



Analysis and Sim for Design, Verification, and Validation

(DARTS dynamics and hardware-in-the-loop test environment)



“Maple seeds” and other Multi-Vehicle Concepts for wider landing allowances and reduced per unit risk

(“Maple seeds” and Mid-Air Deployment concepts, CADRE/PUFFER multi-rover “magazines”)

* Definitely not exhaustive

Key areas of philosophy advancement (1/2)

And things that give us hope for them

Risk associated with Open-Source or Not-Invented-Here Software

(F Prime on Mars Helicopter, ROS Space)

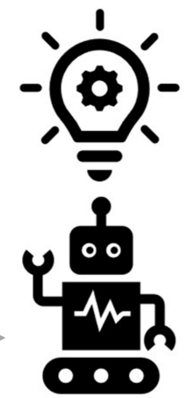
 # defects/kLine of Code

0.5 Open-source projects

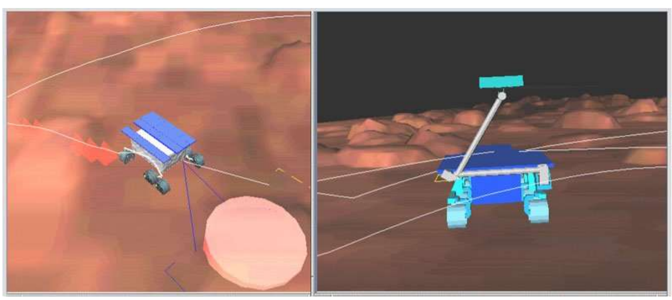
0.6 Linux 2.6 (7 MLOC)

0.1 NASA flight software

On-board Autonomy in relation to Ground in the Loop

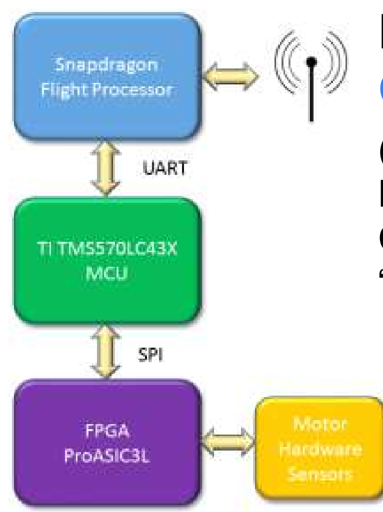


(Perseverance Fast Traverse, Machine Learning for hazard identification, engineering and science data curation)



Simulation and System Level testing

(DARTS dynamics and hardware-in-the-loop test environment)



Risk associated with Commercial Components

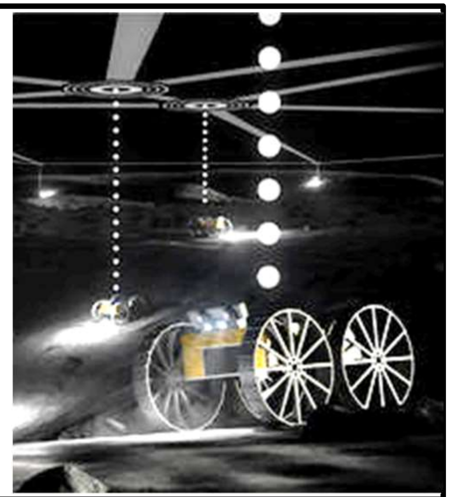
(“Maple seeds” and Mid-Air Deployment concepts, CADRE/PUFFER multi-rover “magazines”)

Key areas of philosophy advancement (2/2)

And things that give us hope for them

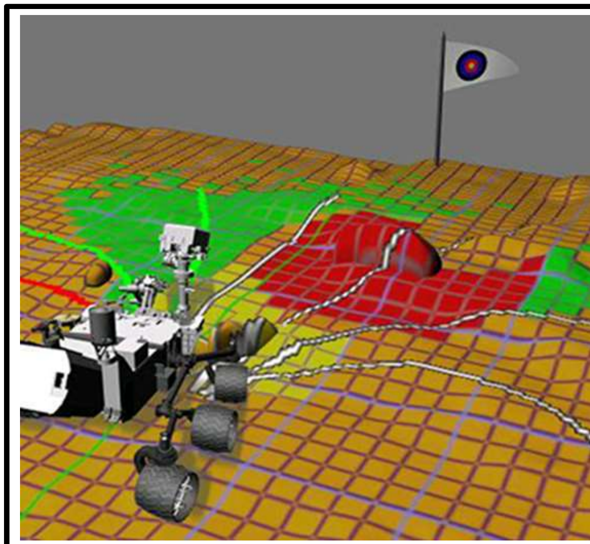
Multi-Vehicle mission scenarios to cover more area per mission

(CADRE rovers, “swarms” of systems, “”CubeSat” standards for surface systems)



Size, Weight, and Power (SWaP) in relation to capability

(PUFFER, Axel)



Mobility subsystem capability in relation to Drive Path

(Perseverance Fast Traverse, Machine Learning for hazard identification)

Let's go back to that System Breakdown (1/2)

What can we realistically do?

Element	Potential Improvement
• Mechanical/ Structure	Smaller and less massive with less design labor and less unit testing through advanced manufacture
• Mobility	Smaller and less massive due to reduced obstacle/hazard capability enabled by advanced nav
• Instrument Pointing/ Instrument Placement/ Sampling	Smaller and less massive with less design labor and less unit testing through advanced manufacture
• Power	Smaller and less massive due to reduced margins enabled by interoception and on-board autonomy
• Thermal	Smaller and less massive due to integration with Structure

Lets go back to that System Breakdown (2/2)

What can we realistically do?

Element	Potential Improvement
• Actuation Drive and Control • Compute and Data	Less expensive due to use of commercial components
• Telecom	Spend less energy by optimizing transmissions
• Localization Algorithms • Perceptions Algorithms • Flight Software	Reduce design and test labor by inheriting code and testing in simulation
• Mission Science and Planning	Reduce labor or increase operational tempo though reduced Ground in the Loop activity per surface system activity

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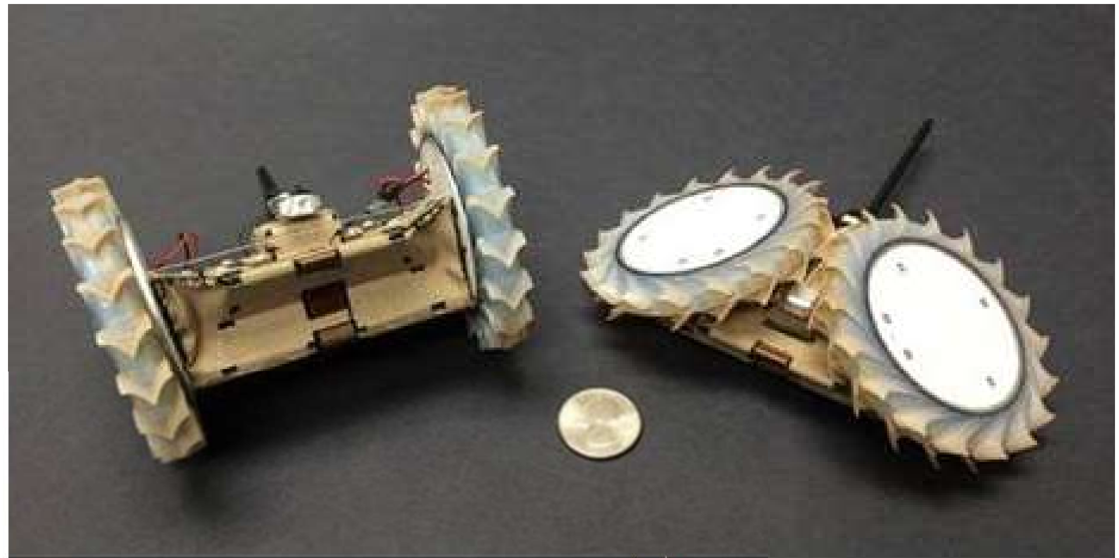

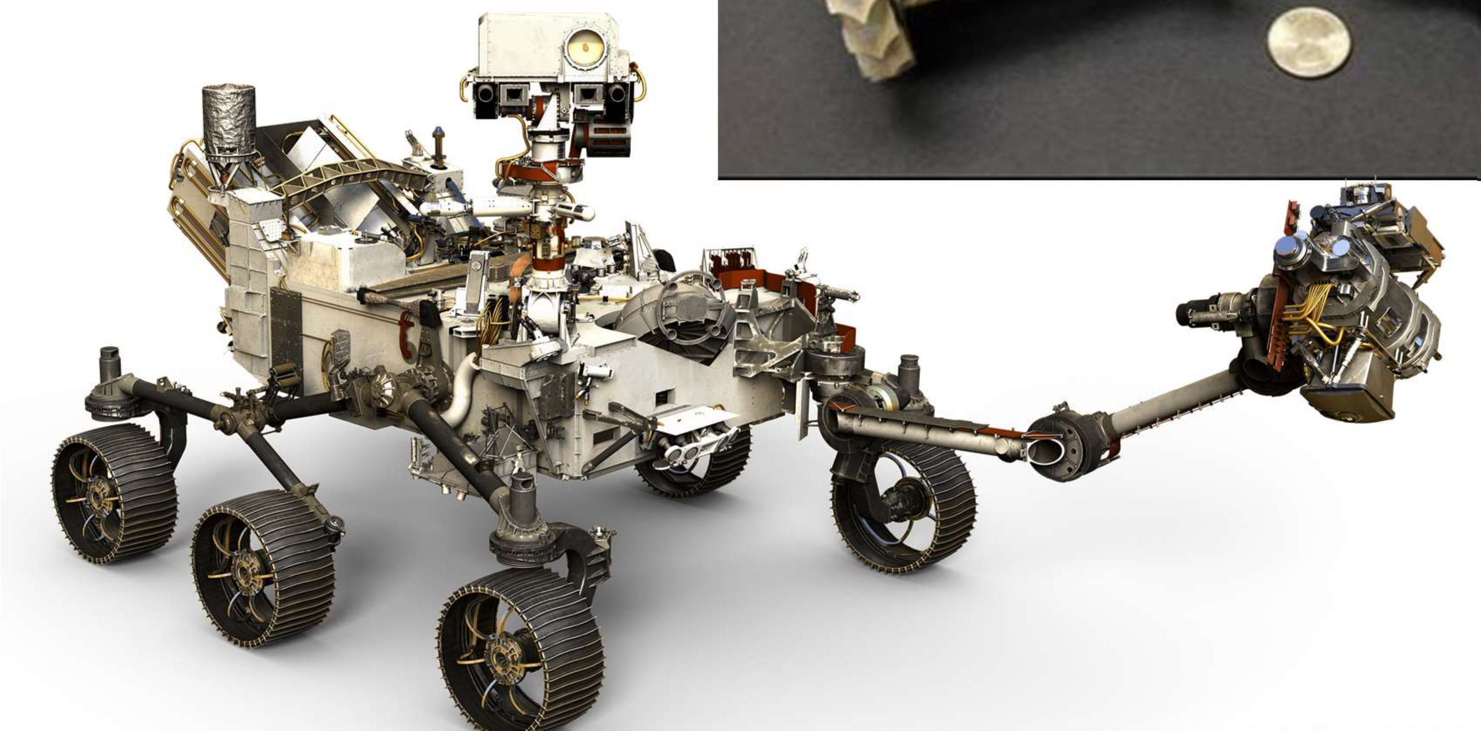

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