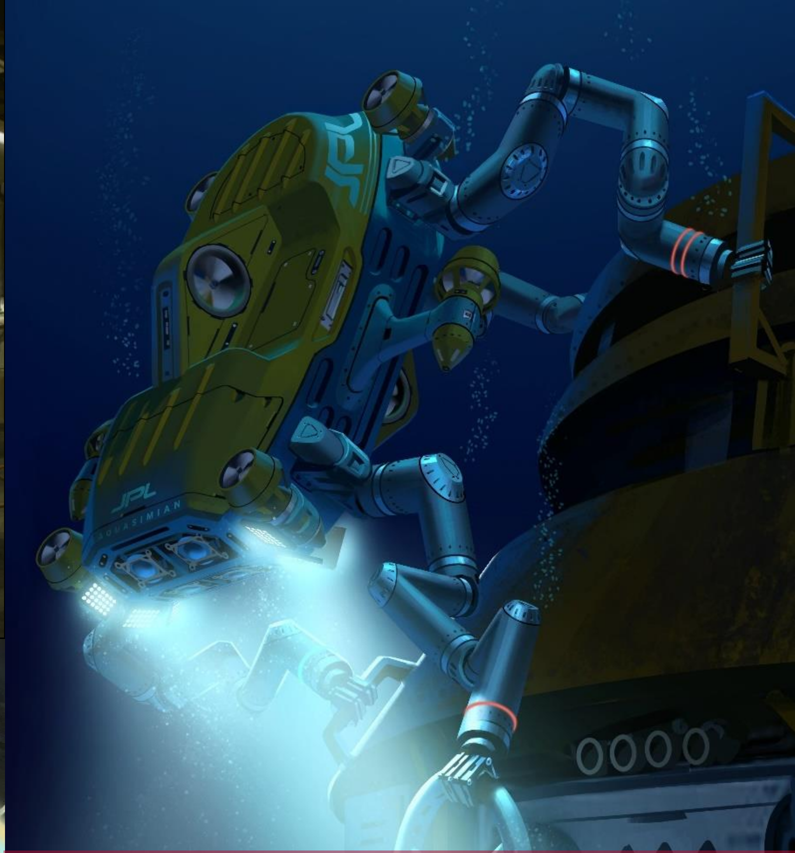


Overview of JPL Robotics

Presenter: Dr. Fernando Mier-Hicks

Mobility and Robotic Systems Section,
Autonomous Systems Division

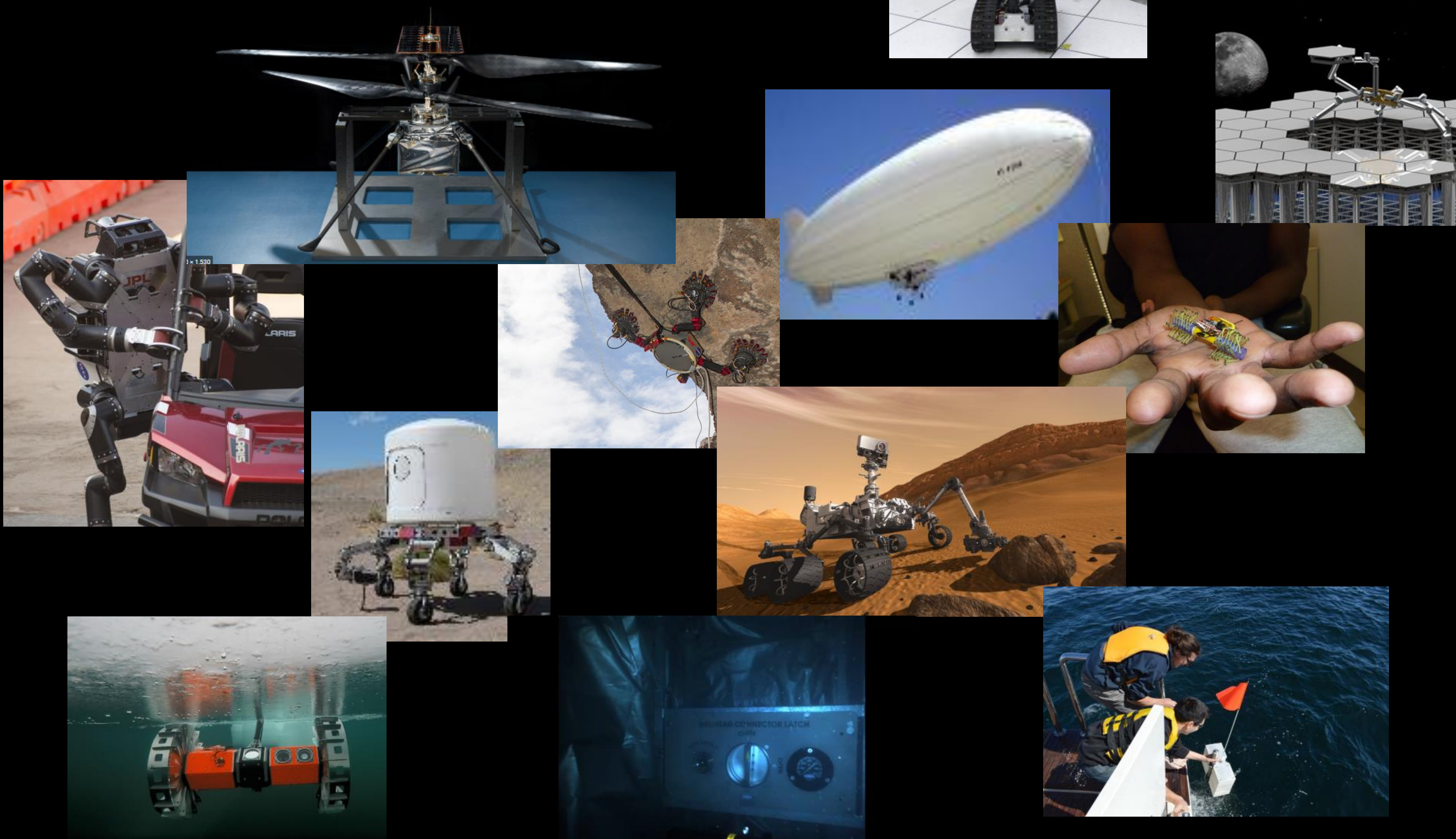
Jet Propulsion Laboratory
California Institute of Technology

A little about me

- Bachelors Mechatronics Engineering from Tec Monterrey, Mexico
- Masters & PhD. in Aerospace Engineering from MIT
- 5 years at JPL
- Have worked in:
  - Perseverance Sample Caching System
  - Mars Helicopter Gravity offload
  - High voltage, 40kV, for ice drilling
- Current jobs
  - Rover driver for Curiosity
  - Mine inspecting robot avionics lead
  - Group lead of avionics group 347A
  - Concept studies for future Mars mission

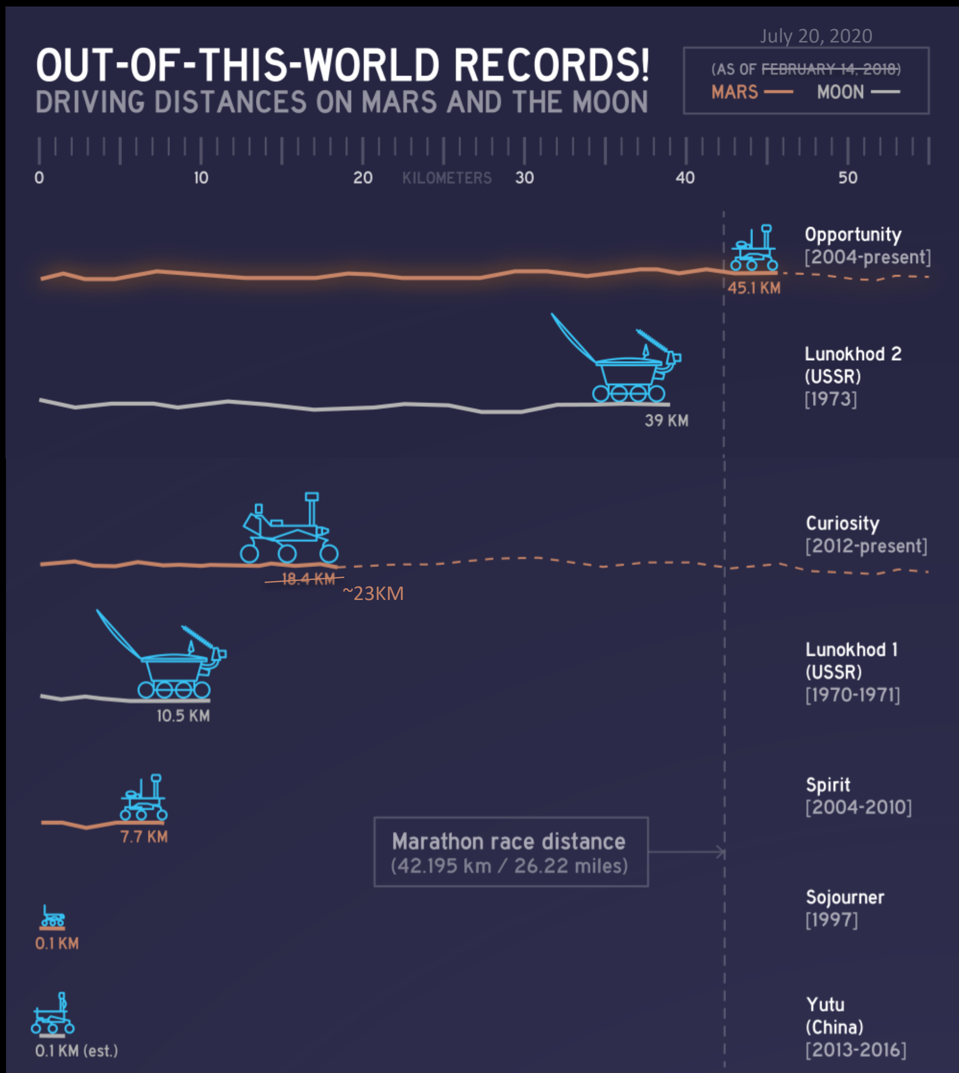
Robots on a Mission

Robot Platforms for all Environments



JPL Develops High-Reliability Robots

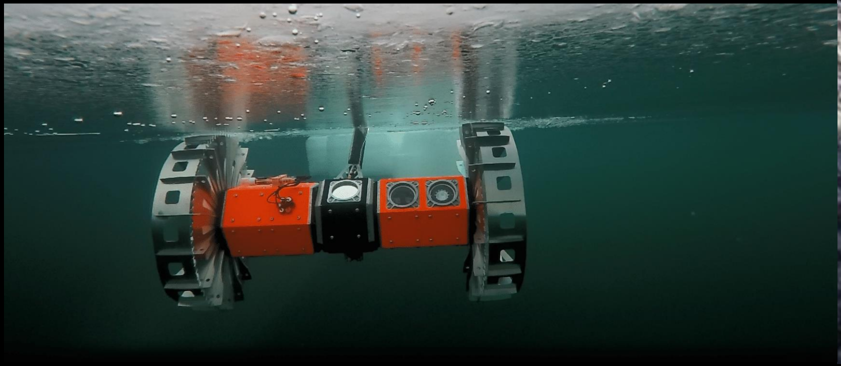
And that takes engineering the complete system



Perseverance Rover and Ingenuity Helicopter Landed February 18, 2021

Key Robotic System Technologies

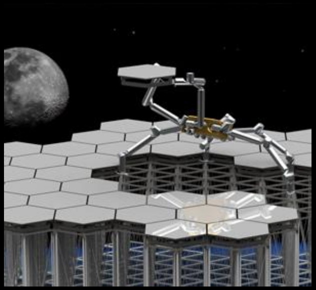
- Field Robot Platforms
- Physics-Based Simulation
- Perception
- Manipulation Planning and Execution
- Mobility Planning and Execution
- Operator Interfaces
- System Design for Robustness and Testing

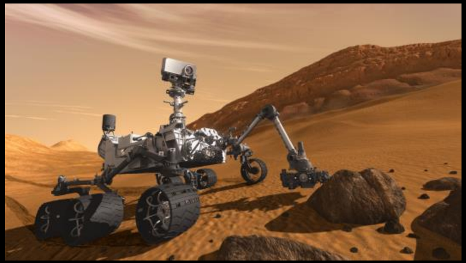


Robot Platforms for all Environments




- End-to-end platform development capability
- Developed in-house and customized commercial-off-the-shelf
- Developed for NASA, commercial, civil, and defense applications
- Range of sizes, shapes, masses, precision, strength, dexterity, etc.
- Harsh environments, reliability, durability
- Lifecycle and environmental testing

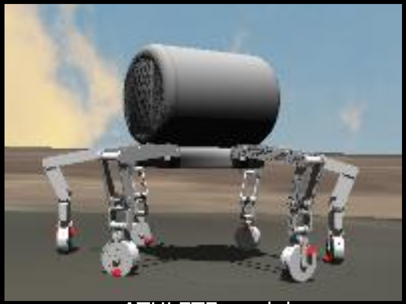


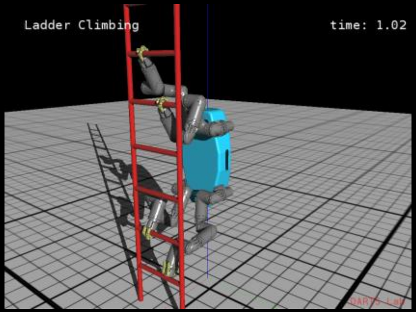





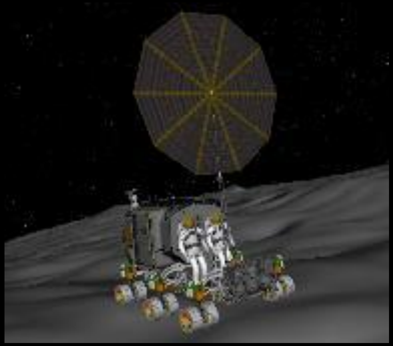
Physics-Based Simulation

- High-fidelity physics-based modeling and simulation
  - DARTS/DSHELL, M3TK
- Includes hardware-in-the-loop capabilities
- Features:
  - Large high-resolution terrain models
  - Contact dynamics and complex mechanisms
  - Terra-mechanics, aerial, surface and sub-surface models
  - Incorporates thermal, power, communication and other dynamics
  - Parametric analysis and Monte-Carlo simulations
  - GPU-based techniques for computation

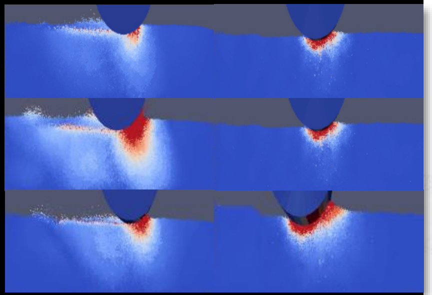

ATHLETE model

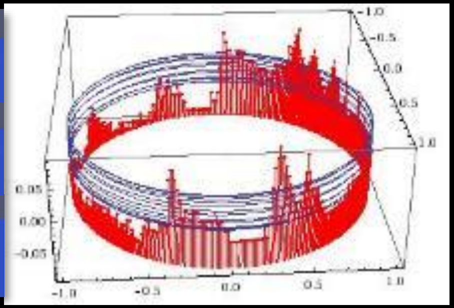


RoboSimian climbing


Simulated Lunar Electric Rover model


Aerobot model


Granular media model of wheel-soil interaction

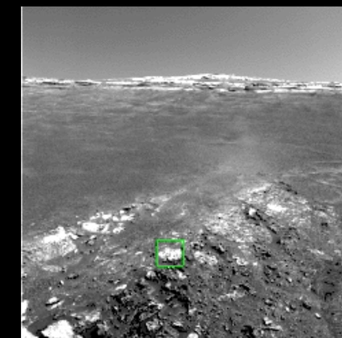

Solar illumination at the South Pole of the Moon

Sensing/Perception

Develop models from sensors in real-time

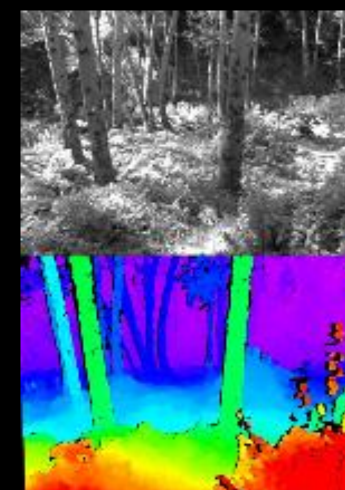
- Stereo-vision
- Environment classification from texture
- Target tracking
- Structure from motion
- Aerial Surveillance
- Object recognition
- Activity recognition
- Shape from shadow/shading
- Odometry
- Force/position/self sensing
- Advanced sensors
    - Spectrometers, imagers
    - *In-situ* Chemistry

Terrain classification: safe traverse region

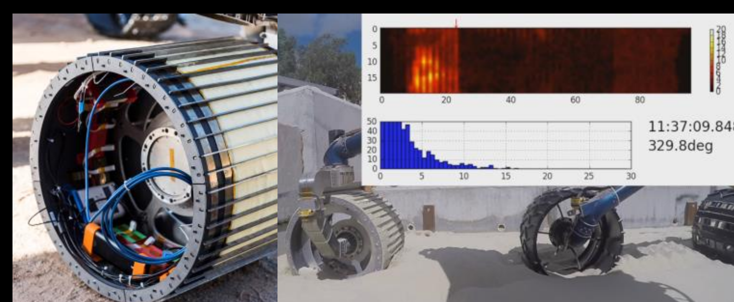


Visual target tracking

Terrain classification: water detection



Real-time stereovision



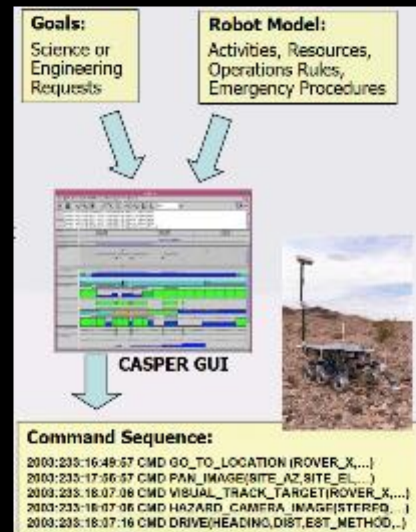
Terrain classification: Tactile Wheel for touch and "taste"

Manipulation Planning and Execution

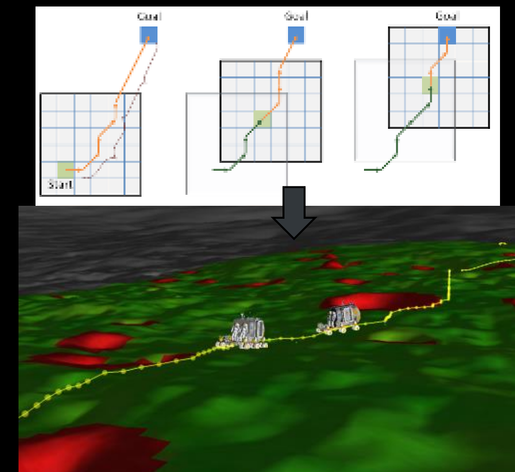
- Ranges from full autonomy to behavior-based supervised autonomy
- Body pose estimation by fusing sensor data
- Manipulation mapping and object segmentation using data efficient 3D voxel representation
- On-line kinematic calibration
- Whole-body pose planner

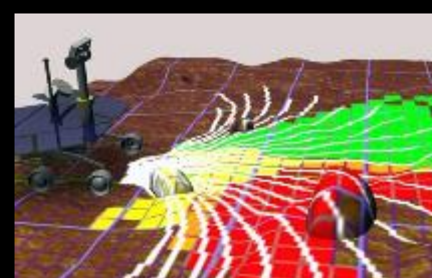
Mobility Planning and Execution

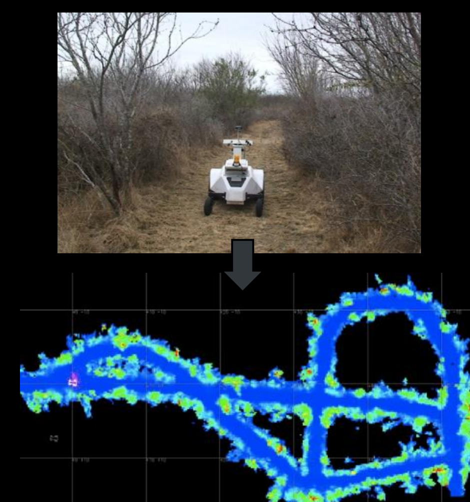
- Map building
- Navigation
- Traversability
- Path planning
- Optimal resource utilization
- Machine Learning for situational awareness
- On-board science
  - Respond to dynamic opportunities – autonomously recognize a science event or target
  - Prioritize data for down-link – send the most interesting information first



CASPER Automated Planning System

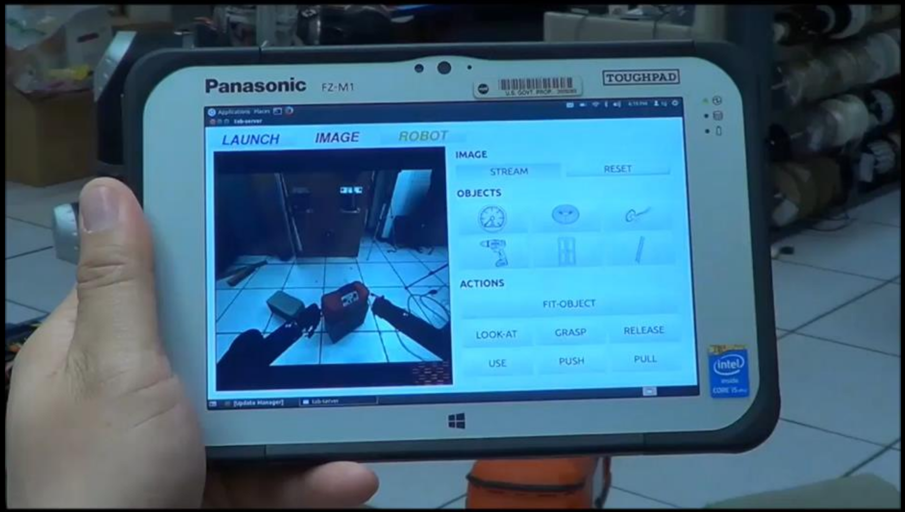

Path planning to avoid hazards

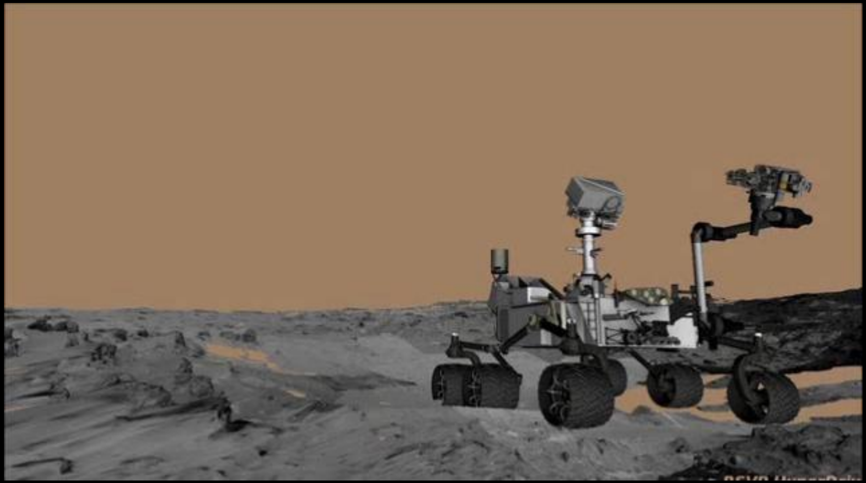

Traversability analysis

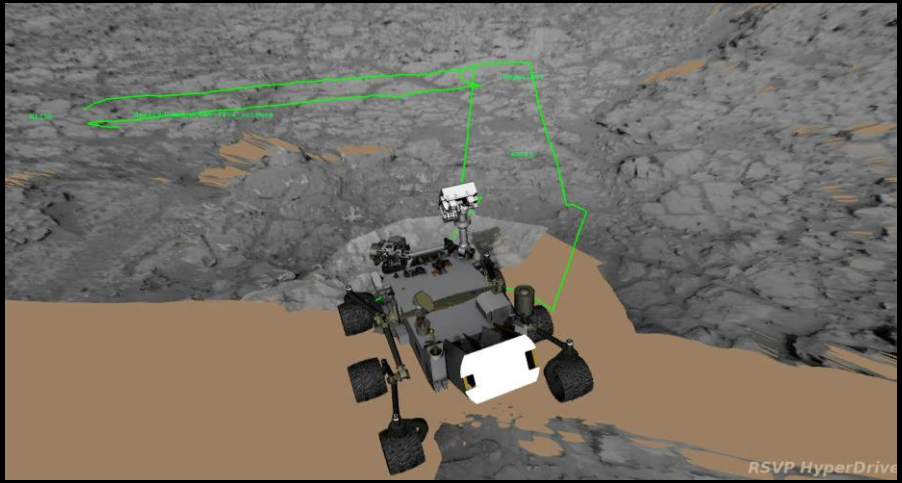

Simultaneous Localization and Mapping

Operator Interfaces

- Ranges from simple/quick to exhaustive
- Command sequence generation & scripting
- Operations simulation & rehearse
- Safety verification
- Engineering data visualization
- Virtual or augmented reality







- Developed for DARPA Robotics Challenge to respond to Fukushima-class disaster scenarios
- Extreme mobility and manipulation with four dexterous limbs
- Designed for transport, operation, and maintenance in the field

- Developed for DTRA and Army programs requiring significant manipulation in human-hazardous environments
- Human-scale strength and bimanual dexterity
- Human-scale mobility speed in semi-structured environments

Ride Along with RoboSimian

This video shows the robot's-eye-view from JPL's RoboSimian on the DARPA Robotics Challenge Finals course on June 5, 2015.

Video Speed Enhanced

Supervised Remote Robot with Guided Autonomy/Teleoperation (Surrogate)

Whole-Body Valve Turn with Mobility
July 16, 2014

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