Mobile Space Robots for Terrestrial Applications

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Mobility: Introduction (videos)

video

Mobility: Background

- A branch in the Robonaut family tree
  - Common design philosophy and components













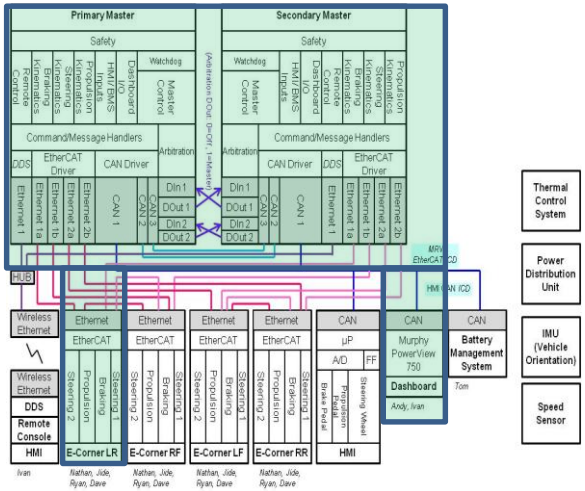


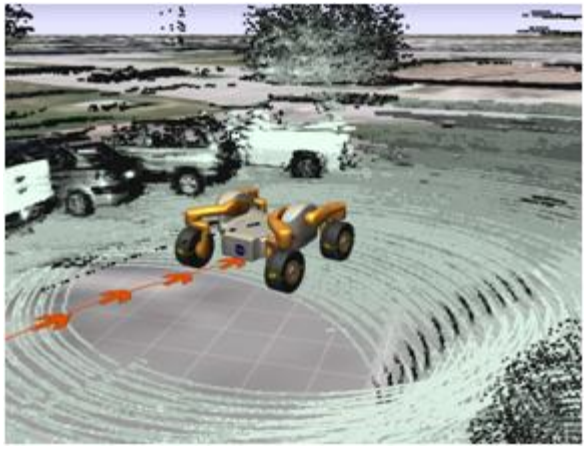





Mobility: Common Themes

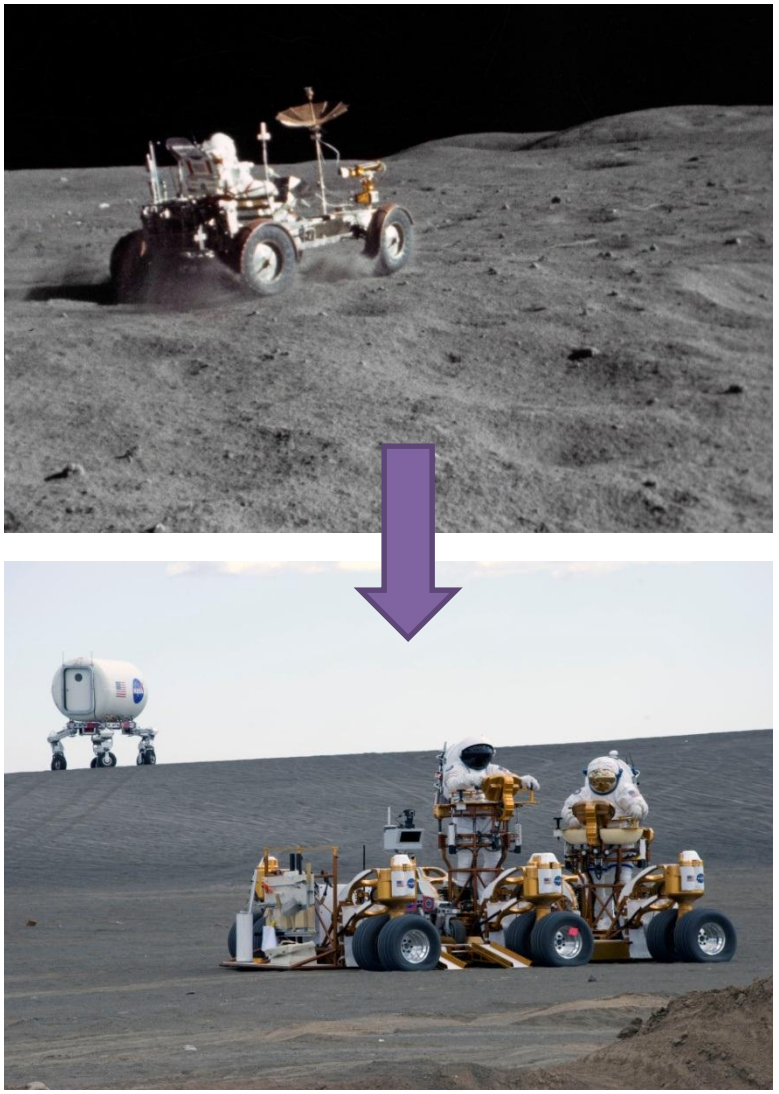
- Safety is paramount
  - Getting crew home is top priority in space
  - Translates to earth
  - Functional redundancy
- Extreme dexterity
  - Independent wheel modules
  - Active suspension
  - Crab steering
- Re-use to cut development time and cost
- Multiple control modes
  - Ride-on
  - Teleoperated
  - Autonomous and shared control modes





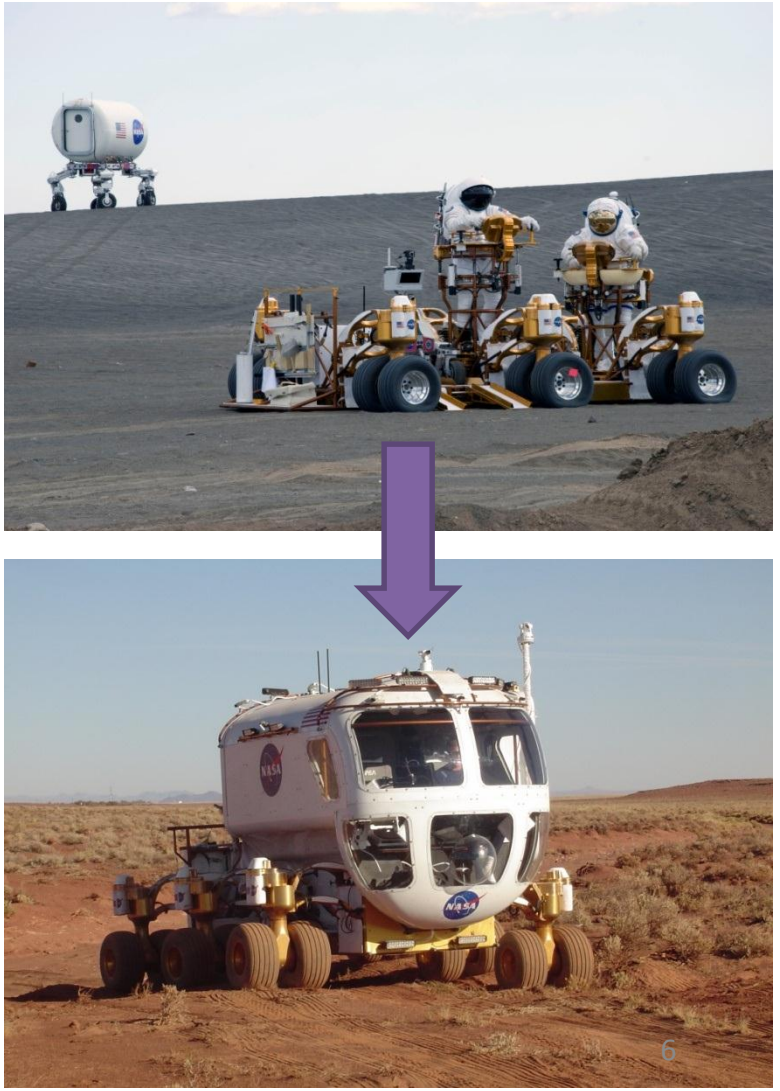
Chariot Chassis

- Developed beginning in 2007
- Concept/prototype of crew rover developed for surface exploration
- Goal: challenge the conventional wisdom of crew rovers
- Designed for extreme terrain mobility
- Six wheeled rover with each wheel module having 3 motions
- Capable of being driven by on-board crew, tele-operation and ground control



Chariot Chassis

- Designed as a modular chassis carrying a variety of payloads
  - Crew in pressurized suits, standing up, Chariot style
  - Configured as a flat deck for general purpose payloads
  - Small Pressurized Rover Cabin (forming NASA's Lunar Electric Rover)
  - Science and surveying instruments
  - Supplementary power
- Currently two models in 1st generation series



Chariot Chassis: Video

Space Exploration Vehicle

- Pressurized Mobile Habitat consisting of:
  - Small Pressurized Rover cabin
  - Chariot chassis
- Crew explores in shirt sleeves
- Access to space through suit ports
  - No airlock
  - Direct access to suits from cabin
  - EVA in 15 minutes vs. 4 hours on Space Station
- Nominal operations: 2 astronauts for 3, 7 or 14 days
  - 4 crew for up to 24 hours

Space Exploration Vehicle

- Features:
  - 2 person cockpit
  - Redundant driving stations
  - Separate crew areas with privacy curtains
  - Storage for up to 14 days
  - Water system
  - Waste control system
  - Exercise devices
  - Hatches with docking ports
  - Aft driving station
  - Aft enclosure for suit dust and thermal protection

Modular Robotic Vehicle

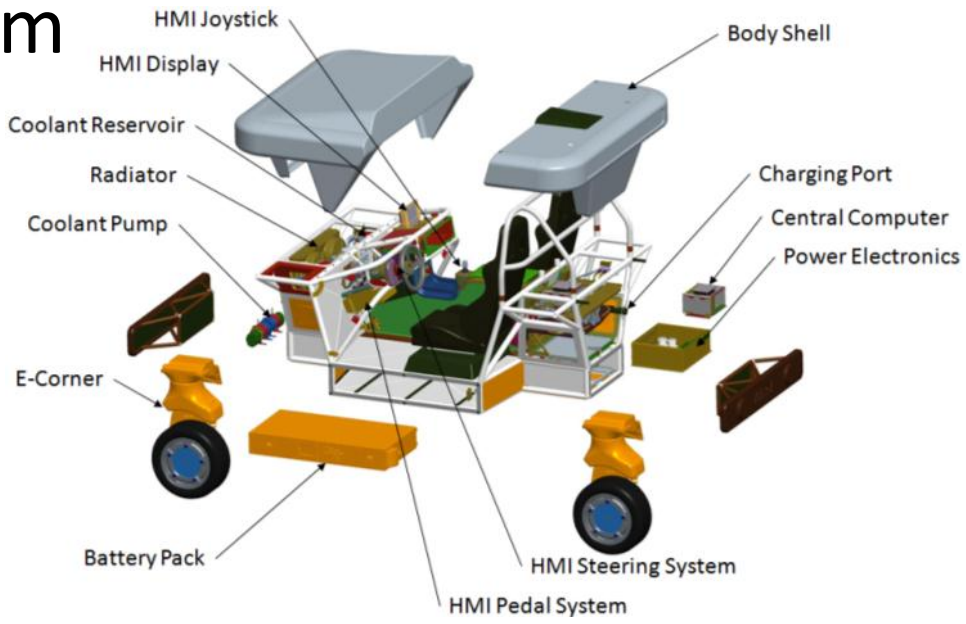
- NASA developed unique skills in Astronaut rovers during NASA's Constellation program (2006-2010),
  - Focus on safety & reliability
  - R&D scale of investment
  - Highly maneuverable vehicles
  - Rigorous testing
  - Different requirements than Mars rovers
  - Dual purpose: Astronaut or robotically driven
- MRV projects spins technologies to terrestrial applications

MRV: Unique Vehicle Capabilities

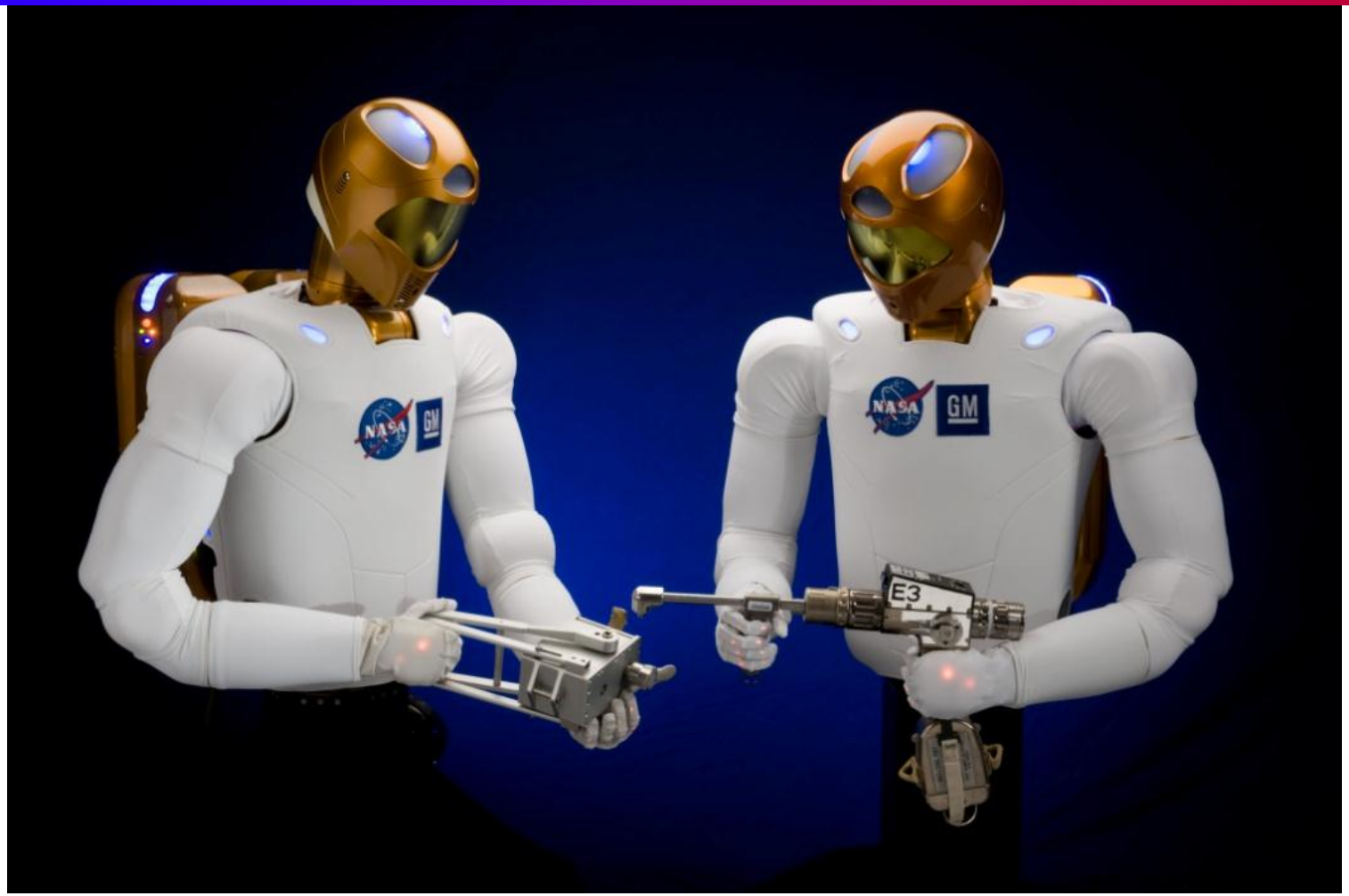
- Fail-operational *drive-by-wire* design
  - Focus on vehicle safety under fault conditions
- Independent, modular wheel systems
- Extreme maneuverability
- Battery electric vehicle
- Designed for robotic control: remote and autonomous driving

MRV: Vehicle Specs

- Design speed: 64 kph (40 mph)
  - Currently computer limited to 25 kph (15 mph)
- Curb weight: 900 kg (2000 lb)
- Footprint: 2.15 x 1.55 m (7’ x 5’)
- Drive-by-wire without mechanical backup



Robonaut Humanoid

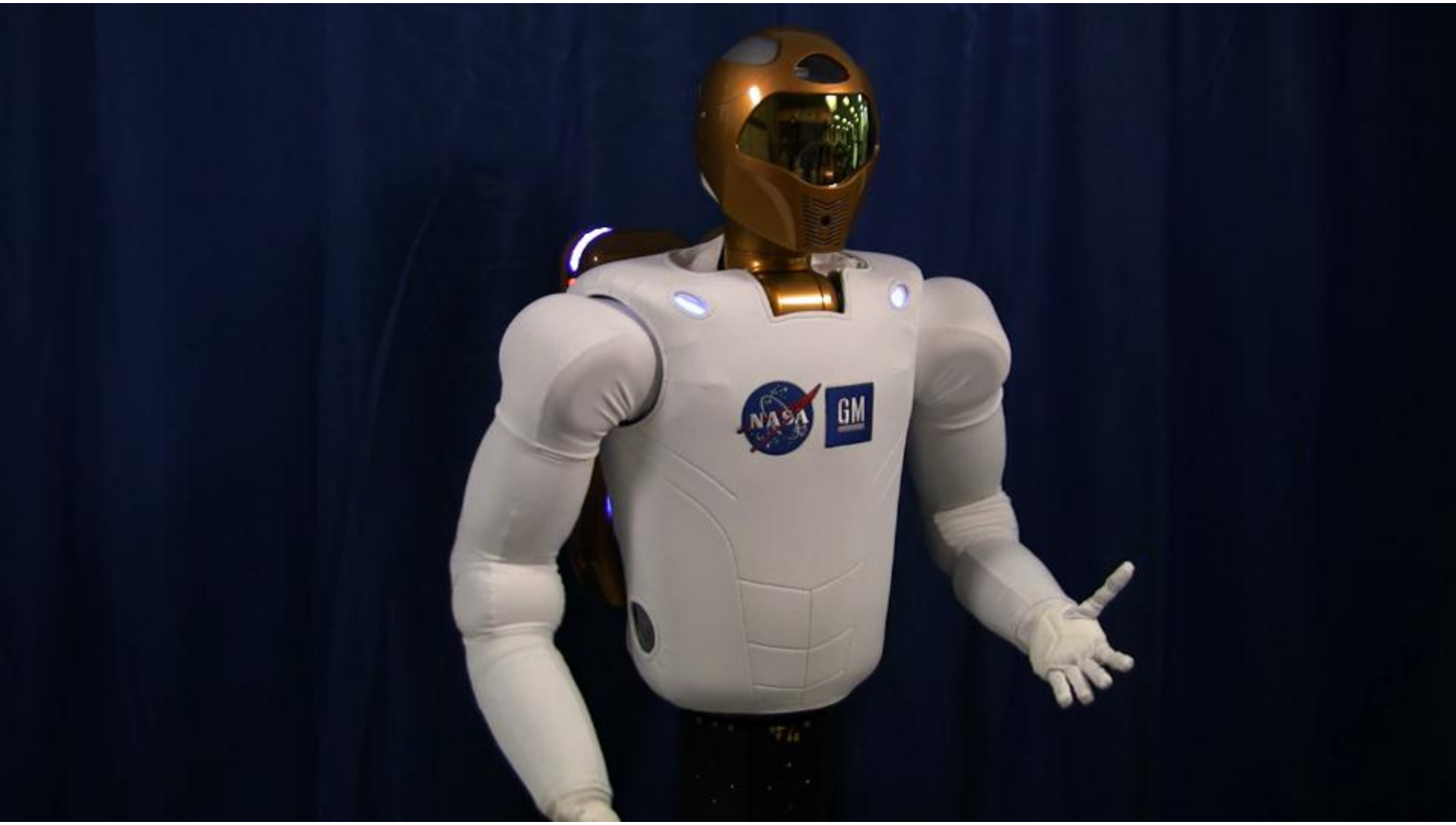


A Great Relationship

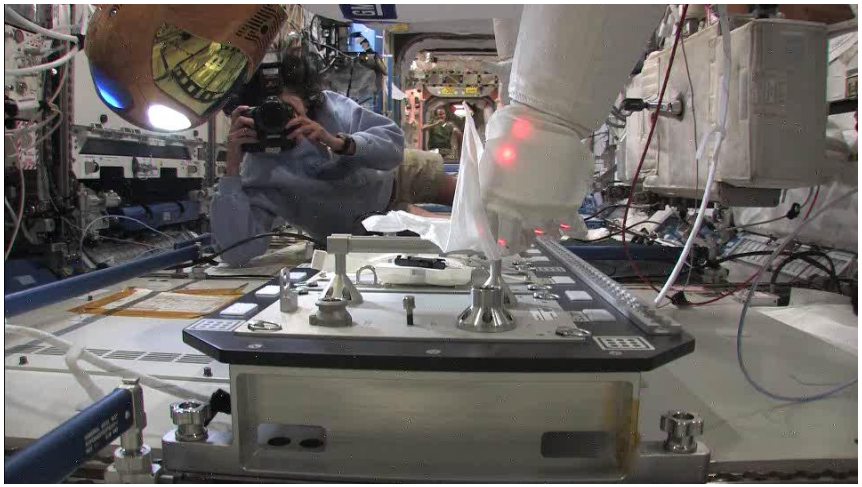
Robonaut Humanoid

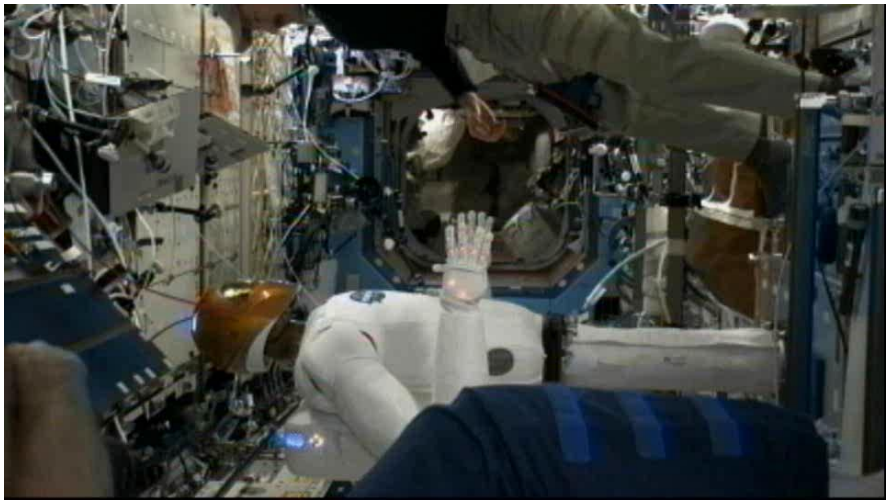
- Developed in partnership with General Motors
- Developed to serve as Astronaut assistant, working safely near humans
- Deployed to International Space Station 2011; legs 2014
- World class dexterity

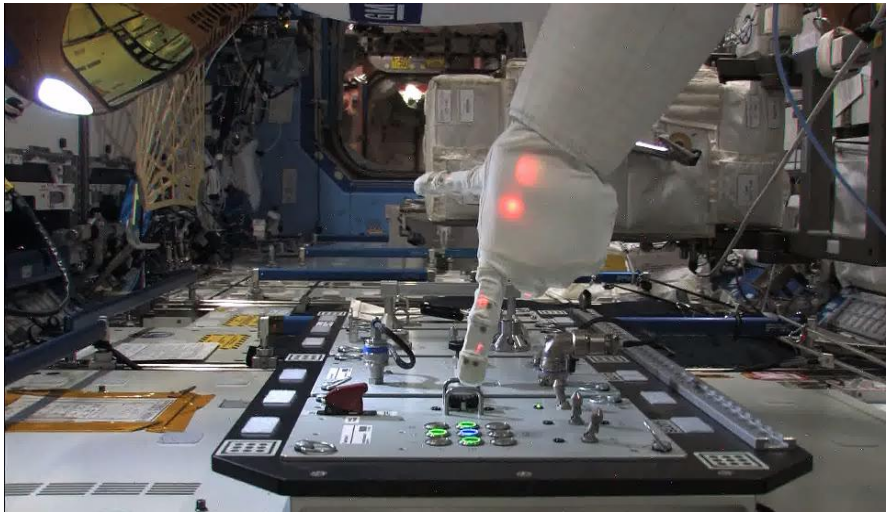
Robonaut 2 Introduction



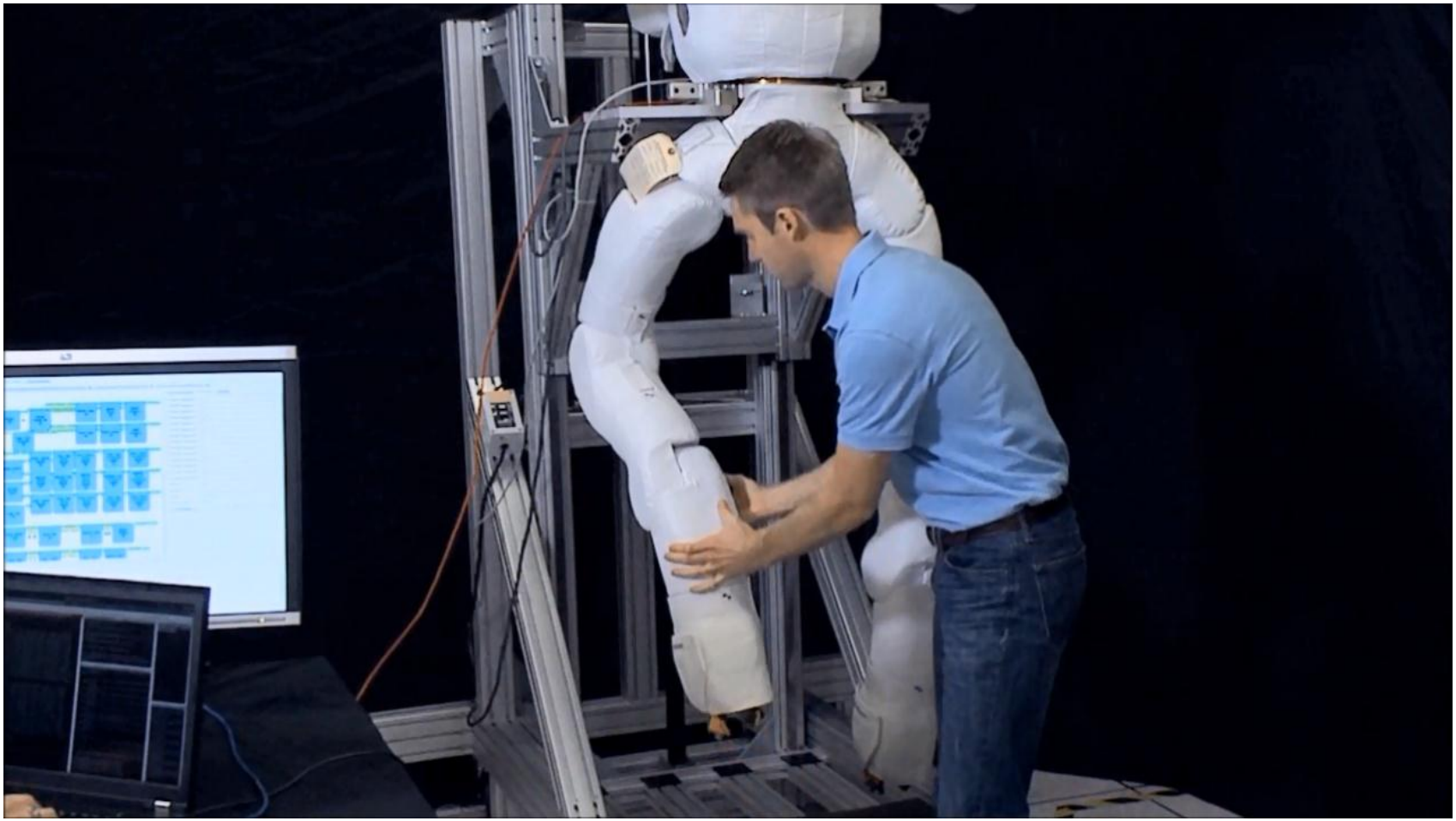
Robonaut ISS Ops







Robonaut ISS Mobility



Valkyrie Humanoid

Walking Humanoid developed for in space surface applications and disaster recovery

- Heavily inspired on inability to access Fukushima after the disaster

Leveraging prior NASA technology investment

- Radiation survivability
- Thermal range
- Mechanism
- Soft goods
- Dexterous tool use

Making significant progress towards walking through National Robotics Initiative grant

- A challenge for Mars tasks is currently being formulated

Valkyrie

Valkyrie Humanoid

Concluding Remarks