Mobile Space Robots for Terrestrial Applications

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Mobility: Introduction (videos)
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
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
• 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

• 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 Humanoid
Concluding Remarks