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
• 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
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
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