NASA's Human Robotic Systems

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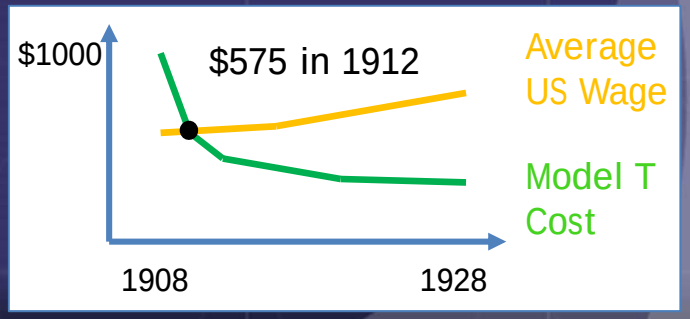
The Robotics Promise

"Robots will do the dull, dirty and dangerous work for humanity"

- Reducing the cost of robotics
- Increasing the capability of robotics



Increasing task capability

What can robots do today?

- Welding, painting, pick-n-place
- Vacuuming, pool cleaning, mowing
- Increasingly: mining, harvesting, spying

What is left?

- A lot!
- Think about the worst jobs to do in the world

Where will new robot capabilities be invented?

The Great Dichotomies in Robotics Today

Mobility

- Moving people or things to where they are needed.

Manipulation

- Definition: Changing (something) by artful means so as to serve one's own purpose.

Hybrid	Hybrid
Mobile Manipulation	Robot Human

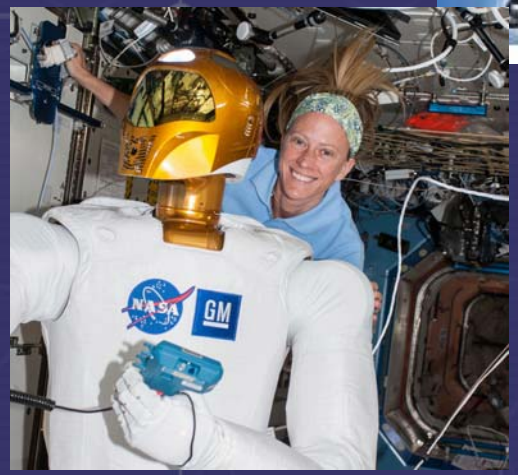
Design Tensions in Robotics Today

Component Advances are Disruptive

- Batteries, computing, sensors, materials, software, communication, lightweight materials, additive manufacturing
- Robots designs must evolve

Safety Around People

- Strong vs safe
- Fast vs safe



Ground Vehicles

Chariot

- 2:1 Payload to weight ratio, 2x redundancy
- Manned or robotic driving, all electric
- Crab steer, active suspension
- 45 degree tip over, 1 psi ground pressure

Modular Robotic Vehicle

- 100 KPH, 100 Km Range
- Manned or robotic driving, all electric
- Crab steer, warm blooded thermal control
- Drive-by-wire safety, redundancy

ISS Robotics

Systems onboard ISS

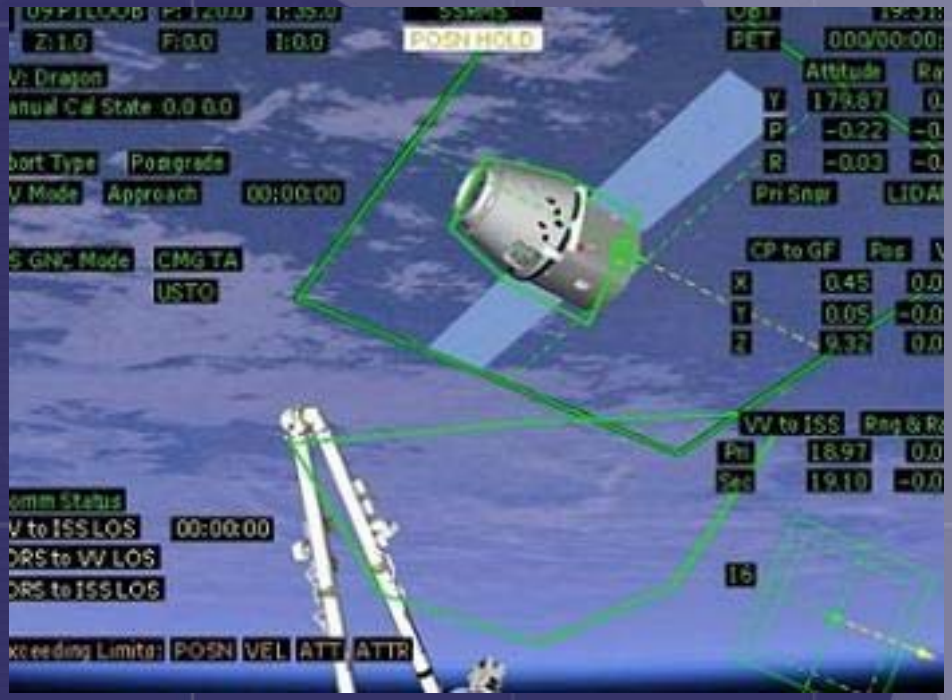
- SSRMS
- SPDM
- JEM

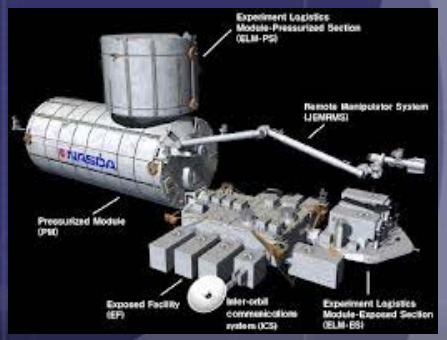
Tasks

- Grappling/berthing
- Astronaut EVA support
- Payload handling and servicing

Operations

- 90% Ground control (night shift)
- All tasks simulated and analyzed





Robonaut 2

History

- Robonaut 1 started in 1996
- Robonaut 2 now on the Space Station

Vision

- Astronaut assistants able to safely work in a world engineered for humans.

Applications

- IVA / EVA Operations (indoor and outdoor)
- Satellite servicing
- Asteroid & surface sampling
- Maintenance & contingency operations

Robonaut 2 0g Legs

History

- Legs developed for climbing on ISS
- Next generation manipulators

Status

- Designed and built in 2012
- Certified in 2013, along with battery
- Delivered for launch on SpaceX-3 (February)

Applications

- IVA / EVA Operations (indoor and outdoor)
- Able to work with ISS interfaces
  - Handrails, WIF, Seat Track

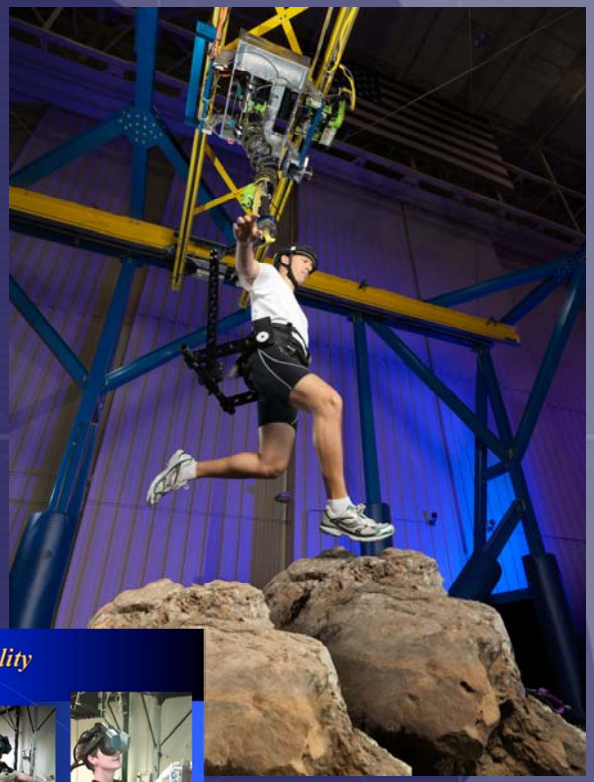
Wearable Robotics

- Robo Glove
  - Worn by a human
  - Reduces wrist fatigue
  - Reduces wrist injury

- Lower Body Exoskeleton
  - Worn by human
  - Assist injured people
  - Amplify strength
  - Use it for exercise

Robots for Dynamic Testing

- **Gravity Offload**
  - **NASA needs to simulate reduced gravity**
  - **Terrestrial applications might include safety or rehabilitation**



- **Dynamic Simulation**
  - **NASA needs to emulate contact or assembly in VR**
  - **Terrestrial applications might be training or collaboration**

Partnerships: Oil & Gas Industry

Inspect Offshore Oil Storage Chamber

- Access underwater chamber
- Gather sonar data
- Collect samples

December 2012

- Problem defined

March 2013

- NASA formulated a concept

August 2013

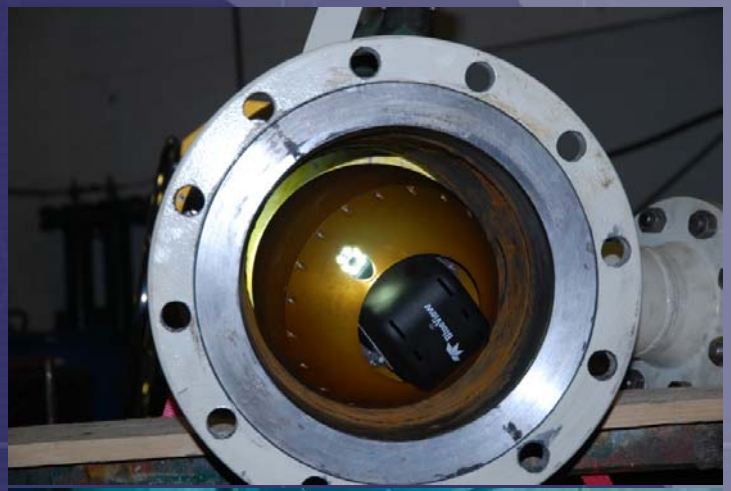
- Prototype completed

October 2013

- Testing at Neutral Buoyancy Lab

November 2013

- Robot delivered and accepted



Partnerships: DARPA Challenge

Disaster Response

- Working in human facilities
- Machines, doors, ladders
- Tools, valves, hoses

July 2012

- DARPA Award Received

October 2012

- Project Start

July 2013

- Robot Powered Up

October 2013

- Baby's first steps

December 2013

- Robot goes to trials