The Robotics Promise

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

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

![Graph showing the decline in average US wages from 1908 to 1928 with Model T car cost comparison.](image-url)
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.
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