DARPA Robotics Challenge
From Trials to Finals

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August 13, 2014

Why a Disaster Response Challenge?

Fukushima Daiichi, March 2011

- "... close study of the disaster's first 24 hours, before the cascade of failures carried reactor 1 beyond any hope of salvation, reveals clear inflection points where minor differences would have prevented events from spiraling out of control." *IEEE Spectrum,* Nov 2011 p. 36

- We are vulnerable to natural and man-made disasters
- HADR is 1 of the 10 primary missions of the US DoD
  - "Sustaining U.S. Global Leadership: Priorities for 21st Century Defense", The White House,+ SecDef, January 2012
- HADR is a universally understood and appreciated mission
- Enables participation of "best and brightest" performers, from anywhere in the world

Human-Related Capabilities

1. Human Environments




Public Internet Images

2. Human Tools



Public Internet Images

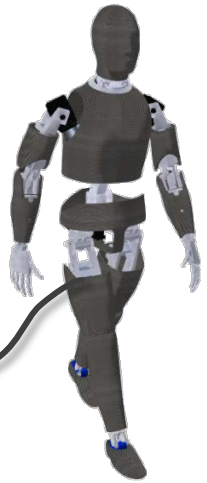
3. Human Interfaces

Public Internet Image

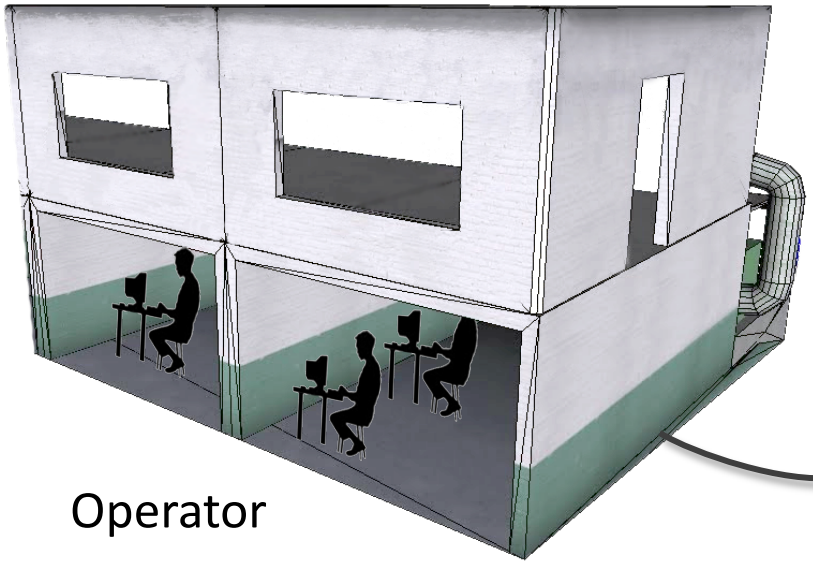
Autonomy

$$Autonomy \propto \frac{1}{Communication}$$

DRC Robot



Degraded Network Emulator



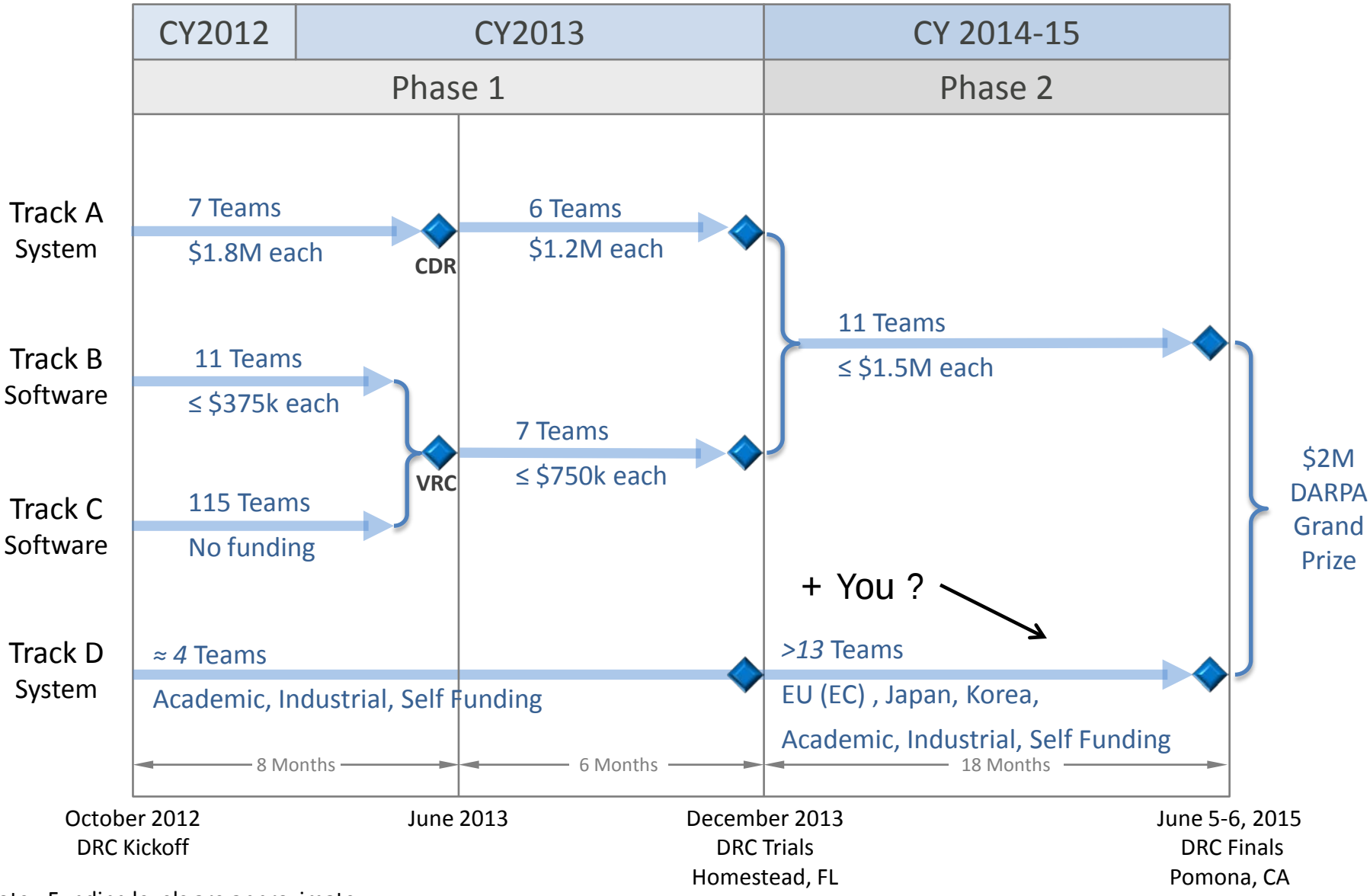
Operator

Anticipated Robotic Challenge Trials Tasks

Capability Exercised

Sample Tasks	Autonomy - Perception	Autonomy – Decision-making	Mounted Mobility	Dismounted Mobility	Dexterity	Strength	Endurance
1. Drive utility vehicle (e.g. Gator, Ranger)	X	X	X		X		
2. Travel dismounted 20 m through various terrains	X			X			X
3. Remove debris blocking entryway	X			X	X	X	X
4. Open door, enter building	X			X	X		X
5. Climb industrial ladder/stairs/walkway	X			X			X
6. Break through wall	X	X			X	X	X
7. Locate and close valve	X	X		X	X	X	X
8. Connect fire hose	X			X	X	X	X

Program Structure

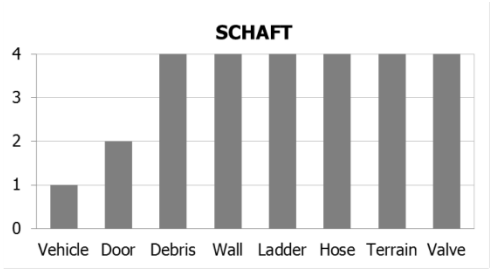


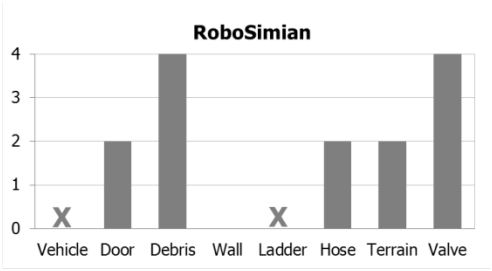
Note: Funding levels are approximate and vary by team.

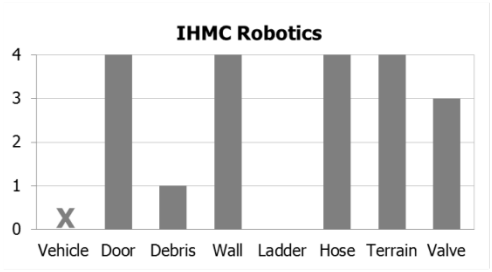
DARPA Robotics Challenge (DRC) Trials Expectations

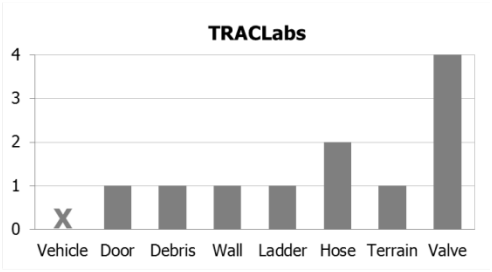
Performer Results: Exceeded Expectations

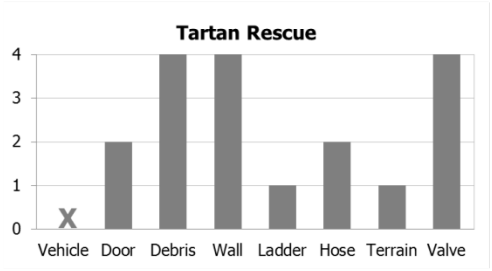
SCHAFT	27
IHMC Robotics	20
Tartan Rescue	18
MIT	16
RoboSimian	14
TRACLabs	11
WRECS	11
TROOPER	9
THOR	8
ViGIR	8
KAIST	8
HKU	3
DRC-Hubo	3
Chiron	0
NASA JSC	0
Mojavaton	0

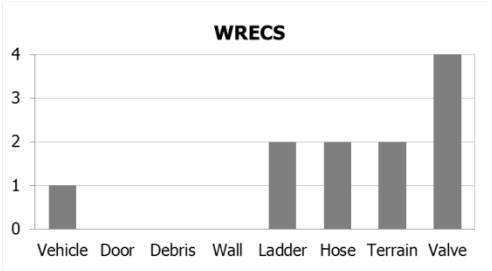


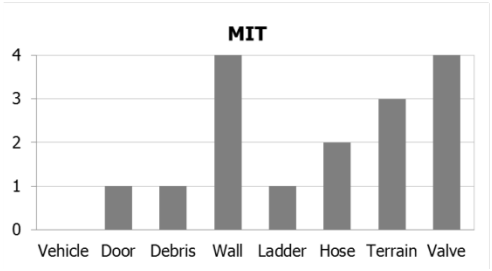


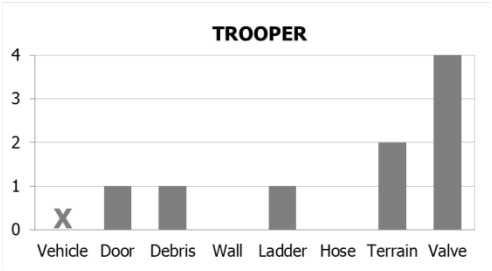






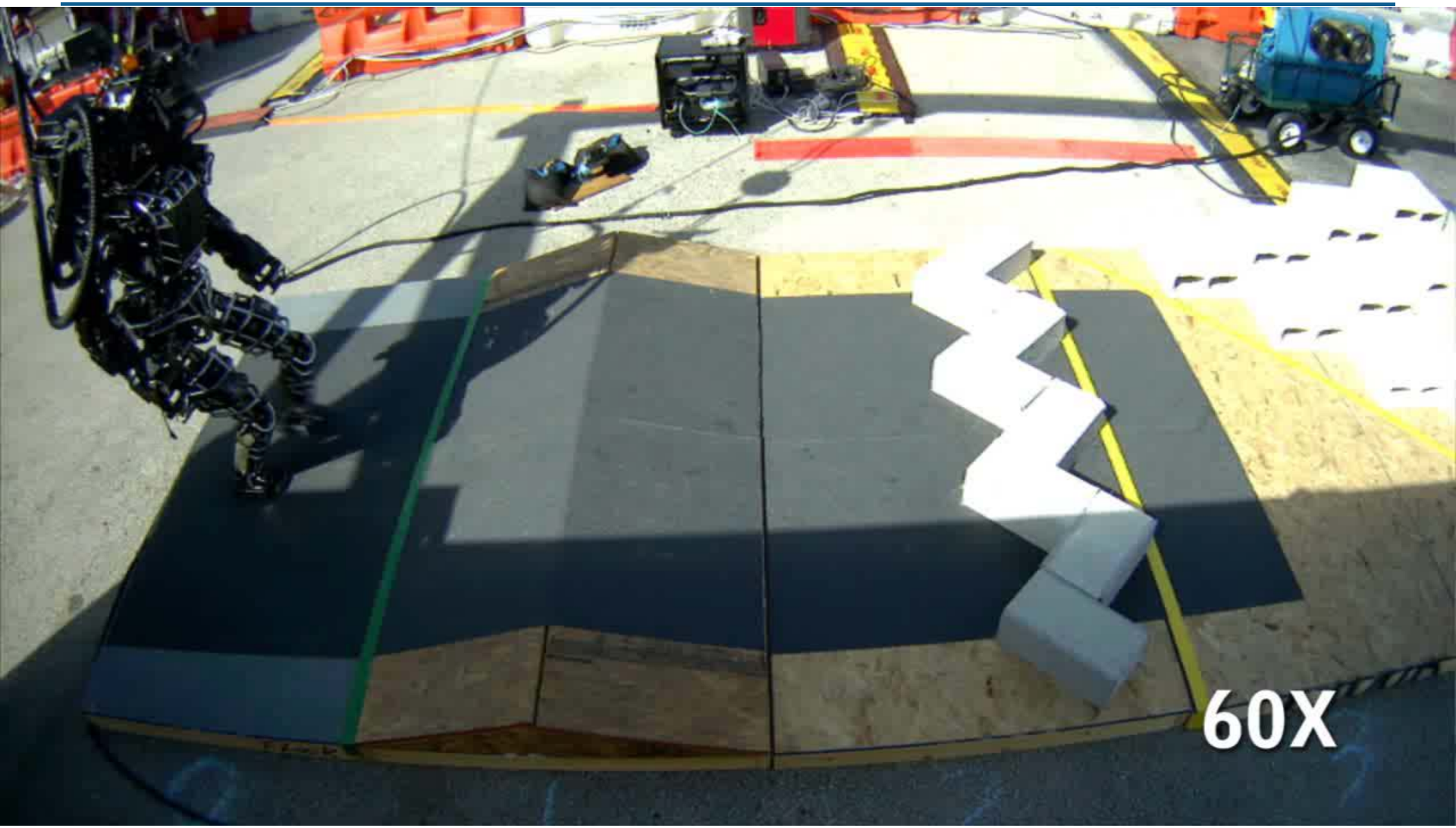






- Green: Team ranked in top 8
- Maximum of 32 points possible

DARPA Robotics Challenge – Rough Terrain Locomotion



What's Really Happening: Human-Robot Synergy

One Perceive – Plan – Act Cycle in Real Time

Close-Up of Operators

A (small number of) Highlights of Day 2 (Saturday)

On-Site + On-Line Statistics

- On-Site:

DARPA Robotics Trials - Attendance Statistics (2 Days)		
Category	**Number of People**	**Number of Teams/Organizations**
Staff	247	N/A
Team Members	383	16 + Boston Dynamics
Media	149	65 Outlets
Exhibitors	286	36 Exhibits
Spectators (estimated)*	5,000	N/A
TOTAL	**6,065**	

*Estimated 2,000 spectators on Friday and 3,000 on Saturday

- On-Line:

Website Statistics

Trials Day One: December 20th
Total visits: 18,585 (New visits: **12,792**; Returning visits: 5,793)
Top visits by country (United States = 11,712, Canada = 874, Japan = 847)
Total page views: 44,799 (Top Pages: Home: 24,572, Teams: 4,036, Gallery: 1,958)

Trials Day Two: December 21st
Total visits: 18, 629 (New visits: **11,631**; Returning visits: 6,998)
Top visits by country (United States = 11,272; Japan = 1,450; Canada = 614)
Total page views: 55,690 (Top Pages: Home: 25,752; Teams: 5,452; Schaft's Team Page: 2,570)

Social Media

YouTube (DARPATV): Live Feeds from the Trials as well as vignettes posted
828,390 views in December 2013 (an increase of 371.66 % from November 2013)
2,611,727 minutes of DARPATV watched (an increase of 1,189.07%)
44,084 views of Day 1 Live Broadcast
19,076 views of Day 2 Live Broadcast

Twitter Traffic: Ongoing Updates
DARPA Mentions: 34,048 Tweets in December
#DARPADRC: 6,119 mentions (possibly reaching **28,345,541** Twitter users)

Facebook: Ongoing Updates
Top DRC Facebook post : "Robotic Realities" infographic seen by 14,100 people

SecDef Chuck Hagel and TTO Director Brad Tousley with Atlas, April 23, 2014

Front Page of the Asahi Shimbun, April 30, 2014

Google gobbles up Japanese robot technology

“Google's acquisition of the Japanese start-up Schaft Inc. last November was a major shock to the Ministry of Economy, Trade and Industry, which had been seeking out ways to cooperate with the U.S. government in robot technology development.

U.S. President Barack Obama met with Schaft's young founders at the National Museum of Emerging Science and Innovation during his Japan visit last week. He kicked around a soccer ball with the humanoid Asimo robot and also observed a blue robot that was still in the developmental stage.

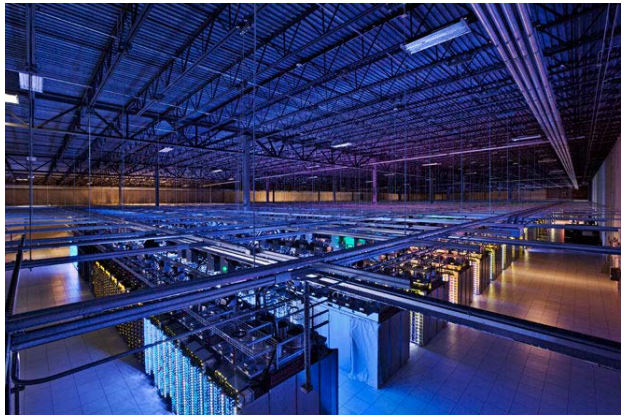
Yuto Nakanishi and Junichi Urata explained to the president that their robot could perform functions in areas where humans cannot enter, such as parts of the crippled Fukushima No. 1 nuclear power plant.

They both gave up their positions as assistant professors at the University of Tokyo to launch their company in 2012.”

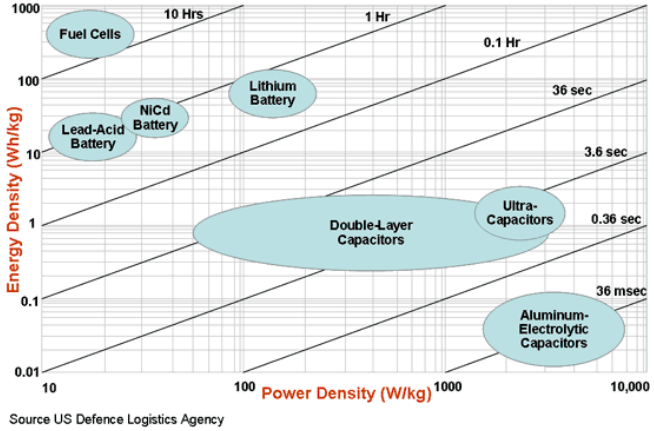
...

Cloud Robotics + Robotics Beyond the Cloud

- World's data storage now measured in Zetabytes (10^21 Bytes)
  - By Comparison – Number of Synapses in Human Brain: ~ 10^14
  - About 10 billion images have been uploaded
- World's computing capacity approaching 1 Zeta OPS
  - Google is one of world's largest consumers and manufacturers of computers
  - Highest performance video games now do 80% of their computing on the cloud
- High speed wireless connection to the internet becoming ubiquitous
  - Example Product: Google Chromecast ($35)
- Batteries have low energy density (approx. 1/10 fossil fuels)
  - SWaP is at a premium in mobile devices
- Hard part of robotics is between the ears (of the robot)
  - Many problems get easier with lots of data + processing
    - Example: Use of maps for autonomous driving
    - Example: Visual object perception
- **<u>Big Idea : Put the robot brain on the cloud</u>**
  - Side benefit – all robots learn from each robot's experience
- DoD still needs to develop competency in:
  - Unstructured, austere environments
  - Intermittent Communications
  - Better-than-human performance
  - Low SWaP
  - Limited a-priori knowledge
  - Critical (human life) missions

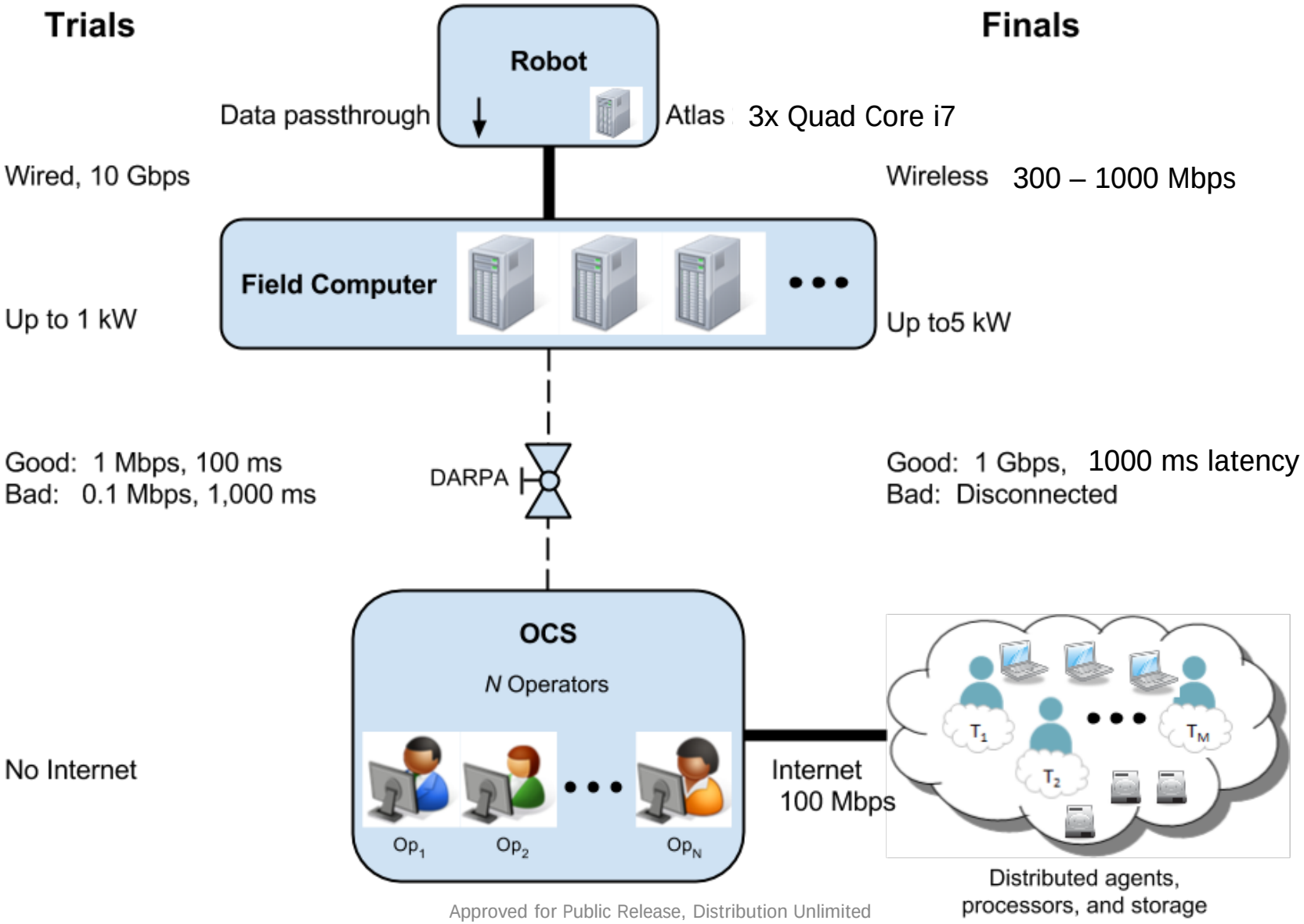


A server room in Council Bluffs, Iowa.
Photo: Google/Connie Zhou

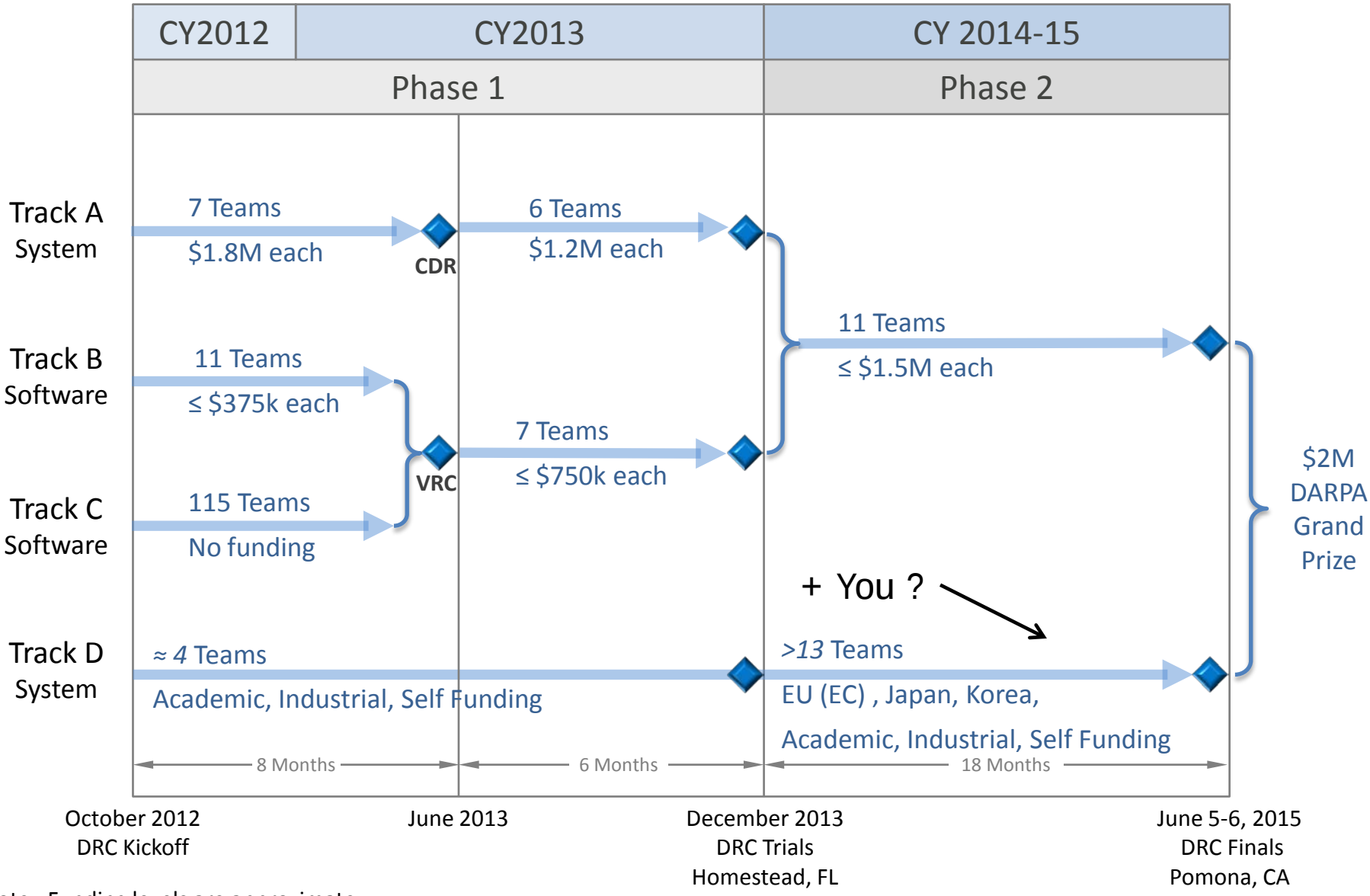


Source US Defence Logistics Agency

DRC Finals Communications Plan
Exploiting the Cloud and the Crowd



Questions ?



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www.darpa.mil