DARPA Disaster Response

Dr. Bradford C. Tousley
Director, Tactical Technology Office

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Robotics and Disaster Response

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Mission

The Defense Advanced Research Projects Agency (DARPA) was established in 1958 to **prevent strategic surprise** from negatively affecting U.S. national security and **create strategic surprise** for U.S. adversaries by maintaining the technological superiority of the U.S. military.

To fulfill its mission, the Agency relies on **diverse performers** to apply multi-disciplinary approaches to both advance knowledge through basic research and **create innovative technologies** that address current practical problems through applied research.

As the DoD's **primary innovation engine**, DARPA undertakes projects that are finite in duration but that create **lasting revolutionary change**.

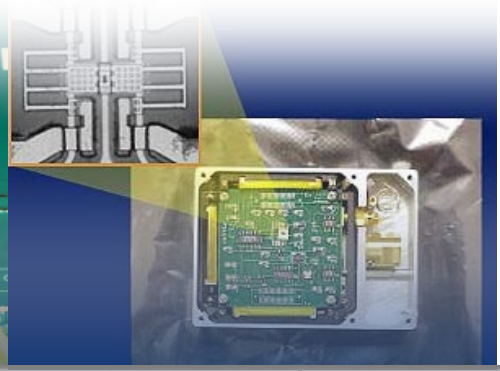
DARPA history

SATURN F1
Rocket Engine

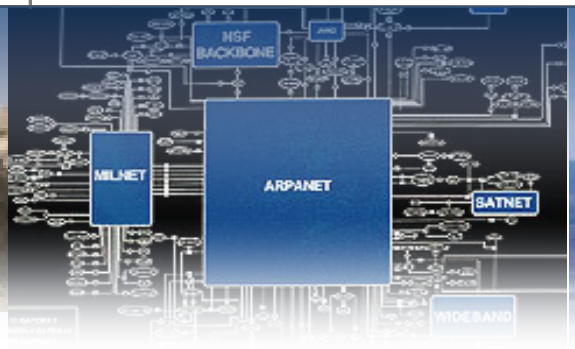
Stealth Fighter

Speech Recognition

Microelectromechanical Systems
(MEMS)



1960 1970 1980 1990 2000



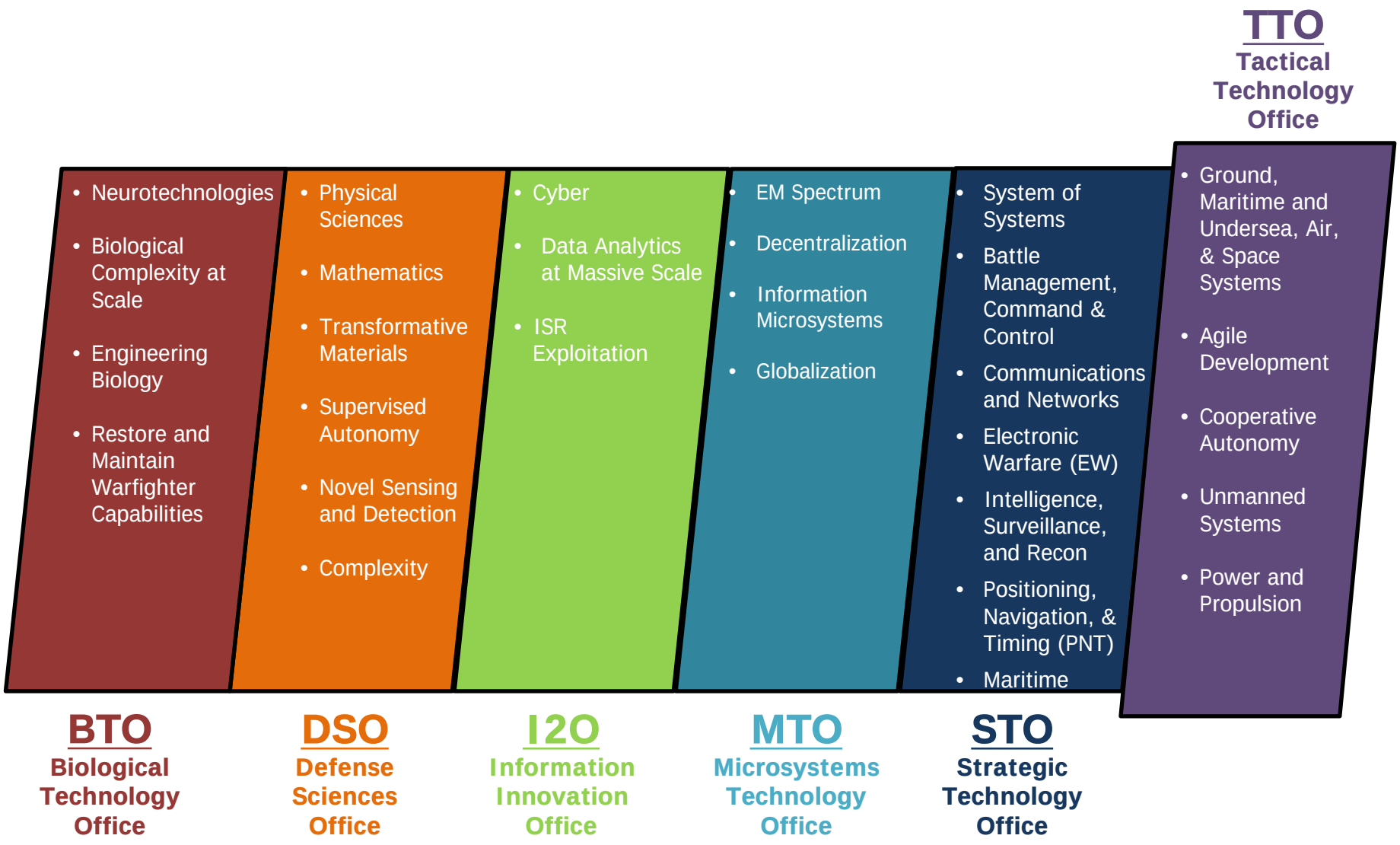
ARPA Established
1958

M16 Assault Rifle

ARPANET

Global Hawk

DARPA technical offices



Tactical Technology Office (TTO)

Vision

TTO will rapidly develop new prototype military capabilities that create an asymmetric technological advantage and provide U.S. forces with decisive superiority and the ability to overwhelm our opponents

Objective

To provide or prevent strategic and tactical surprise with very high-payoff, high-risk development of revolutionary new platforms, weapons, critical technologies and systems, approaches addressing affordability, as well as rapid agile development

Cross Cutting Themes

Agile development approach, cooperative autonomy, unmanned systems, power and propulsion

System Focus Areas

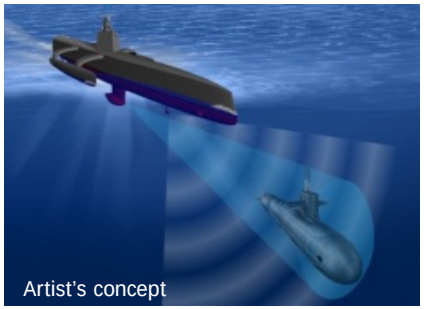
Ground Systems

Amplify unit / soldier effectiveness

Artist's concept

Maritime and Undersea Systems

Control the sea, influence events on land



Artist's concept

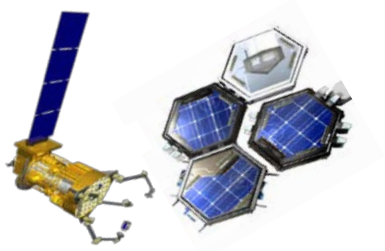
Air Systems

Control the air anytime / anywhere

Artist's concept

Space Systems

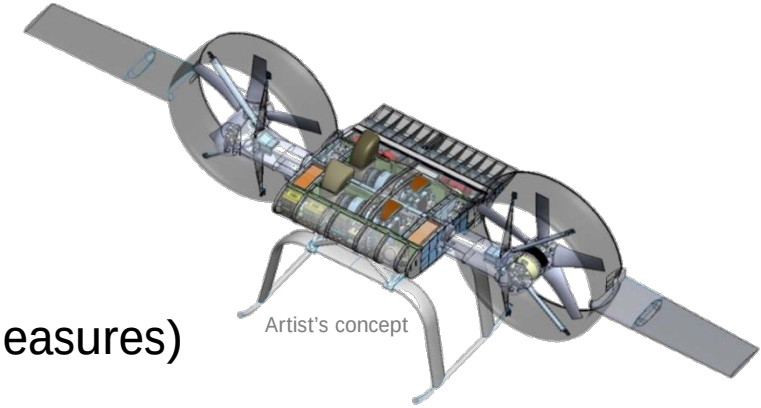
Normalize and simplify space



Artist's concept

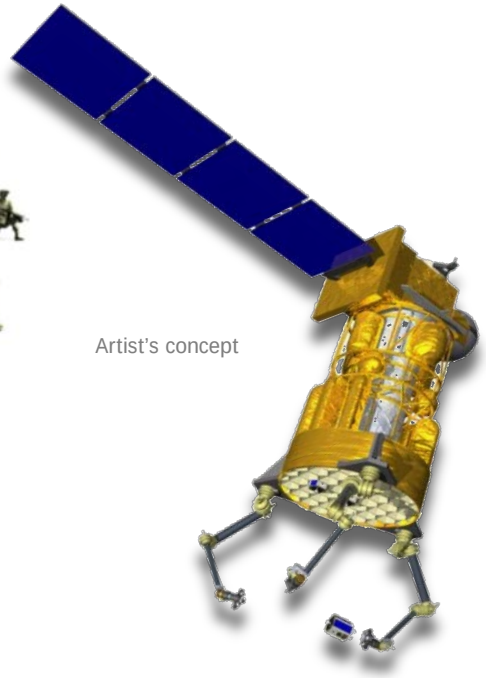
Tenets of our programs

- Big wins; decisive superiority
- Demonstrating prototypes
- Unmanned leverage (maximize effectiveness)
- Drive cost-effectiveness (system and countermeasures)
- Agile program execution


Artist's concept


Artist's concept


Artist's concept


Artist's concept

DARPA Robotics Challenge (DRC)

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
- Humanitarian assistance / disaster response (HA/DR) 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
- HA/DR is a universally understood and appreciated mission
- Enables participation of "best and brightest" performers, from anywhere in the world

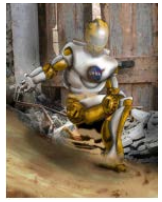
DARPA Robotics Challenge (DRC)

DRC aims to develop robot systems for disaster response, expanding DoD capability for humanitarian assistance disaster recovery missions through an international competition

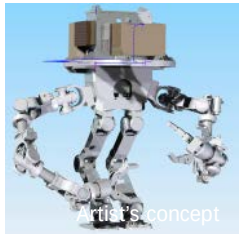
CMU NREC

Drexel

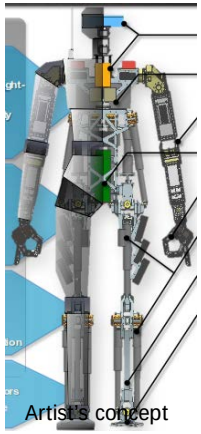
JPL



JSC



SCHAFT



VT

Systems Teams: Developed own robots and software

HKU

IHMC

MIT

Lockheed Martin

TORC

TracLabs

WPI

Software Teams: Developed own software to operate DARPA-provided Atlas robots

Objectives:

- Develop human-level robot mobility and dexterity for austere human environments
- Develop robotic capabilities to use human tools, from screwdrivers to vehicles
- Enable robot supervision by untrained operators over low-quality communications links
- Improve robot design quality and lower acquisition costs through a new class of simulation tools

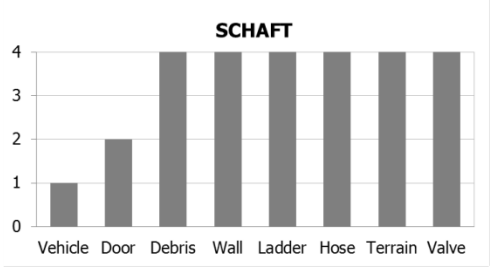
Key Technologies:

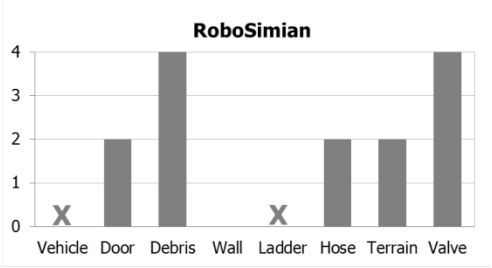
- Predictive modeling and simulation for control
- Supervised autonomy from perception to mobility of legged systems and bi-manual manipulation
- Real-time interactive, physically validated simulation tools for robot design
- Effective robot operator interfaces over low-bandwidth, high-latency communications links

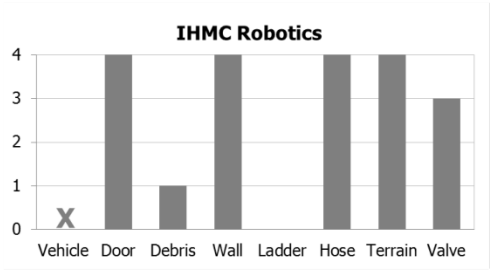
What's really happening: Human-robot synergy

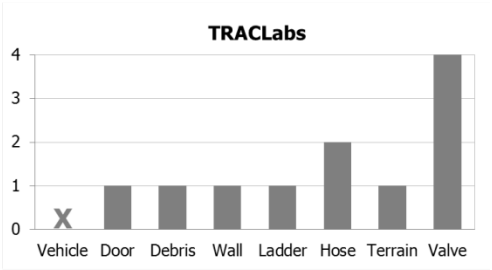
Performer results: Exceeded expectations

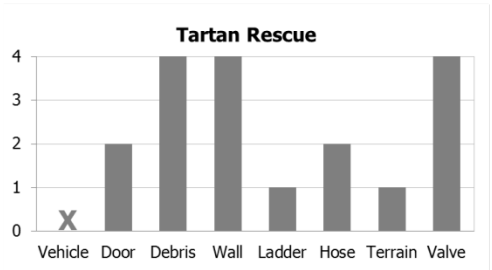
	Points Scored
SCHAFT	27
IHMC Robotics	20
Tartan Rescue	18
MIT	16
RoboSimian	14
TRACLabs	11
WRECS	11
TROOPER	9
THOR	8
ViGIR	8
KAIST	8
HKU	3
DRC-Hubo	3
Chiron	0
NASA JSC	0
Mojavaton	0

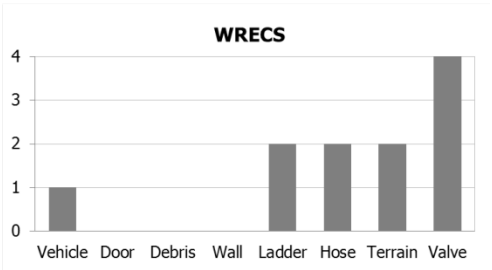


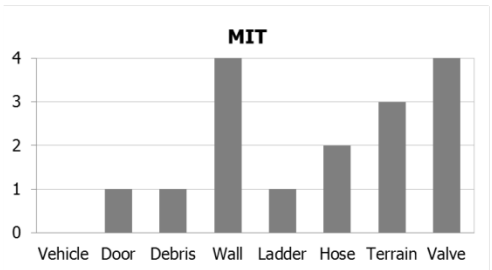


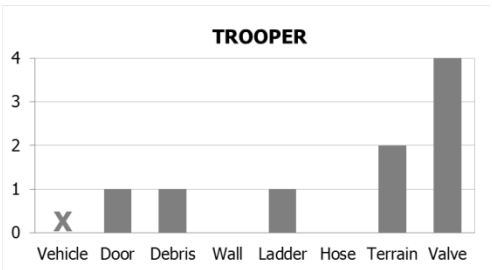










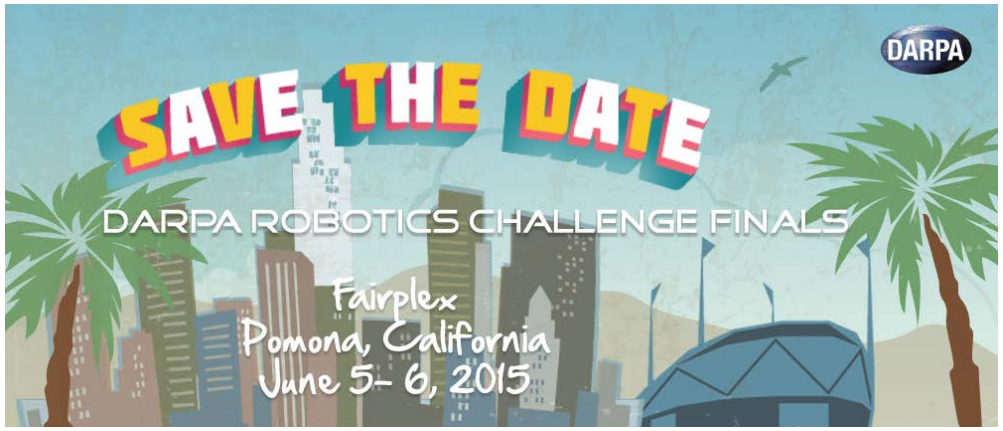


- Green: Team ranked in top 8
- Maximum of 32 points possible

*X= did not compete in event

DRC finals

From **June 5-6, 2015**, California will be the stage for the **DARPA Robotics Challenge (DRC) Finals**. Teams from around the world will meet at **Fairplex** in Pomona to compete for the $2 million prize to be awarded to the team that best demonstrates human-supervised robot technology for disaster response.



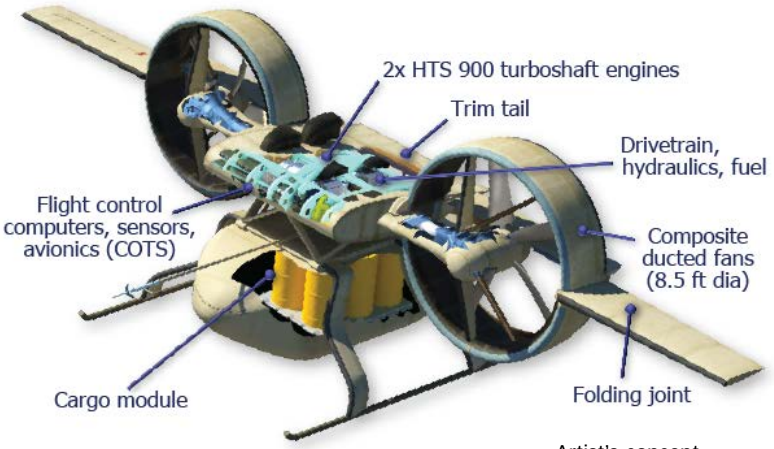
The 11 finalists are:

- **IHMC Robotics** (Florida Institute for Human & Machine Cognition, Pensacola, Florida)
- **Tartan Rescue** (Carnegie Mellon University, National Robotics Engineering Center, Pittsburgh, Pennsylvania)
- **Team MIT** (Massachusetts Institute of Technology, Cambridge, Massachusetts)
- **RoboSimian** (NASA Jet Propulsion Laboratory, Pasadena, California)
- **Team TRACLabs** (TRACLabs, Inc., Webster, Texas)
- **Team WPI-CMU** (formerly Team WRECS, Worcester Polytechnic Institute, Worcester, Massachusetts)
- **Team Trooper** (Lockheed Martin Advanced Technology Laboratories, Cherry Hill, New Jersey)
- **Team ViGIR** (TORC Robotics, Blacksburg, Virginia; TU Darmstadt, Germany; Virginia Tech, Blacksburg, Virginia; Oregon State University, Corvallis, OR)
- **Team THOR** (University of California, Los Angeles, California)
- **Team Valor** (Virginia Tech, Blacksburg, Virginia)
- **Team KAIST** (Daejeon Metro City, Republic of Korea)

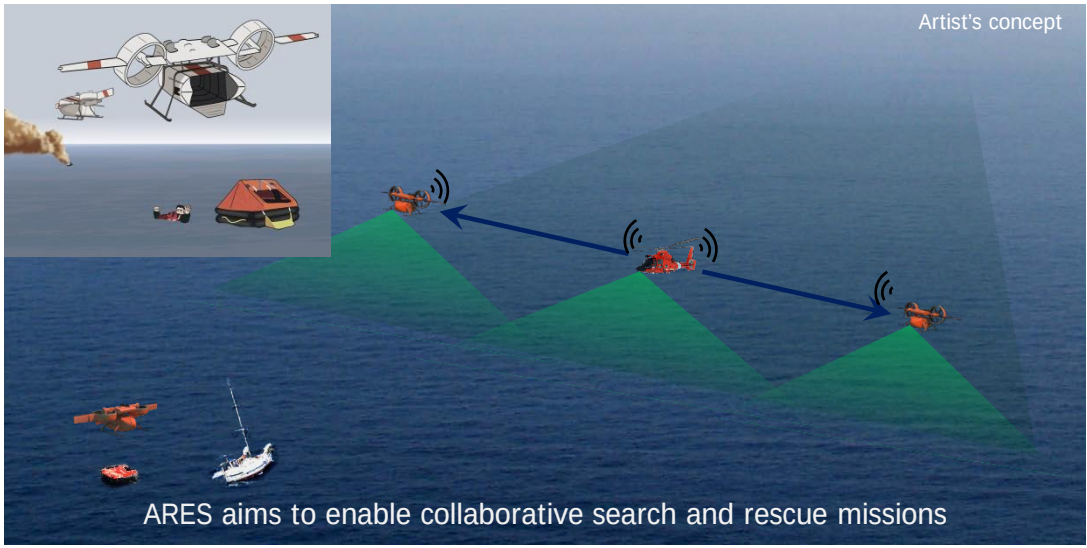
Aerial Reconfigurable Embedded System (ARES)

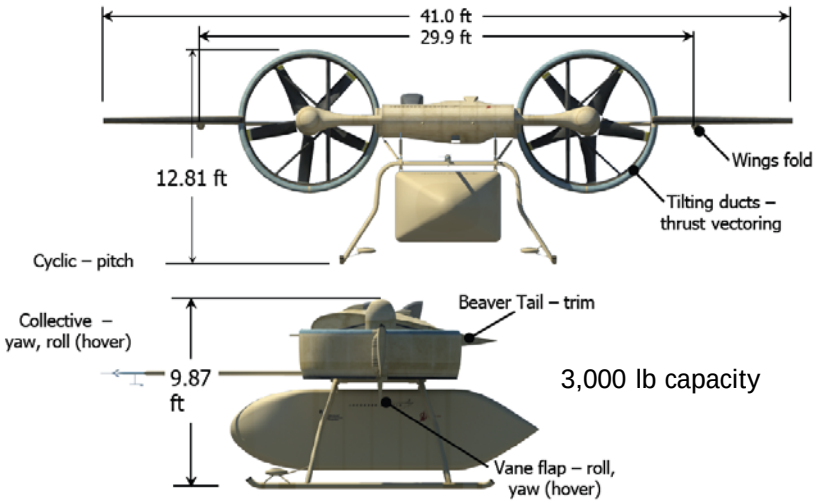
Aerial Reconfigurable Embedded System (ARES)

Goal: Modular vertical takeoff and landing (VTOL) flight module operated as an unmanned aerial vehicle (UAV)



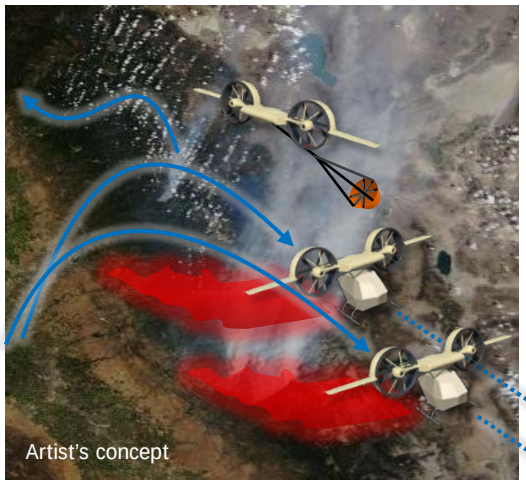
Artist's concept





3,000 lb capacity

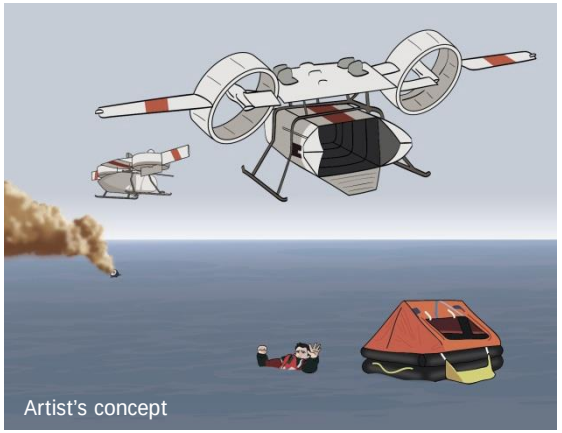
Artist's concept



Modularity would enable ARES to perform:

- Search and Rescue (SAR)
- Casualty evacuation
- Cargo resupply
- Humanitarian Relief
- Firefighting
- Infrastructure inspection

Summary



Search and Rescue

Cargo Delivery (to be demonstrated)

CASEVAC

- ARES Demonstrator is scheduled to fly in FY16:
  - Cargo module delivery and flight module return
  - VTOL and transition to and from forward flight
- Operational ARES would enhance the effectiveness of small units and would enable organic capabilities
  - Operation from tight landing zones and ships to support dispersed personnel in the field
  - Would allow ground units to resupply, receive ISR data, and improve CASEVAC response times
  - Affordable mission-specific modules designed to work with a common air vehicle
- Potential follow-on efforts with service users would include:
  - Integrating AACUS autonomy and sensing systems
  - Incorporation into USA Network Integration Evaluation (NIE) demonstrations
  - Incorporation into Weapons Training Instruction (WTI) demonstration by USMC MAWTS-1
  - Incorporation of advanced adaptive landing gear

ARES (formerly known as Transformer)

Fire **L**ine **A**dvanced **S**ituational Awareness for **H**andhelds (FLASH)

FLASH Overview

Objective: Adapt DARPA military technology to demonstrate the potential of mobile ad-hoc networks (MANET) and tactical tablet computing to provide powerful, flexible shared situational awareness for the first responder community. Apply ongoing DARPA investments towards giving firefighters and C2 nodes an ability to accurately and rapidly employ resources against wildfires.

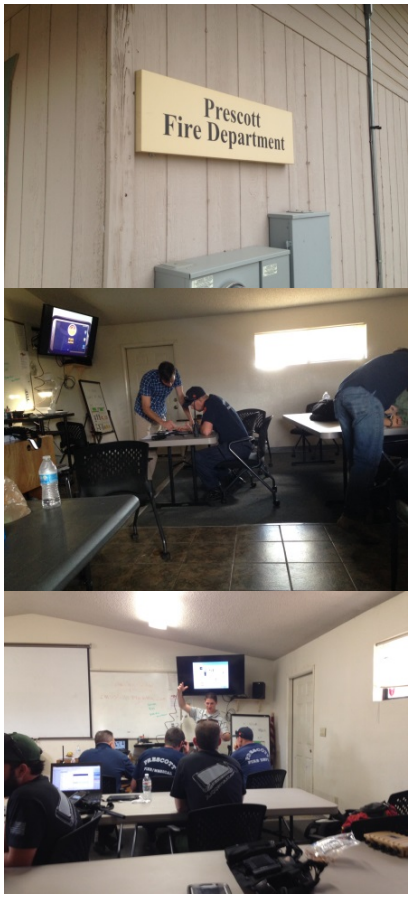
FLASH equipment

Tactical vest and software

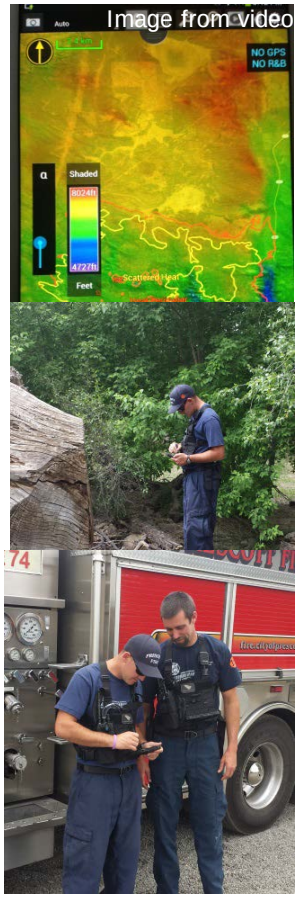
User trials and feedback sessions

FLASH demonstration highlights May 2014

26 MAY Memorial Day – Equipment Setup



27 MAY – Training Day 1 at Prescott, AZ



28 MAY – Live Demo Walkthrough

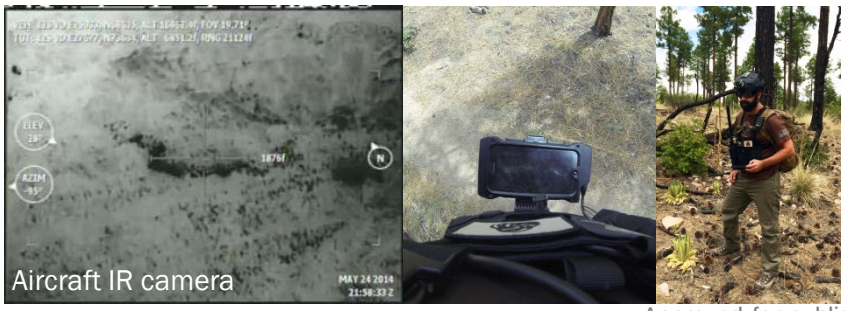
29 MAY – First Live Demo in Prescott, AZ with Connection to DARPA

Successful demonstration with multiple nodes locally and in DC area, dismounted ground, unattended ground sensors, airborne nodes, and command & control elements locally at Prescott and remotely at DARPA

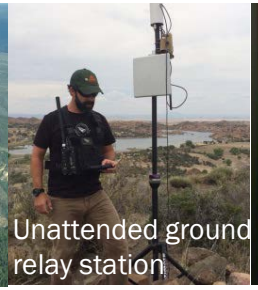
FLASH demo video highlights

The following video shows a speed-enhanced visualization of the May 29, 2014, demonstration in Prescott, Arizona. The colored lines emanating from the demonstration's command center represent real-time data links among the various participants on the ground, in the air and in the command center.

FLASH equipment loan enabled extended evaluation



Active network with multiple nodes, dismounted firefighters, ground relays, and airborne in Prescott, with reach back to DARPA in Virginia



Tactical Expandable Maritime Platform (TEMP)

Tactically Expandable Maritime Platform (TEMP) Humanitarian Assistance/Disaster Relief

TEMP aims to develop a modular technology to convert an unmodified commercial containership into a surrogate naval platform and to develop modular humanitarian assistance / disaster response (HA/DR) package

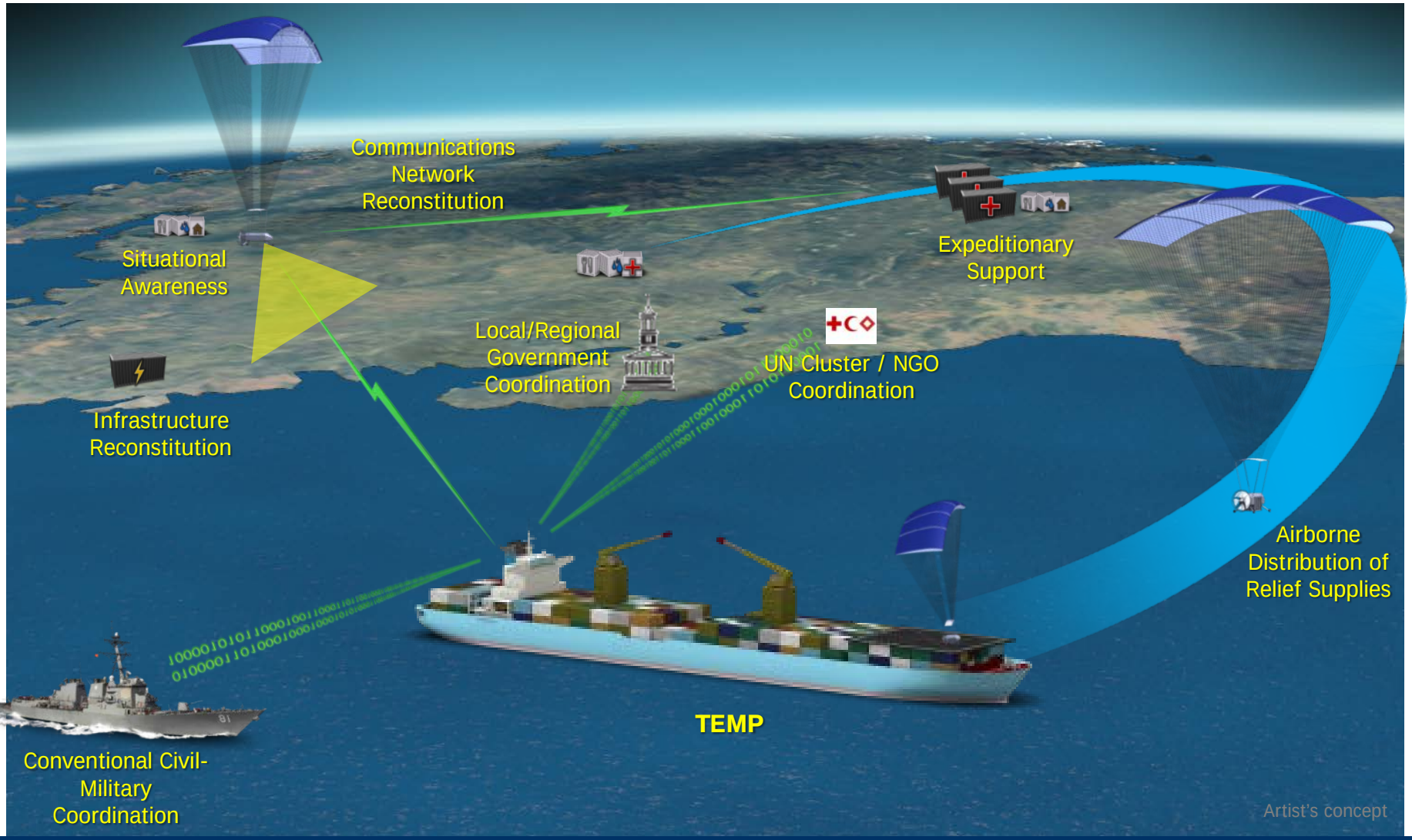
Program Technologies

- **Unmanned ParaFoil Delivery System** – Low-cost/high payload unmanned air vehicle for delivery of urgent supplies
- **Captive Air Amphibious Transport (CAAT)** – Innovative amphibious vehicle for delivering containerized cargo across the shoreline
- **Modular motion stabilized crane** – Rapid installation on ship, motion compensation up to sea state 3

Goals

- Modular system installed directly on an unmodified commercial container ship, operational within a few days of loadout with 30-day endurance
- HA/DR system would provide throughput of 125,000 lbs/day by air and 1,000,000 lbs/day across the shoreline

Envisioned Humanitarian Assistance/Disaster Relief (HA/DR) operations



Goal: Distribution of Immediate Lifesaving Relief Supplies

Envisioned Components of an HA/DR program

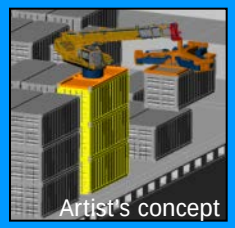
CONOPS / REQUIREMENTS

- Stakeholder coordination
- Requirements derivation
- Architecture design
- CONOPS development
- Integrated system performance analysis

Artist's concept

QinetiQ North America

HA/DR MISSION SYSTEMS



Artist's concept

Artist's concept

- Shipboard handling
- Modular crane
- Airborne distribution
- Surface distribution
- Situational Awareness
- C3

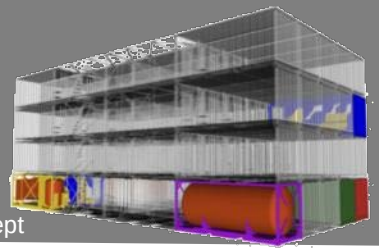
Raytheon

PLATFORM INTEGRATION

- Shipboard infrastructure
- Shipboard services
- Container access and integration
- Crew safety and support

Ingalls Shipbuilding
A Division of Huntington Ingalls Industries

NAVATEK



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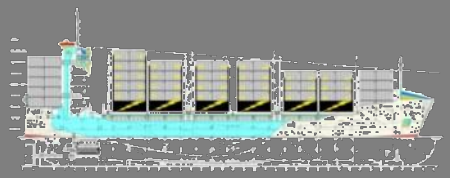

Artist's concept

www.darpa.mil