Transitioning to Autonomy: Lessons from Disaster Robotics

Dr. Robin Murphy

Center for Robot-Assisted Search and Rescue

Texas A&M University

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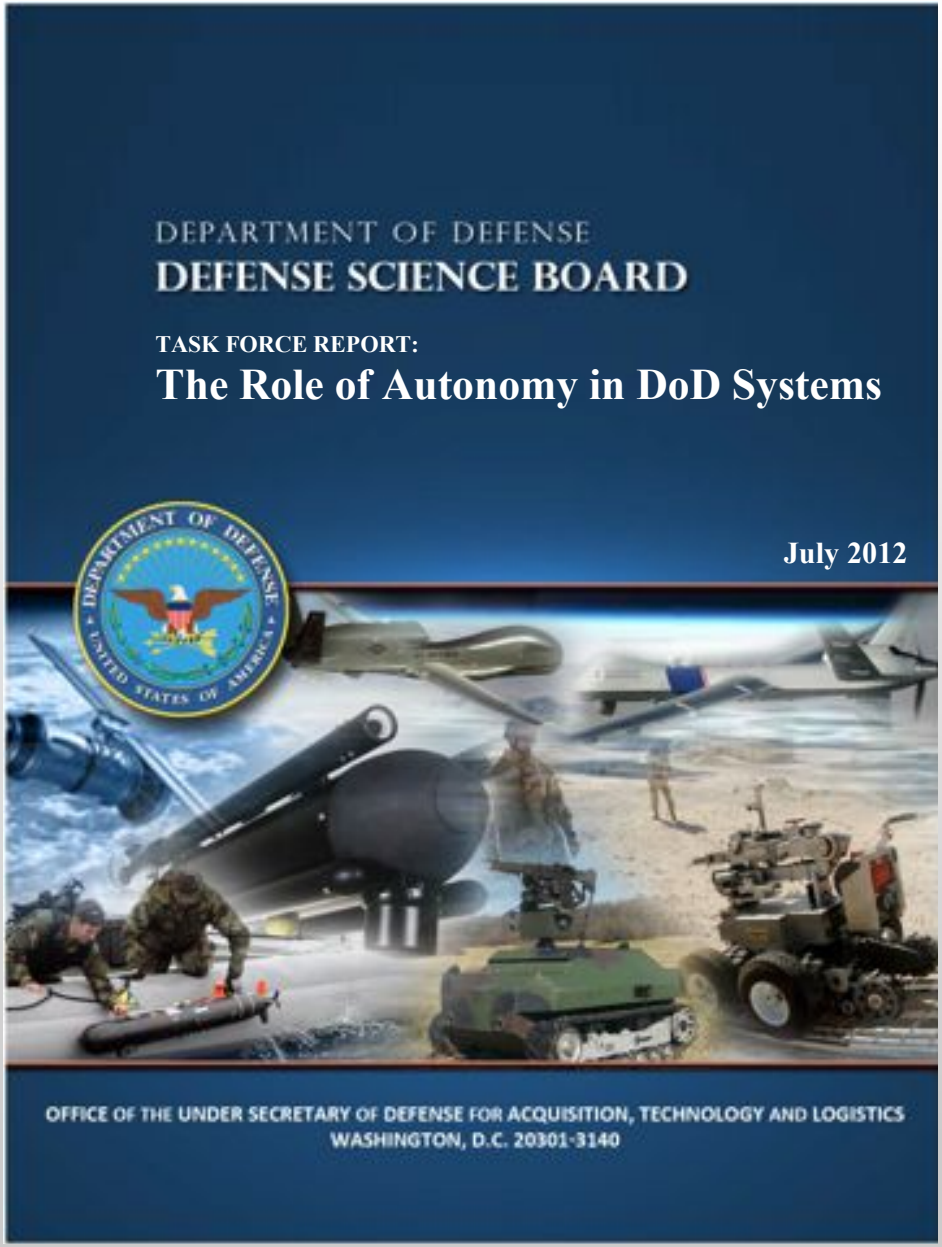
Outline

- Defense Science Board Study
- Autonomous capabilities
- Human oversight “behind” the SUAS
- Manned and unmanned aircraft
- Humans “in front” of SUAS

DSB 2012 STUDY


DEPARTMENT OF DEFENSE
DEFENSE SCIENCE BOARD
TASK FORCE REPORT:
The Role of Autonomy in DoD Systems
July 2012
OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS
WASHINGTON, D.C. 20301-3140

Impact

- Unmanned systems are having a worldwide impact (offensive and defensive) across the DoD, but we are operating in relatively benign conditions and at the initial stages of innovation for autonomy
  - Uses are primarily in air and ground applications to date
  - Marine systems have not achieved widespread usage
  - Space system benefits are primarily ground-based staff reduction and enhanced mission flexibility
- Main benefits of autonomous UxS* are to extend and complement human performance, not provide a direct replacement of humans
  - Extend human reach: perception, action, speed, persistence, size, scale, fatigue
  - Permit delegation and reduction of cognitive load – if explicitly designed to do so
  - Expand the adaptive capacity of the warfighter (e.g,. more options, more flexibility)
  - Synchronize activities of UxS, software, and warfighter over wider scopes and ranges
- Consequence of these systems include:
  - New forms of data overload
  - Gaps between responsibility and authority
  - Challenges in coordinating joint activity that may require more people or investment

* Unmanned ___X__ System, where X designates the domain – air, ground…

Recommendations

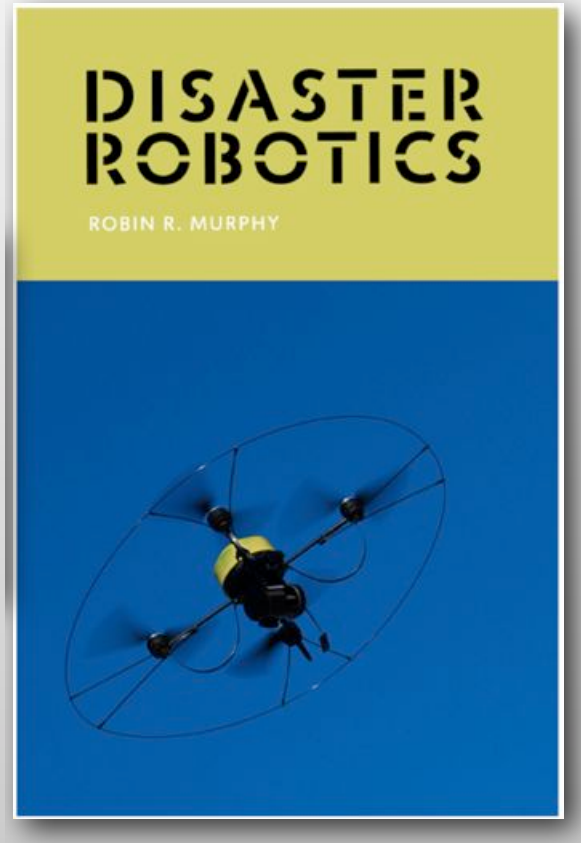
Technology

- Abandon efforts to define levels of autonomy and develop an autonomous system reference framework that
  - Focuses on how autonomy supports specific capabilities
  - Identifies cognitive functional responsibilities to be delegated to the human or the computer
  - Makes visible the systems level trades inherent in the design of autonomous capabilities
- ASD(R&D) should work with Services to develop a coordinated S&T to strengthen autonomy technology with emphasis on
  - Natural user interfaces and trusted human-system collaboration
  - Perception and situation awareness to operate in a complex battle space
  - Large-scale teaming of manned and unmanned systems
  - Test and evaluation of autonomous systems
- Stimulate the S&T program with challenge problems motivated by operational experience and evolving mission requirements
  - Create focused on-site collaborations across academia, government/NFP labs and industry
- Strengthen the government technical workforce for autonomy by attracting AI and software engineering experts and establishing career paths and promotion opportunities that will retain them

HOW DOES THIS RELATE TO DISASTERS? AND HOW DO I RELATE TRANSPORTATION?

Disaster Robotics, MIT Press 2014

- Updated: 44 Disasters in 13 countries, 18 are SUAS
  - CRASAR: 18 with 8 of the SUAS
- Plus over 35 exercises
- 50% of the terminal failures were human-robot interaction



SUAS for Disasters

Transportation Can Be Involved

What I Look For…

- Where are the humans?
- What are the autonomous capabilities needed?
- Where is/should be human oversight? What happens when something goes wrong?
- Will there be any manned aircraft in the area?

WHERE ARE THE HUMANS?

Humans “Behind” and “In Front”

Operator/flight director/ responsible party

Non-operators who may interact with the robot

WHAT ARE THE AUTONOMOUS CAPABILITIES NEEDED?

Autonomous Capabilities?

- Flight following terrain to stay in AGL
- Sense and avoid obstacles, less so about manned aircraft
- Autonomous take-off and landing

Opportunities: Autonomous Capabilities

- Diagnostics/checklist
- Health/FDIR

Recommendations from DSB Study

- Consider echelons: how can autonomy benefit different stakeholders, not just the pilot
- Consider timelines: not just flight
- Consider tradespaces in design: optimality versus flexibility, etc.

WHERE IS/SHOULD BE HUMAN OVERSIGHT? WHAT HAPPENS WHEN SOMETHING GOES WRONG?

Air Traffic Control Metaphor Fallacy

- UAS are autonomous so one person can supervise multiple UAS, just like an Air Traffic Controller
- When an UAS experiences trouble, person can take-over control of that UAS
- **NOT!**

www.projectrho.com

Murphy, R.R. and J.L. Burke. 2010. The Safe Human-Robot Ratio (Chapter 3), in Human-Robot Interactions in Future Military Operations, F.J. M. Barnes, Editor Ashgate. p. 31-49.

Air Traffic Control Fallacy

- UAS are supervised by Air Traffic Controllers
- When an UAS experiences trouble, person can take control of that UAS

- **ATC do not become pilots during a crisis, they communicate and advise pilots**
- **Pilots are physically situated within the aircraft and have different skill sets**

Murphy, R.R. and J.L. Burke. 2010. The Safe Human-Robot Ratio (Chapter 3), in Human-Robot Interactions in Future Military Operations, F.J. M. Barnes, Editor Ashgate. p. 31-49.

Human Out of the Loop Control Problem

- Human *out-of-the-loop (OOTL) control* studies since 70's show that **people may not seamlessly not take over from automation failures** *(Kaber & Endsley; Kessel & Wickens, Young)*

CIDRE SWAT exercise Wichita, KS 2007

Quiz:
Can you do this?

Exocentric versus egocentric viewpoint
Mediated viewpoint
Skill sets
Attention
Context and Displays

Quiz:
Can you do this **in 5-8 Seconds**?

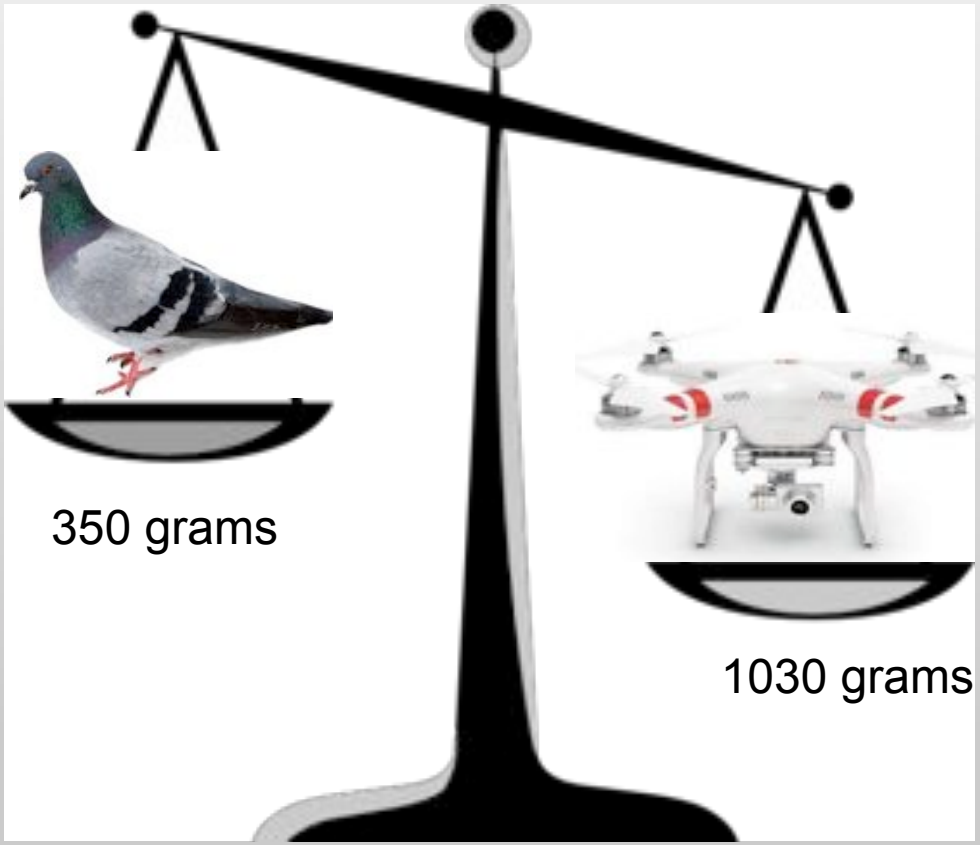
Exocentric versus egocentric viewpoint
Mediated viewpoint
Skill sets
Attention
Context and Displays

Operators Turned Off Autonomy At Fukushima

WILL THERE BE ANY MANNED AIRCRAFT IN THE AREA?

Why I Care About Manned Aircraft

SUAS Are More Dangerous Than Exploding Pigeons



Manned Aircraft Don't Follow the Rules Either

Manned-Unmanned: Thoughts

- GA can't see SUAS, even if they were looking
- We have to look for them
- SUAS staying in "safe lane" or "altitude" isn't guaranteed: *who writes the software? Who validates the software?*

RETURN: WHERE ARE THE HUMANS?

Humans “In Front”

Smithsonian Magazine

Why Are People So Comfortable With Small Drones?

The FAA will soon allow commercial drones to fly in U.S. airspace, but researchers have found that they aren't seen as much of a nuisance at all

By Richard Conniff
SMITHSONIAN MAGAZINE | SUBSCRIBE
JUNE 2014

Duncan, B. A., & Murphy, R. R. (2012*A preliminary model for comfortable approach distance based on environmental conditions and personal factors* Paper presented at the 2012 International Conference on Collaboration Technologies and Systems (CTS).

What Could Go Wrong?

Lessons from Disaster SUAS

- Focus on autonomous capabilities over the entire process and set of stakeholders
- The UAS will be a joint cognitive system with people "behind" the robot- if only for oversight
- Assuming the human will be able to take-over is not realistic: system intelligence has to be better
- People, and people in manned aircraft, will be "in front" of the SUAS doing unpredictable things