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Sandia National Laboratories






Unmanned Aerial Systems

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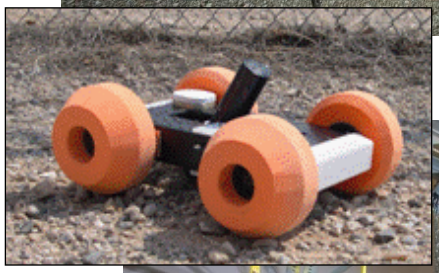
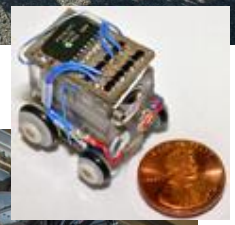
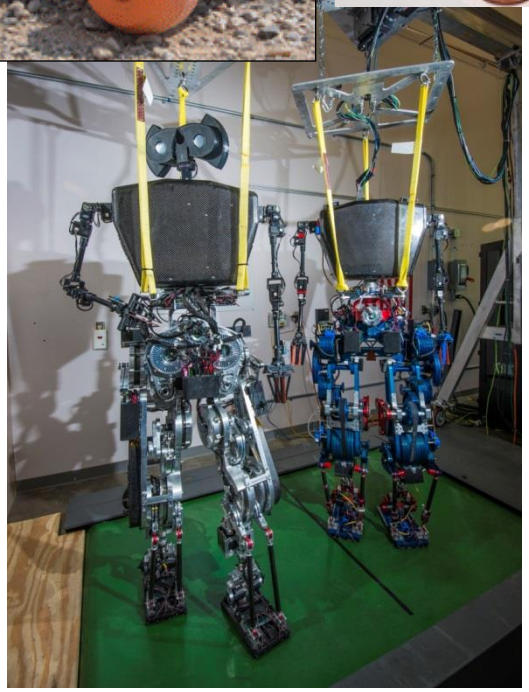
Sandia Robotics







- Sandia Interest in Unmanned Aerial Systems
  - Testing and deployment of technology
  - National Security Challenges
  - Protection of government assets and facilities
  - Environmental research and sensing
  - Development of advanced robotic vehicles
  - Integrated simultaneous control of ground, maritime, aerial unmanned vehicles.

Challenges

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- **Unmanned Aerial Systems (UAS) are the fastest growth sector within the US aviation industry!**
  - **Estimated 1,000,000 sold in the U.S. in 2015 alone**
  - **Near misses happening regularly**
    - **Dozens > 9,000 ft. above ground level (hobbyist ceiling is 400 ft.)**
    - **First mid-air collision with manned aircraft reported**

Privacy Concerns

- **What is trespassing with small UAS?**
- **Delicate balancing act: public/privacy concerns vs. national security?**
- **Current UAS Technologies were not developed to comply with existing Federal Aviation Administration (FAA) airworthiness standards**
- **Technology revolution has moved development from graduate laboratories to high school student basements**
- **Current research is poised to continue transforming UAS capabilities (rapid evolution!)**
- **Detection and timely assessment of small UAS at range is a challenge**
- **Neutralization is problematic for technical and policy reasons**
  - **Continental United States operations may limit use of some technologies**

Use the Capabilities/Manage the Challenges

Technology and Applications Exploding

Delivery


Policing


Safety/Monitoring


Farming


Security

Movie Production


Wildlife Management


Aerial Photography


Selfies

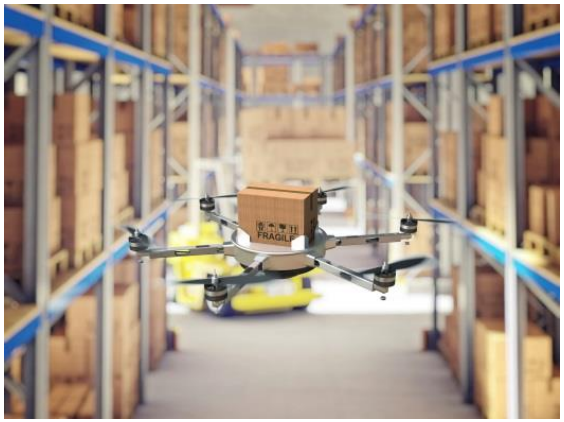

Disaster Response


Search and Rescue

Illicit Uses

Quadcopters are a popular type of UAS

UAS of all types and sizes will be in New Mexico



Energy efficiency is a Key Driver to UAS development

Google: Internet from the Sky

Photo courtesy of Google, Inc.

Impact to Telecommunications

Example UAS Capabilities

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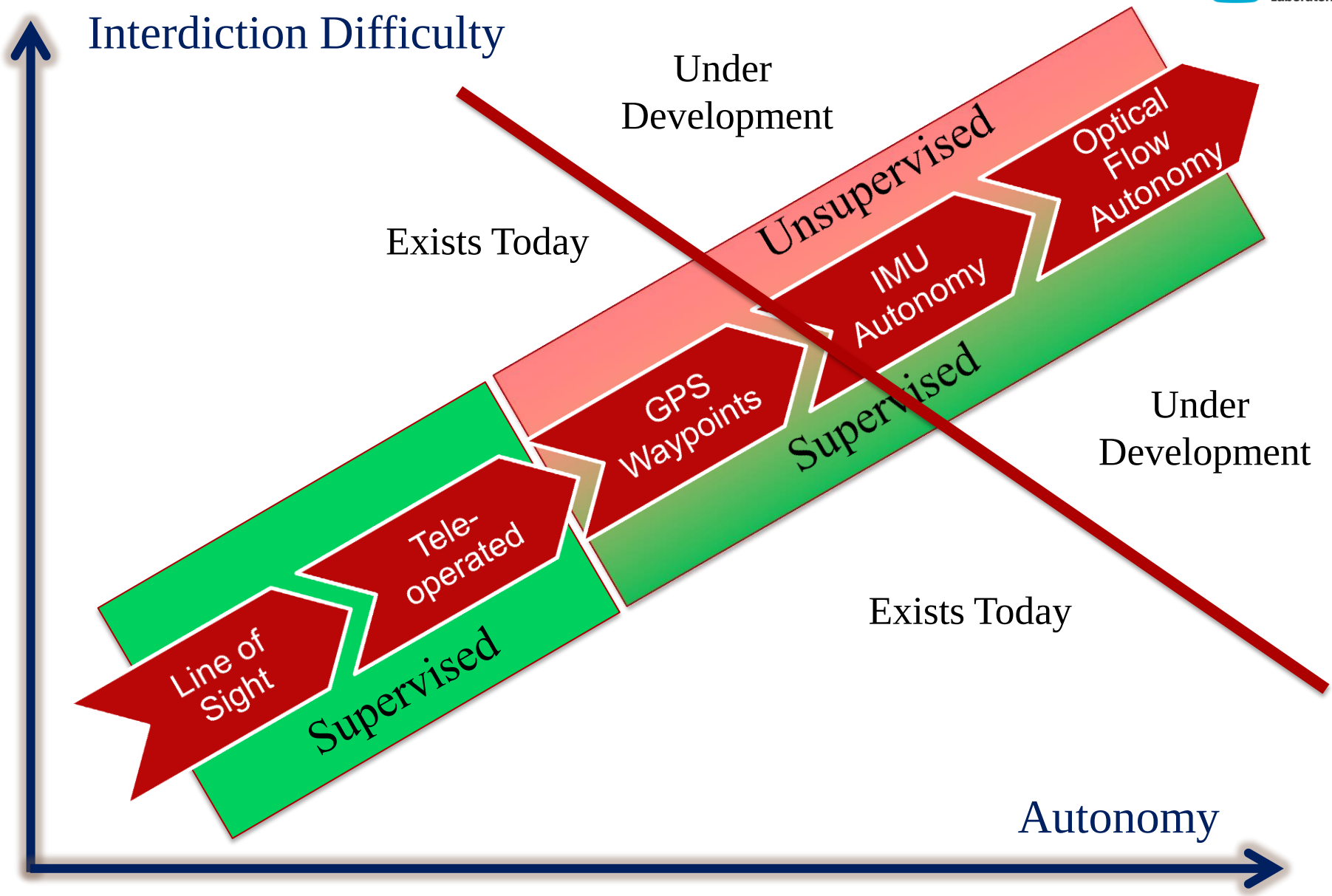
Hexacopter:

- 4lb payload
  - 10-12 minutes
- 10lb
  - 5minutes

Octocopter:

- 12lb payload
  - 10-12 minutes
- 20lb
  - 5 minutes

Speeds of 60-80 MPH


Interdiction Difficulty
Under Development
Exists Today
Unsupervised
Optical Flow Autonomy
IMU Autonomy
GPS Waypoints
Supervised
Under Development
Exists Today
Tele-operated
Line of Sight
Supervised
Autonomy

Government Use of UAS

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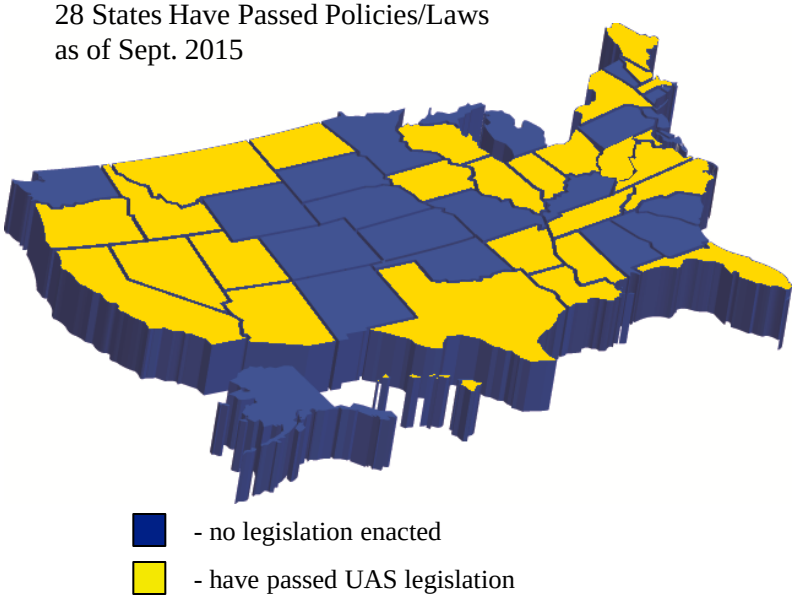
- **National security**
  - Military
  - Site protection
- **Homeland security**
  - Situational awareness
  - Pursuit/response
- **Infrastructure protection/inspection**
  - Critical infrastructure
  - Landmarks

- **Near-term development solutions**
  - Situational awareness
  - Determine intent
  - Attribution
- **Mid to long-term development solutions**
  - Alarm assessment
  - Tagging and tracking
  - Delay and denial tactics
  - Bird-on-bird neutralization

State Legislation to Date

28 States Have Passed Policies/Laws
as of Sept. 2015



- no legislation enacted
- have passed UAS legislation

Category	# States* with Legislation Passed
Privacy	12
Law Enforcement Restriction	12
State Operations	7
Hunting Restrictions	6
Critical Infrastructure / Use at Public Events	4
Weaponization	2
State Primacy of UAV Laws	1
Restrictions Over Prisons	1

* - Cities and municipalities have enacted most radical laws to date

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ABQ Photo courtesy Bill Tondreau www.sumnerdene.com

Key Points for Small UAS

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- UAS technology is rapidly evolving
- Care must be taken to not limit security and public service use
  - As policy is developed, it is important to consider all impacts of regulations that may affect local and national security and local/state economy
- Very Large Market Forces and Potential
  - Major corporations are sponsoring the advancement of UAS
  - Applications are still being identified

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Questions?

Future Direction for UAS R&D

- Investigating the future for use of UAS
  - Autonomy
  - Push button swarms – one person controlling platforms
  - COTS integration
  - Payloads
  - Multi-purpose platforms (additive mfg.)
- Rapid technology evolution
  - No comm link
    - No signal to sense or defeat
    - Attribution?
  - Rapid, reactive control
    - Low and fast
    - Randomizes behavior from blue perspective
  - No attribution…!!


Photo: Sandia National Laboratories

Google: Internet from the Sky


Photo courtesy of Google, Inc.


Photo: Sandia National Laboratories

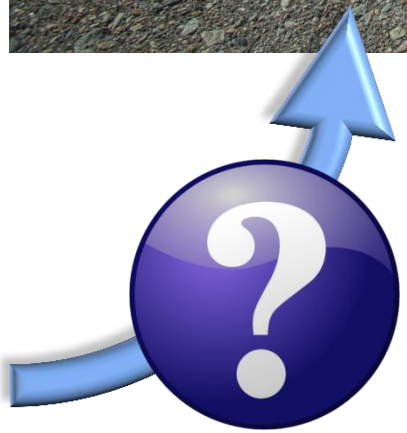

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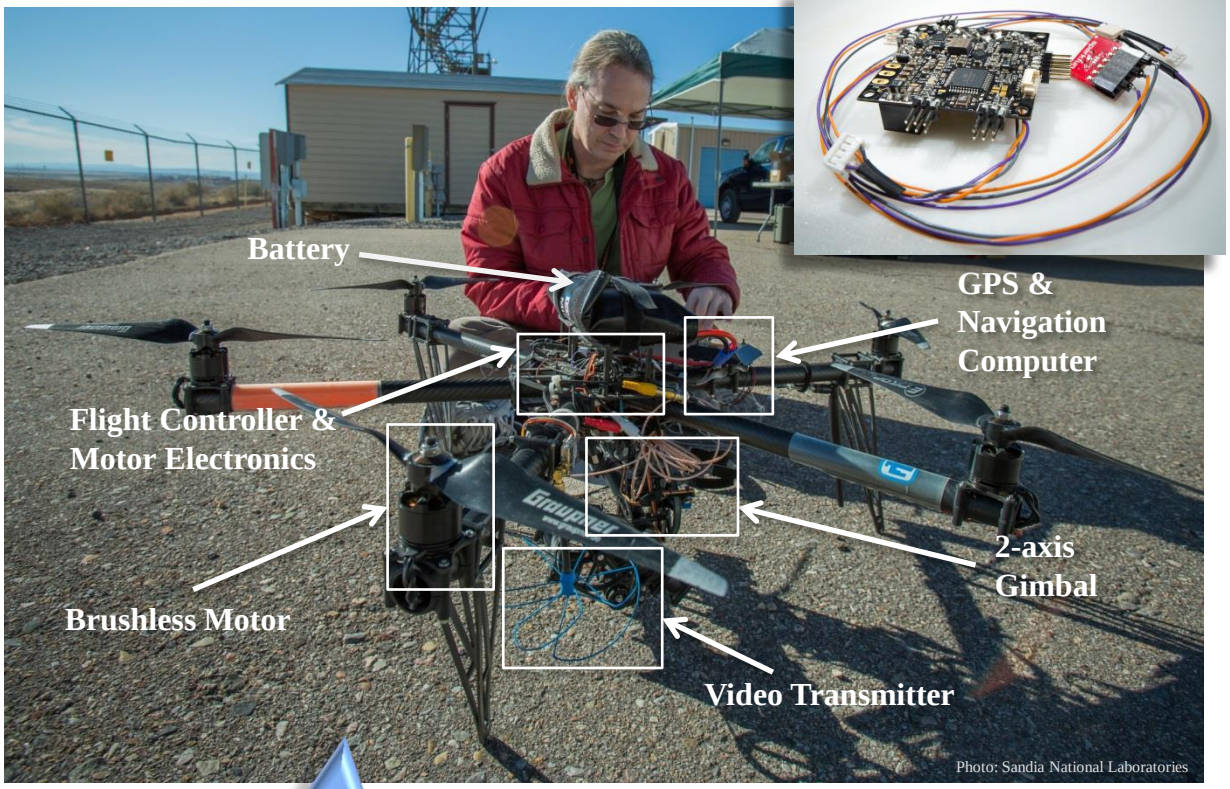
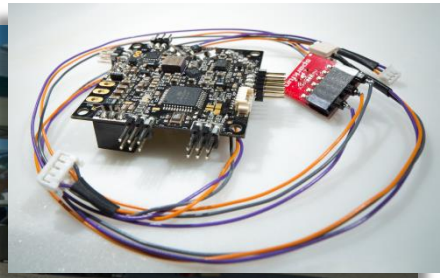
Photo: Sandia National Laboratories


Battery
GPS &
Navigation
Computer
Flight Controller &
Motor Electronics
2-axis
Gimbal
Brushless Motor
Video Transmitter
Photo: Sandia National Laboratories



Notional Aircraft Separation

	Visual	Radio	Transponder	Ground Radar	Air Traffic Control	Altitude Separation Regulations
Airport Airspace						
Class Bravo						
Class Charlie						
Class Delta						
Class Echo/Golf						
Inflight						
Class A (+18,000 ft)						
VFR (3000 AGL - 17,999MSL)						
IFR (3000 AGL - 17,999 MSL)						
Equipment Availablity						
Airliner						
Helicopter						
Light Aircraft						
Glider						
Hot Air Balloon						
Advertising Ballon						
Hang Glider						
Kite						
Crane						

Mandatory

Optional

This is a simplification of airspace separation - See FAA regulations for details