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Title: 3D Background Oriented Schlieren Imaging to Detect Aerial Improvised Explosive Devices

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3D Background Oriented Schlieren Imaging to Detect Aerial Improvised Explosive Devices

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Mentors
Dr. Garrett Kenyon
Dr. Harald Dogliani

UAS Detection

TEAM

- Chris Oshman - Ph.D Mechanical Engineering (MEMS Fabrication of Thermal/Fluidic Systems)
- Dustin Demoin - Chemistry graduate student at University of Missouri - Columbia working on a radiopharmaceutical project
- Michael Ham - LANL P21 Image processing

Detection

Rezwan Ferdaus

www.boston.com

blog.heritage.org

GPS guided UAS

- 2011 - arrested for plotting to fly 3 remote control planes into the US Capitol and the Pentagon
- $6500 remote-controlled plane that could be guided by GPS and fly at 100mph (160km/h).

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Prevent a UAS 'Boston'

- UASs will become common for commercial use
- Rapidly advancing technology such as silent engines, better batteries, GPS, surveillance
- Small UAS platforms in the real world are difficult to detect.

  -Keith Lindsay, LANL

UAS Detection

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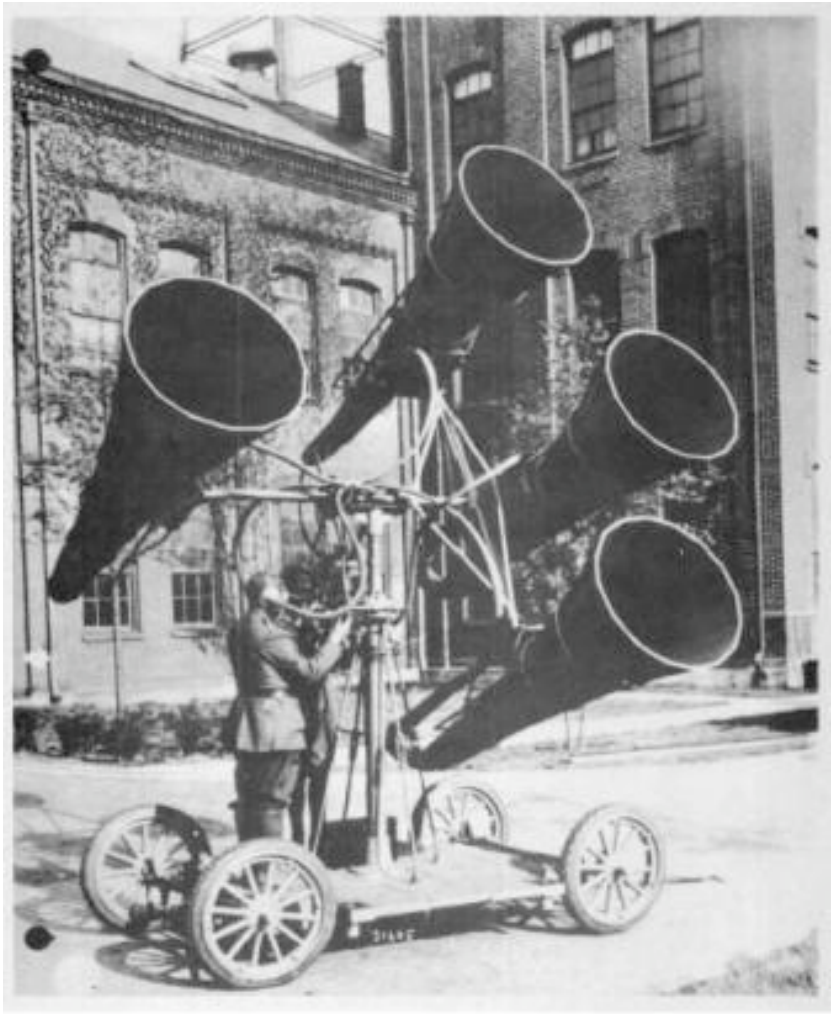
Aircraft Detection Technologies



Early Aircraft Sound Detection

dodlive.mil

UAS Detection

RAdio Detection and Ranging

http://computer.yourdictionary.com/radar

Small UASs - low radar cross section, stealth possibilities

UAS Detection

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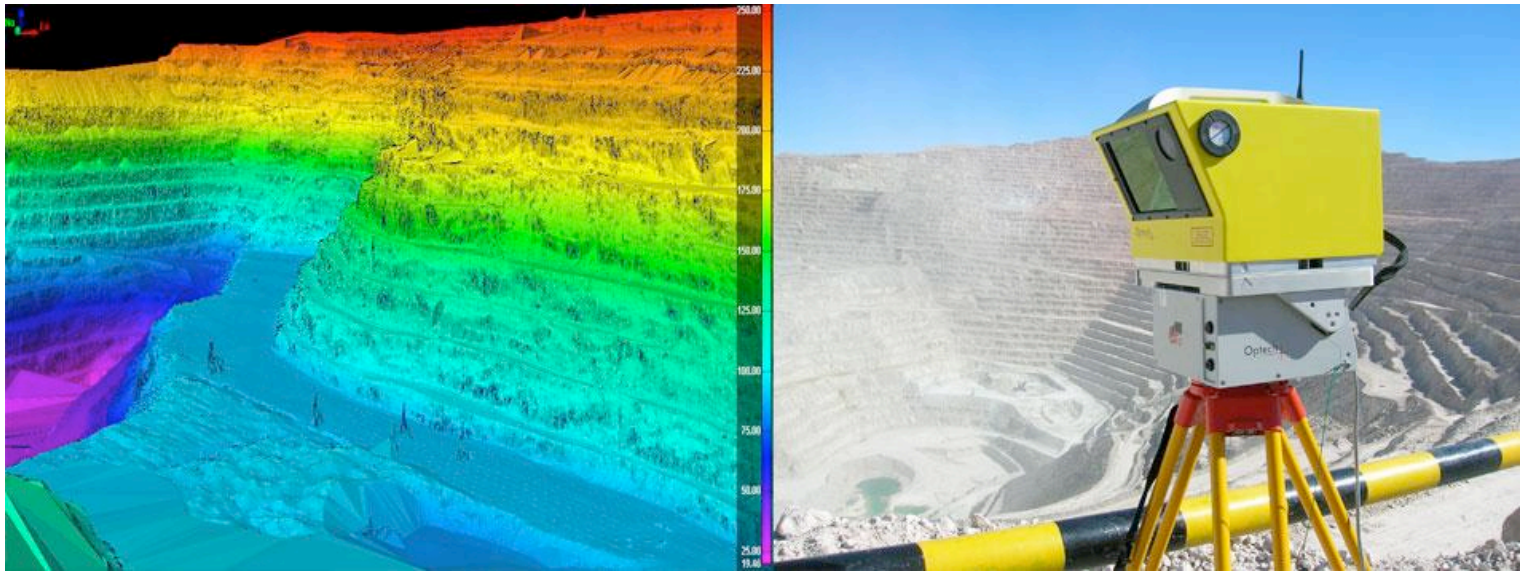
LIDAR
Laser Imaging Detection and Ranging



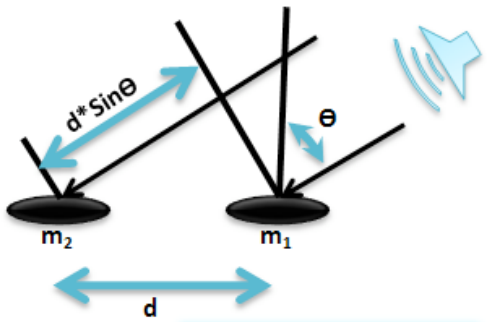
http://www.mapping-solutions.co.uk/applications/images/lidar_mining.jpg

Least expensive LIDAR system ~$20,000

UAS Detection

Acoustic Source Localization

- Use of microphone array
- Detect and characterize UAV
  - Are there changes to UAV sound based on payload, modifications from designer, age of system, etc.?
  - How big would your library of sounds need to be to account for differences?
  - Limited range
  - Active research to decrease noise
  - Use swarm



$$\theta = \sin^{-1}\left[\frac{\zeta * C}{f_s * d}\right]$$

C – Speed of sound
ζ – Time Delay between Microphones
F_s – Signal Sampling frequency
d – Inter Microphone Distance

http://www.eng.uwaterloo.ca/~dcbickfo/project.html

IR

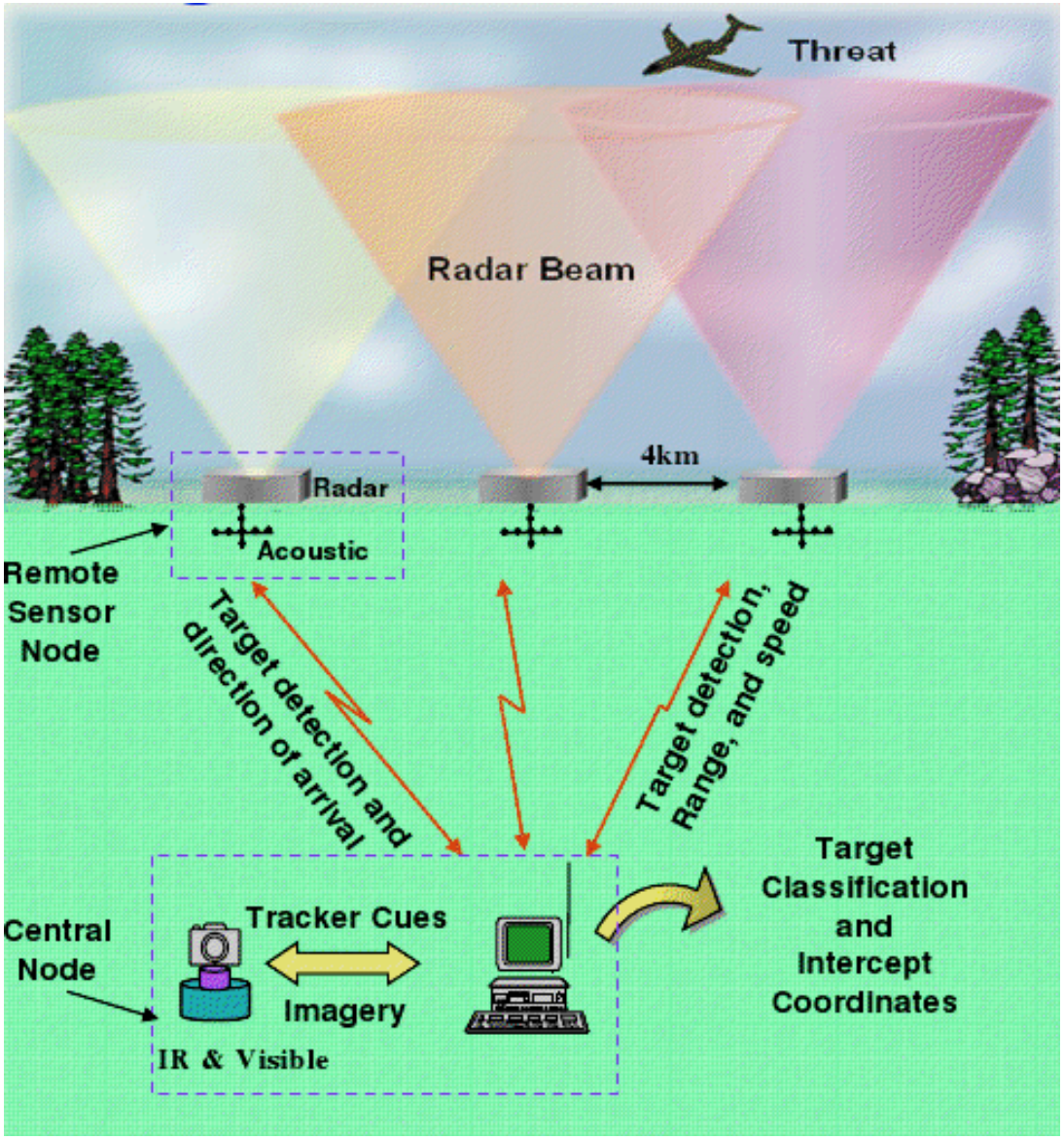
Infrared Detection of Heat Signature

- Proof of concept showed use at 5 km possible for Cessna-sized UAS
- Active research to reduce heat signature

Weiqun, S., G. Arabadjis, B. Bishop, P. Hill and R. Plasse (2007). Development of an Experimental Prototype Multi-Modal Netted Sensor Fence for Homeland Defense and Border Integrity. Technologies for Homeland Security, 2007 IEEE Conference on.

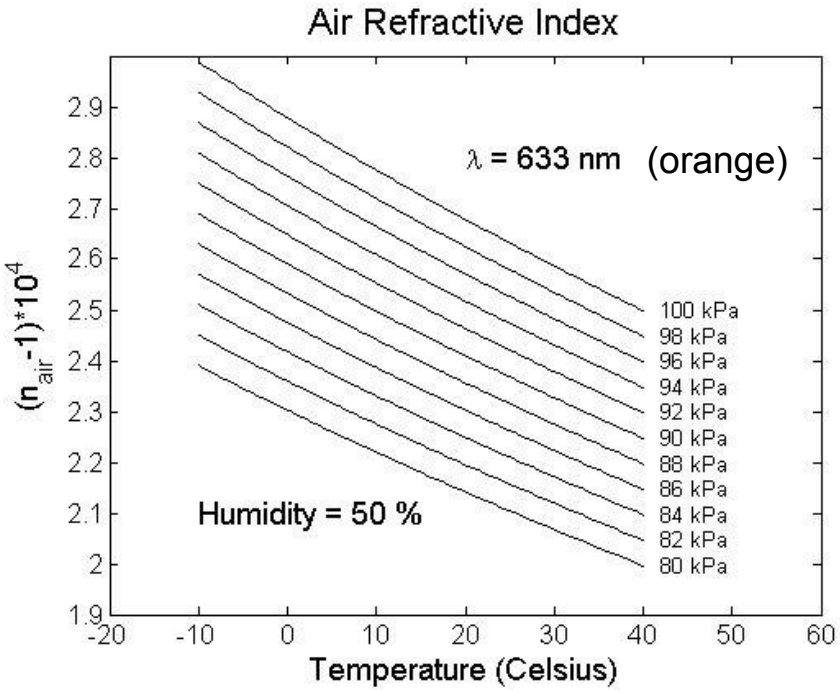
UAS Detection

Sensor Fence

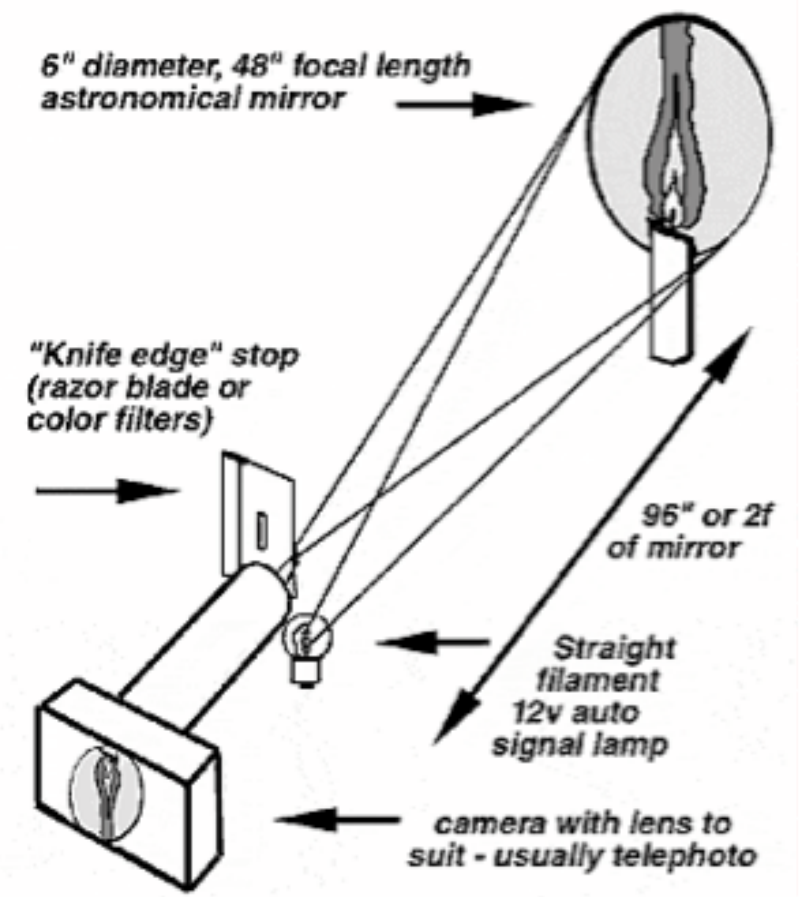


Weiqun, S. et al.

Physics of Schlieren



www.mathworks.com



www.rit.edu

UAS Detection

Traditional Schlieren in Action

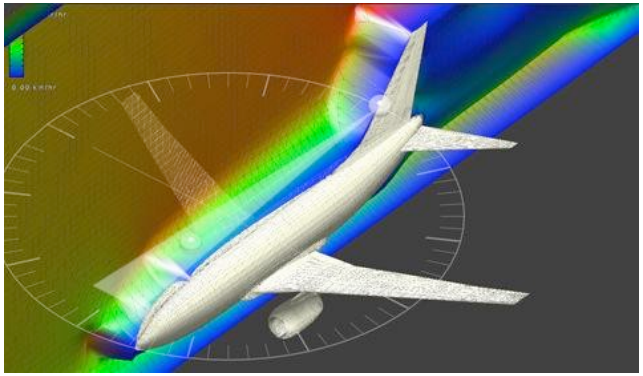
www.youtube.com

Detection

Technique works by...

Searching for changes in index of refraction caused by:

Pressure



www.deskeng.com

Temperature

www.fluke.com

Exhaust

www.nationalgeographic.com

UAS Detection

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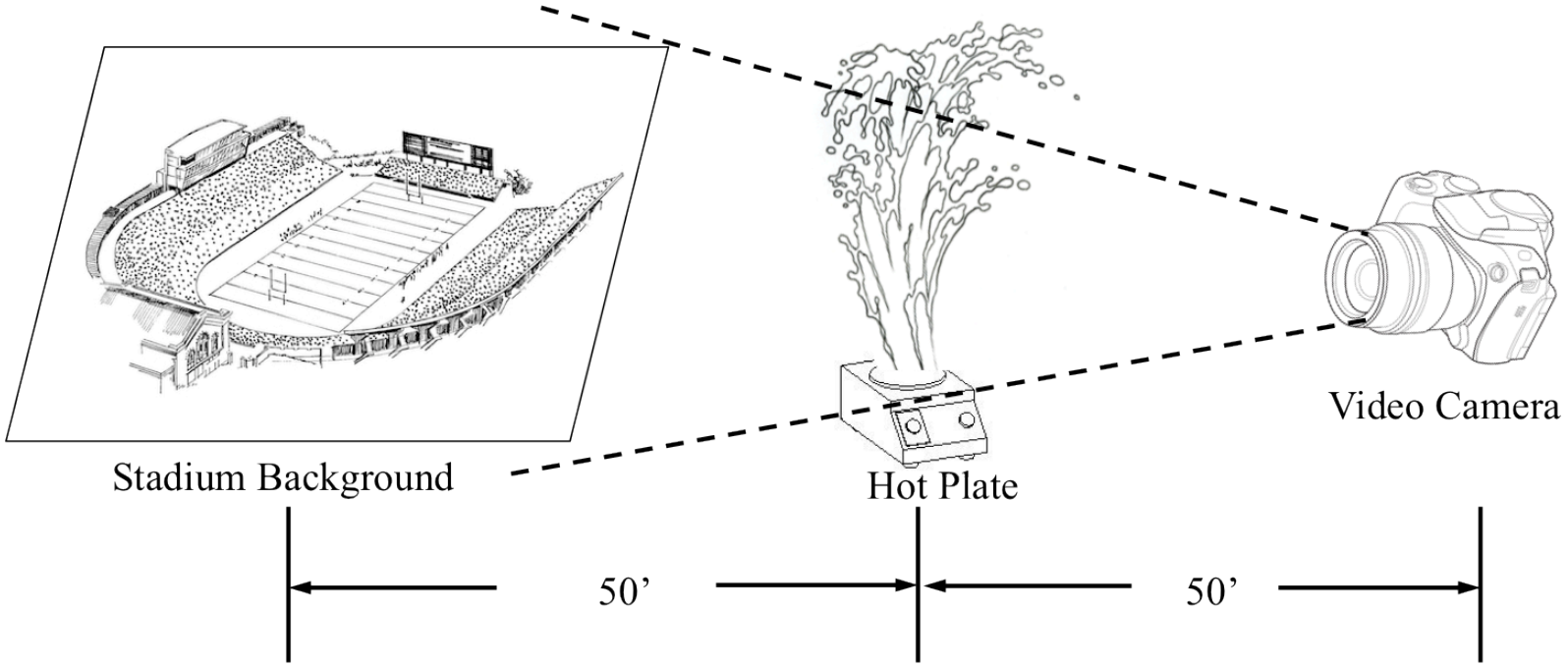
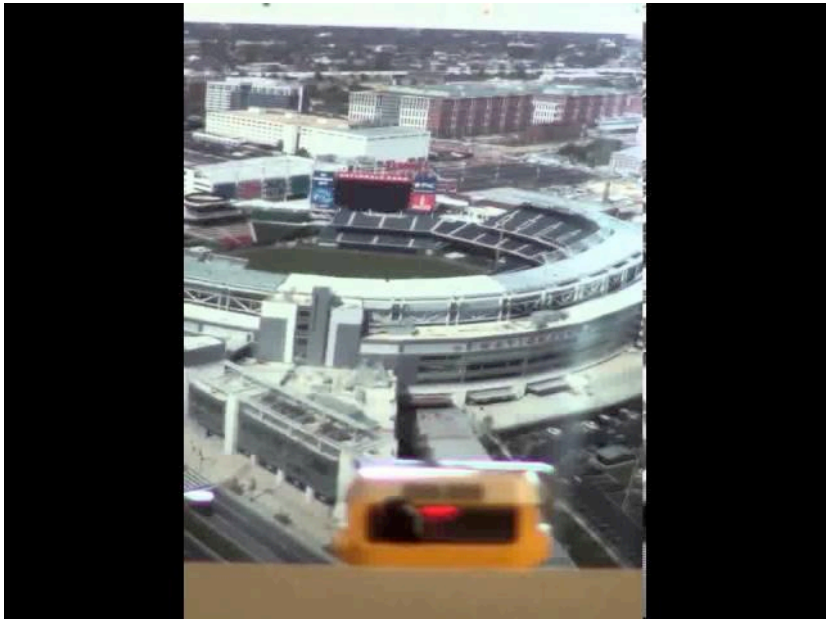
Background Oriented Schlieren
(aka BOS)



UAS Detection

BOS Proof of Concept

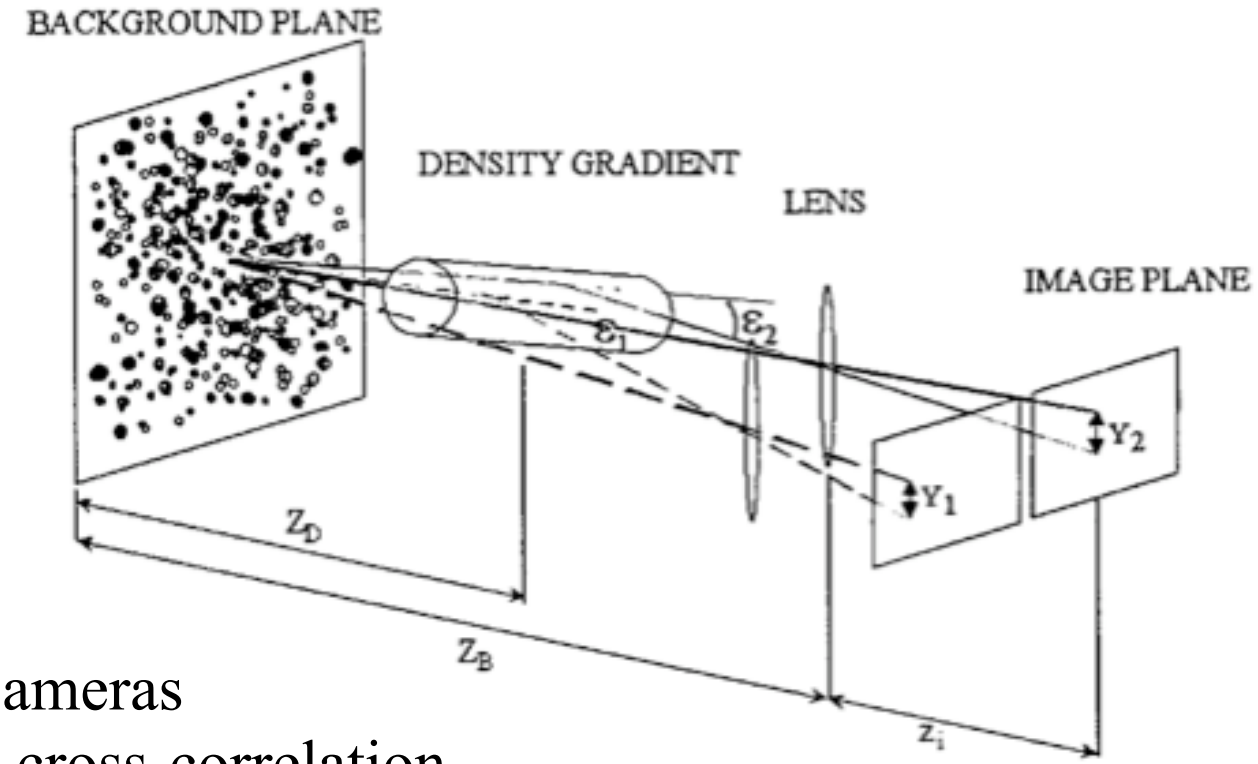


- Typical urban background target (crowded stadium)
- Hot plate at 200 °C creating air disturbance
- Detectable plume from 50' distance

UAS Detection

BOSS

(Background Oriented Stereoscopic Schlieren)



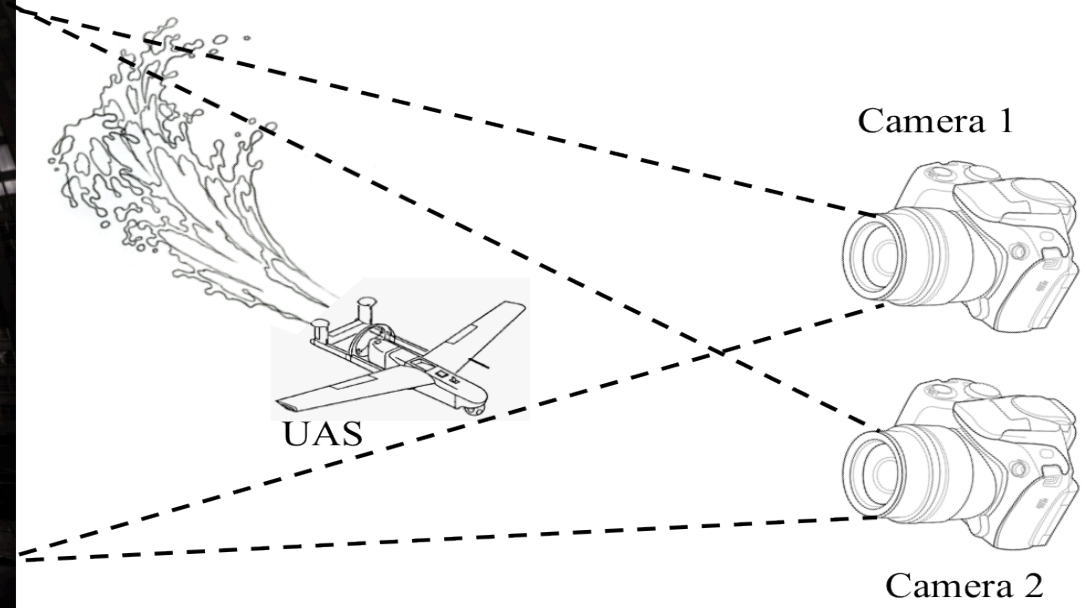
- Two cameras
- Image cross-correlation
- Added distance dimensionality

Richard, H.. European Research Office, 2001

Detection

BOSS Video

Urban Landscape



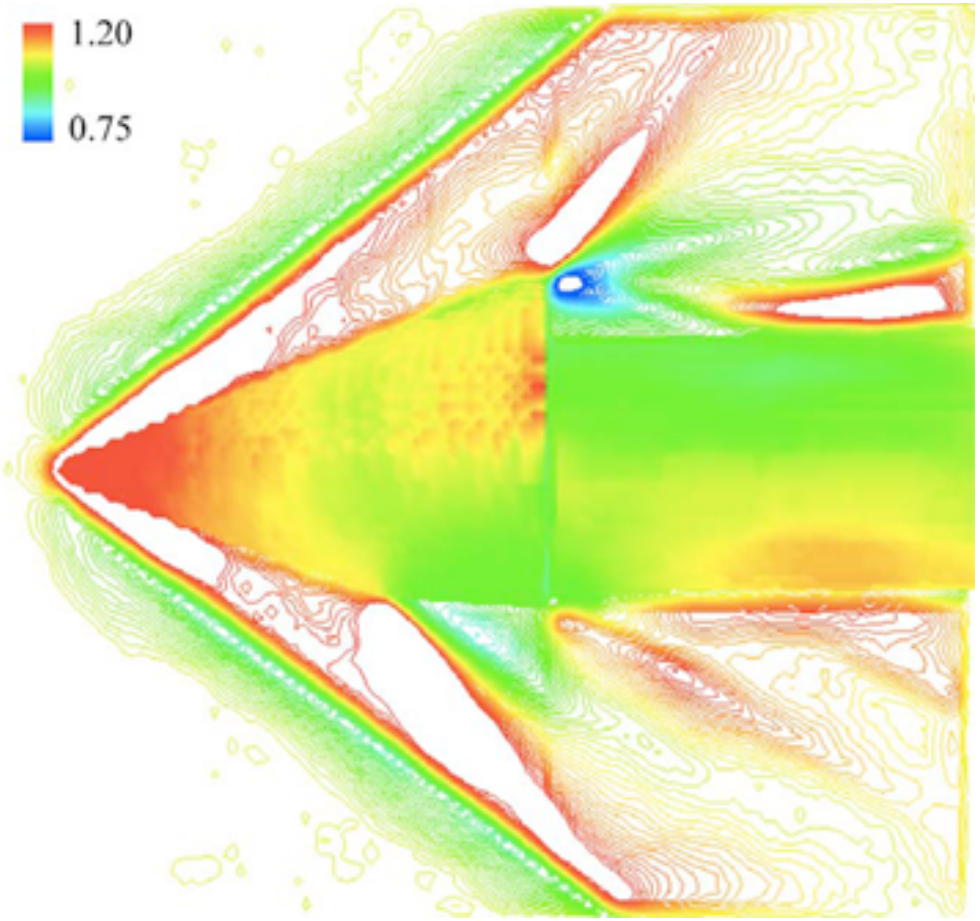
Dyed Smoke in vapor plume from a landing airplane.

Airplane through a cloud.

Photo Credits NASA, Wikimedia

3D-BOS

Imaging air flow around an object in a wind tunnel

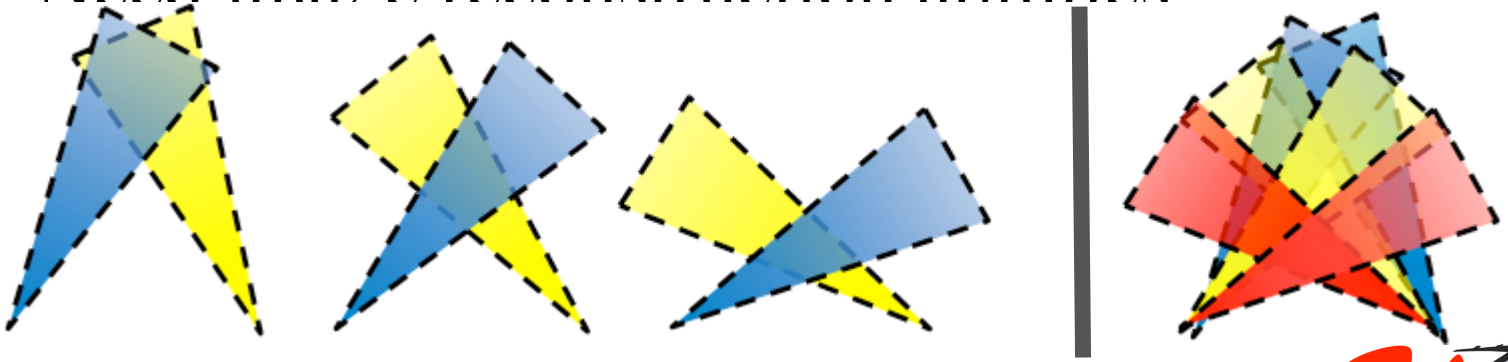


Ota et al."Computed-tomographic density measurement of supersonic flow field by colored-grid background oriented schlieren (CGBOS) technique." 2011.

UAS Detection

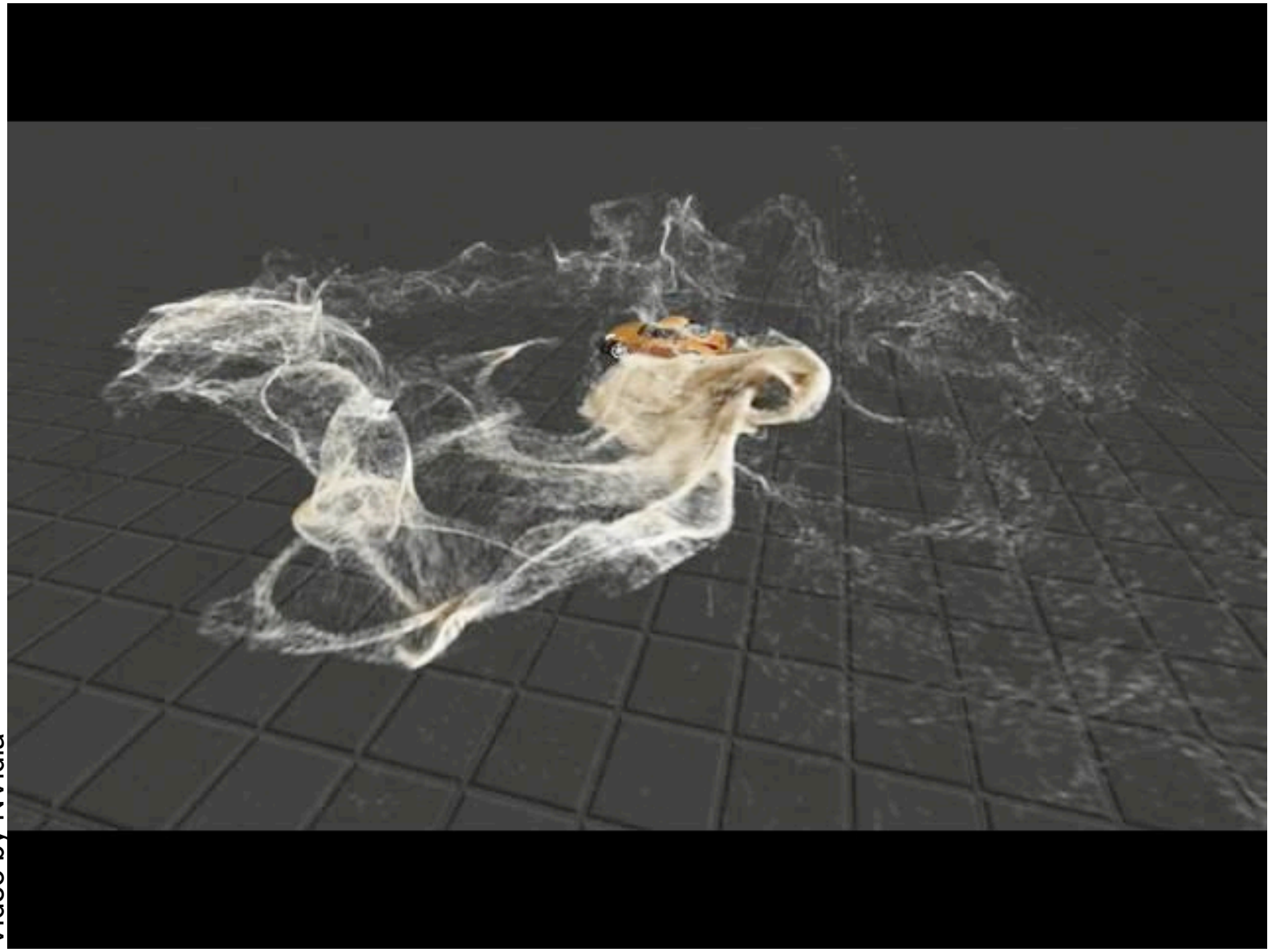
3D-BOSS
3-D Reference-Free Background-Oriented Schlieren

- Utilize steroscopic views from cameras to generate 3-D air flow and then sweep the area to determine the changes in the air with respect to the movement along an axis
- Need image reconstruction abilities



UAS Detection

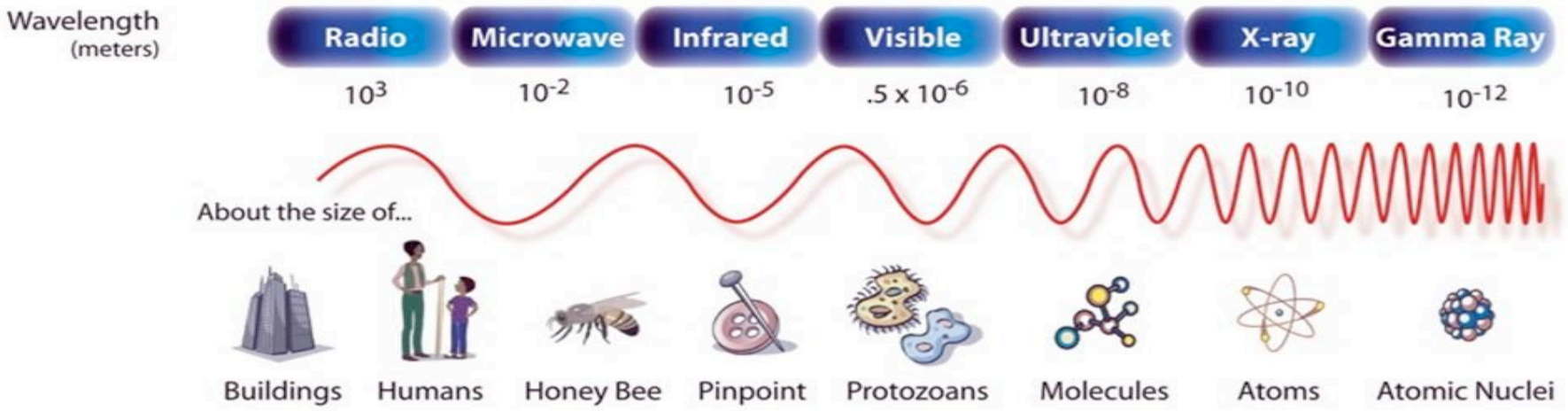
End Goal



Video by NVidia

Alternate Wavelength 3D-BOSS

- Explore Schlieren imaging using non-visible wavelengths
- IR, Ultraviolet, microwave, etc.



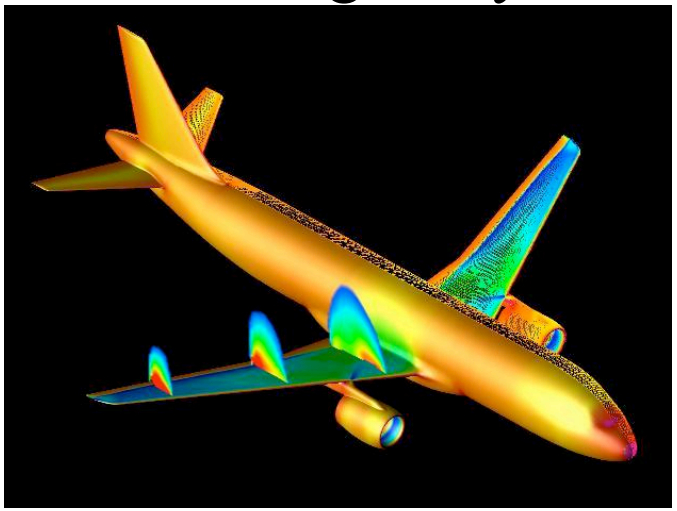
www.nasa.gov

UAS Detection

Potential Issues

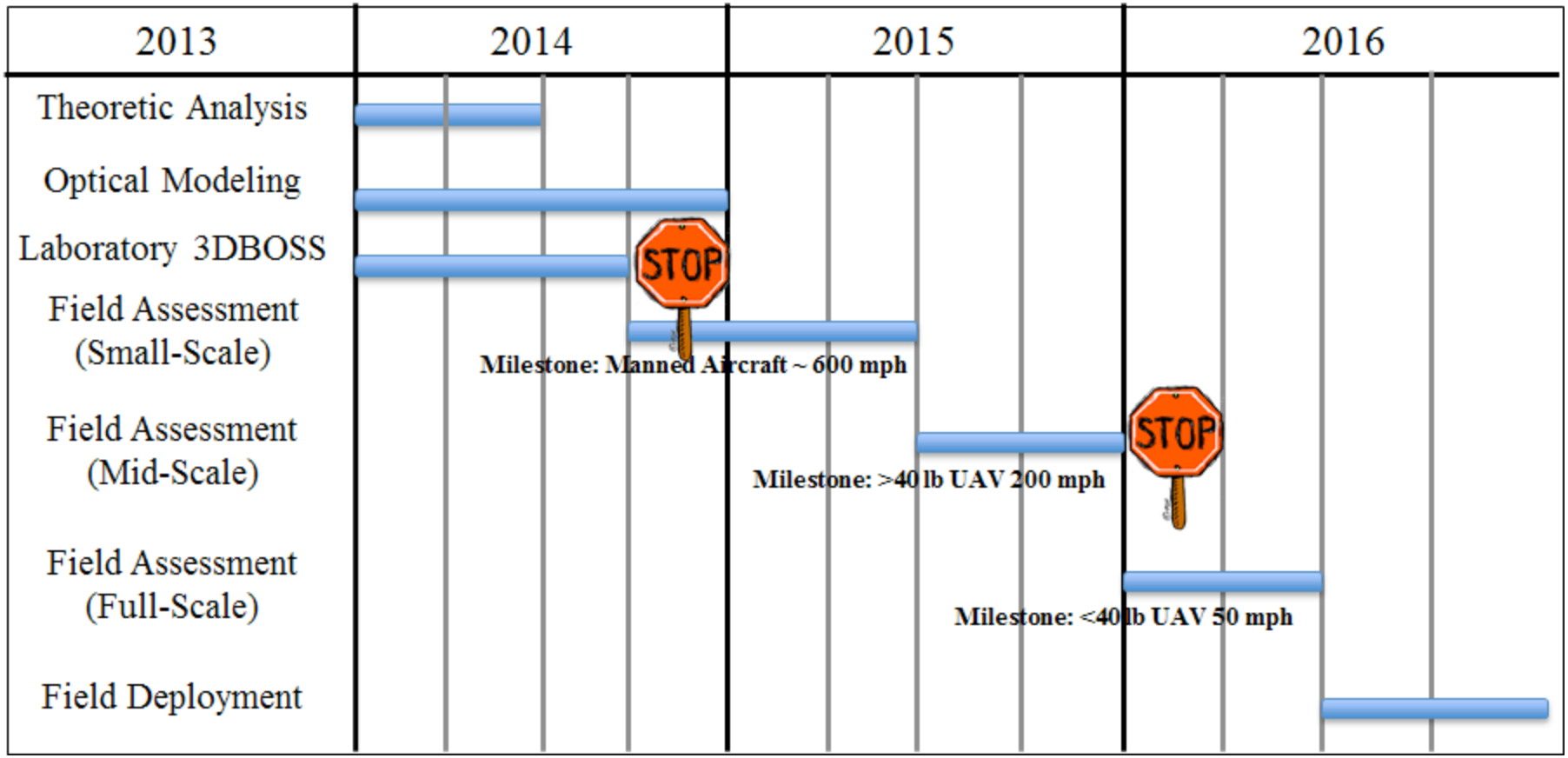
- Long distance imaging may prove very challenging

- Air pressure change from propellers and wings may be too subtle for detection



adg.stanford.edu

Milestones



UAS Detection

Budget Justification

- 4 full-time graduate students
- 2 full-time postdocs
- 2 half-time staff members
- Additional funds will be used to promote interdisciplinary ties between LANL subject matter experts and our research group
- $200k a year for materials and travel.
  - Variety of cameras
  - Image analysis equipment
  - Image processing software

$1.18M/yr for 3 years

Detection

Impact at LANL

- Addition line of defense from unfriendly UAS attack
- Portable lightweight system for vehicle mounting or even for use by the individual warfighter


persianblog.ir


army.gov

World Impact

- Turbulence detection for commercial air travel
- Tool for weather prediction
- Introduction of new technology


wikimedia.com


cnn.com