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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

Chris Oshman, Dustin Demoin, Michael Ham

Mentors

Dr. Garrett Kenyon

Dr. Harald Dogliani

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





www.boston.com

Rezwan Ferdaus



blog.heritage.org

GPS guided UAS

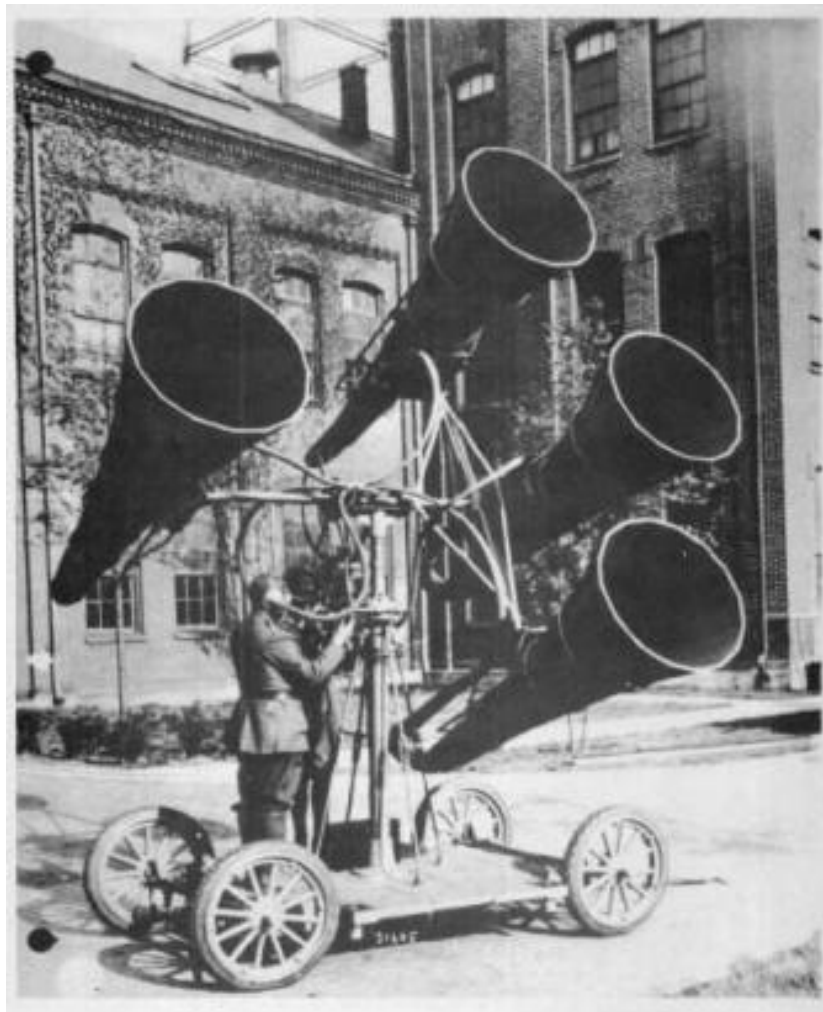
- 2011 - arrested for plotting to fly 3 remote control planes into the US Capitol and the Pentagon
- \$6500 remote-controlled plane that could be guided by GPS and fly at 100mph (160km/h).

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.

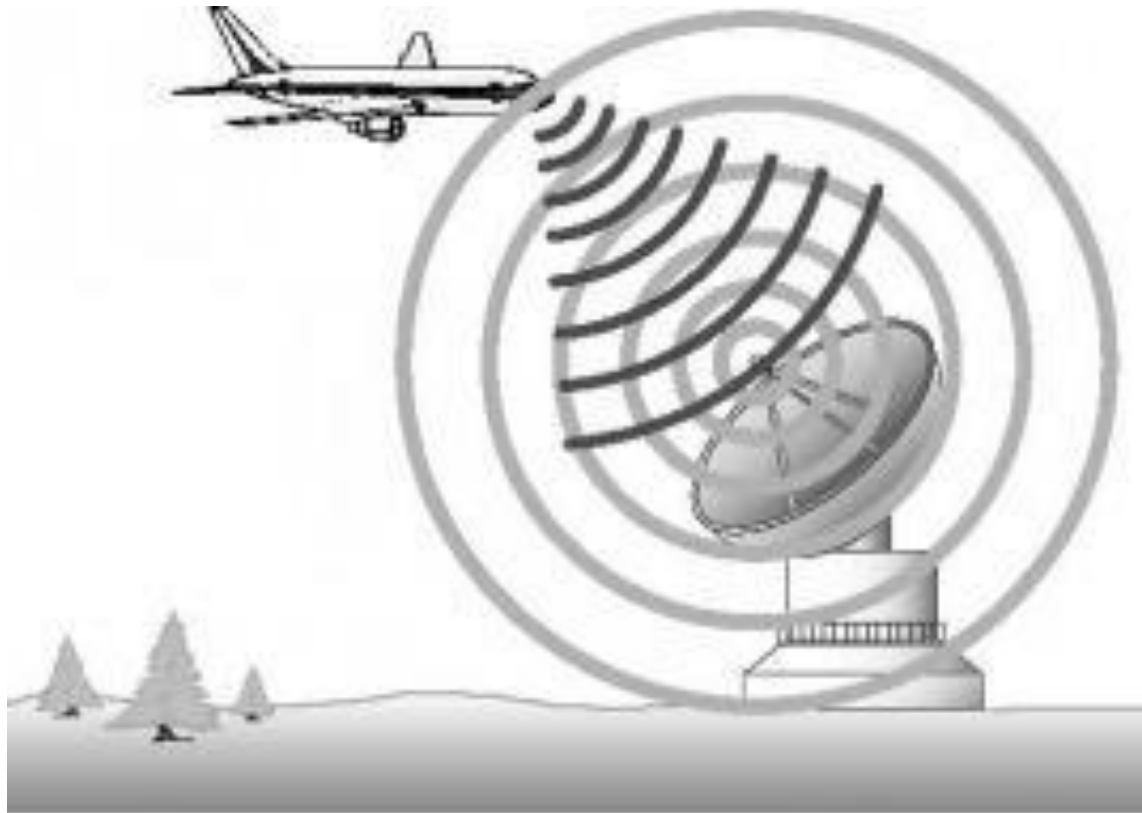
-Keith Lindsay, LANL

Aircraft Detection Technologies



Early Aircraft Sound Detection
dodlive.mil

Radio Detection and Ranging



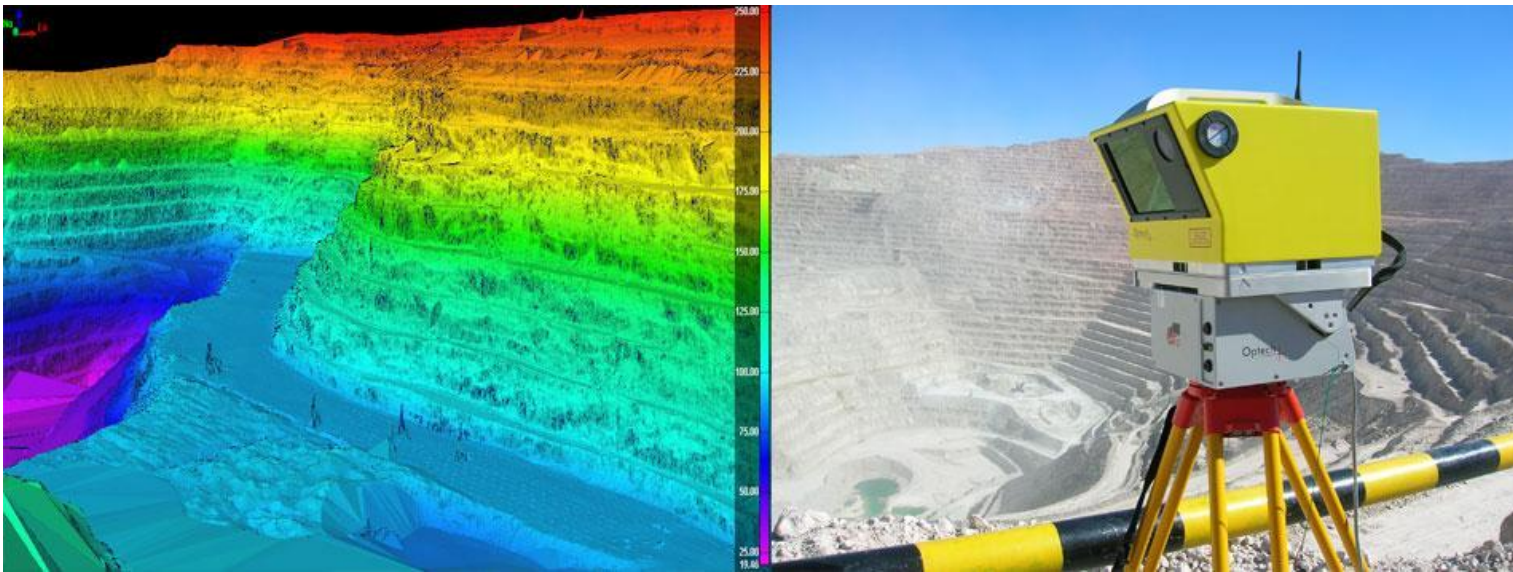
<http://computer.yourdictionary.com/radar>

UG/OGS Information Services

Small UASs - low radar cross section,
stealth possibilities

LIDAR

Laser Imaging Detection and Ranging

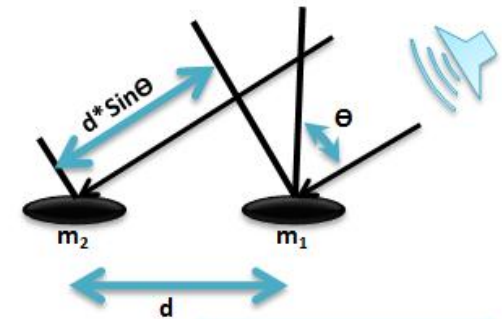


http://www.mapping-solutions.co.uk/applications/images/lidar_mining.jpg

Least expensive LIDAR system ~\$20,000

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

IR

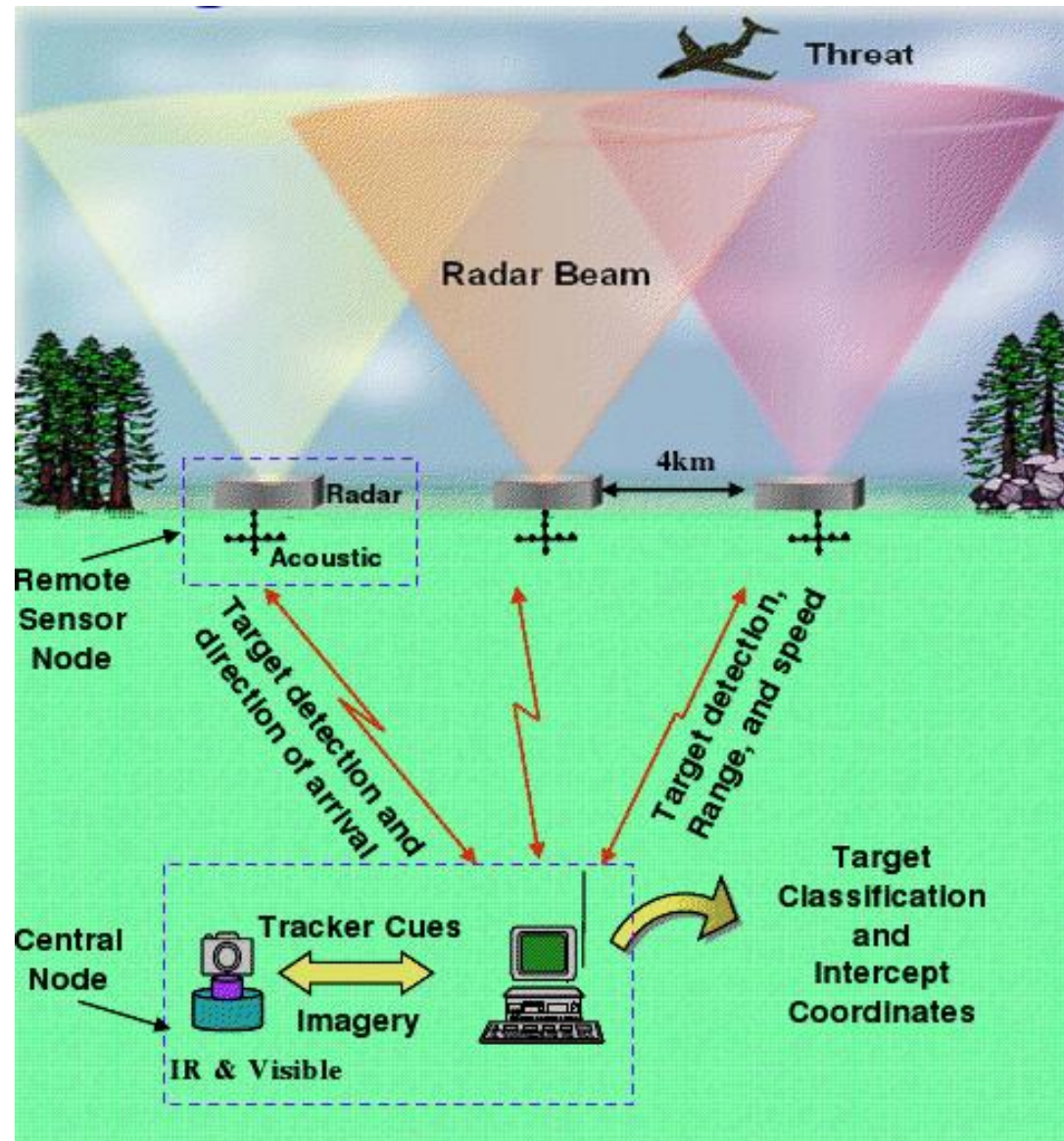
Infrared Detection of Heat Signature

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



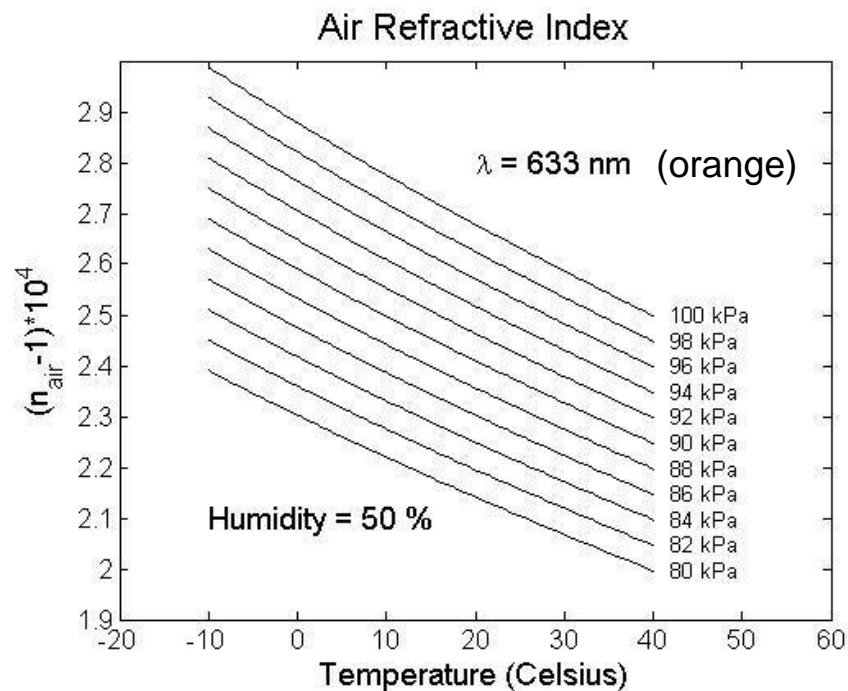
Weiqun, S., G. Arabadjis, B. Bishop, P. Hill and R. Plasse (2007). Development of an Experimental Prototype Multi-Modal Netted Sensor Fence for Homeland Defense and Border Integrity. Technologies for Homeland Security, 2007 IEEE Conference on.

Sensor Fence

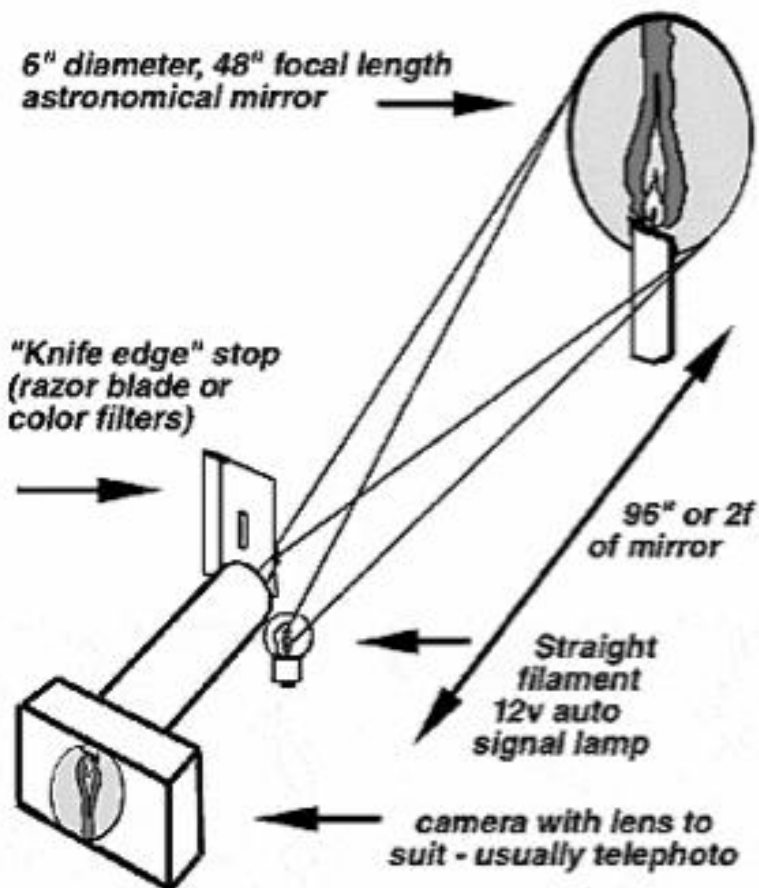


Weiqun, S. et al.

Physics of Schlieren



www.mathworks.com



www.rit.edu

Traditional Schlieren in Action

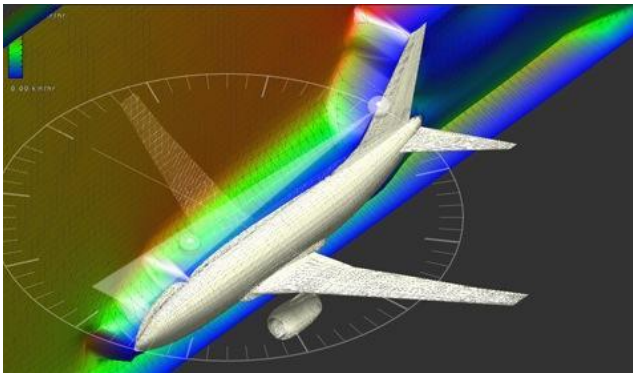


www.youtube.com

Technique works by...

Searching for changes in index of refraction caused by:

Pressure



www.deskeng.com

Temperature



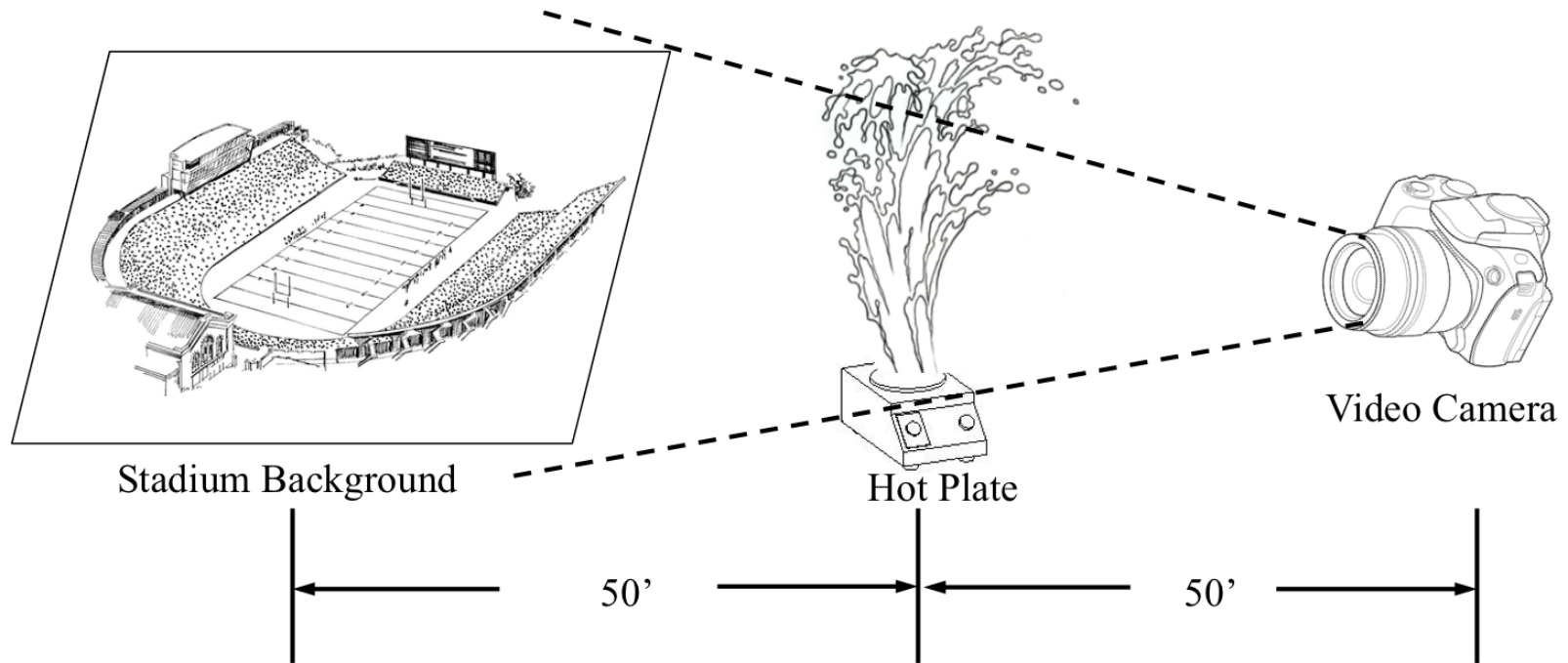
www.fluke.com

Exhaust



www.nationalgeographic.com

Background Oriented Schlieren (aka BOS)



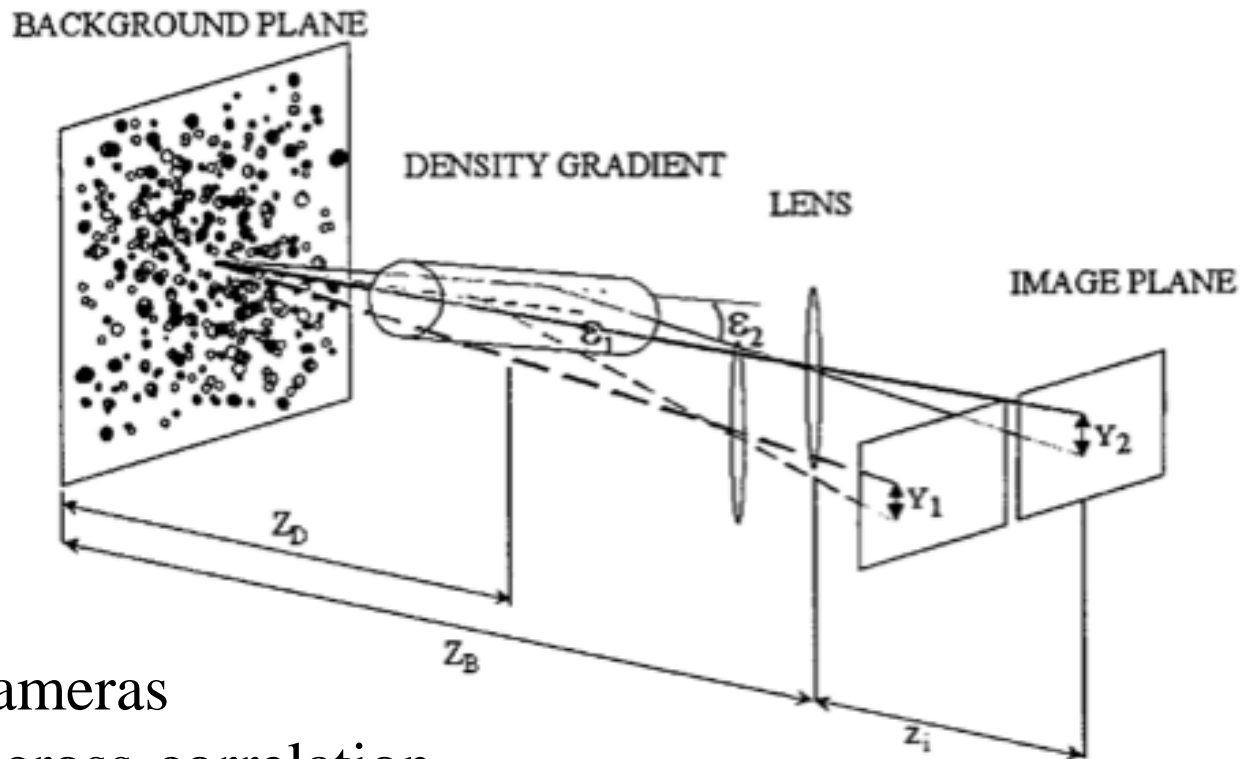
BOS Proof of Concept



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

BOSS

(Background Oriented Stereoscopic Schlieren)



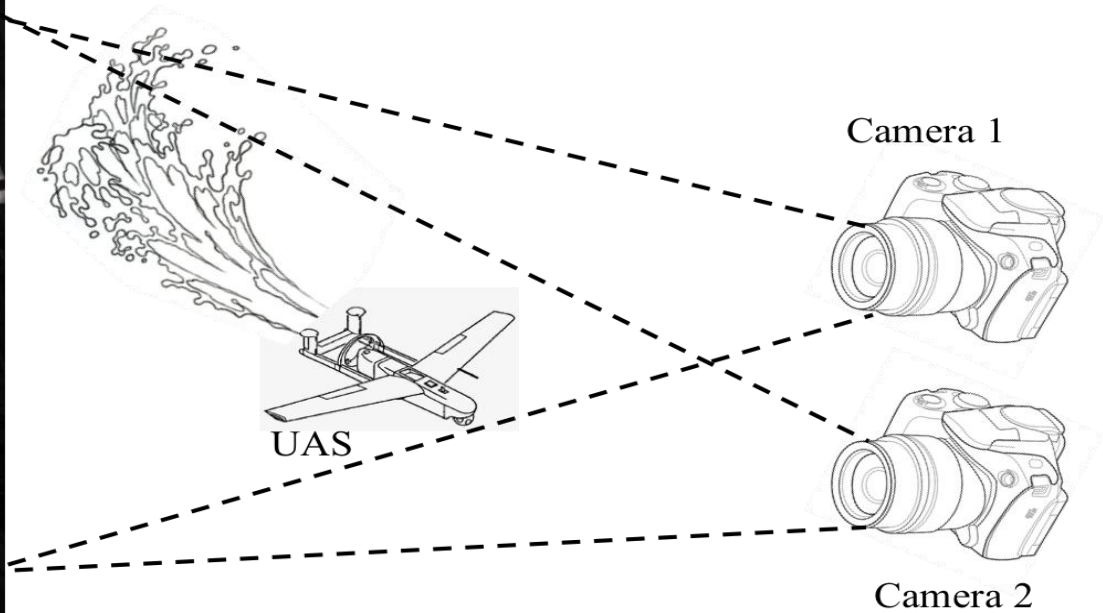
- Two cameras
- Image cross-correlation
- Added distance dimensionality

Richard, H.. European Research Office, 2001

BOSS Video



Urban Landscape



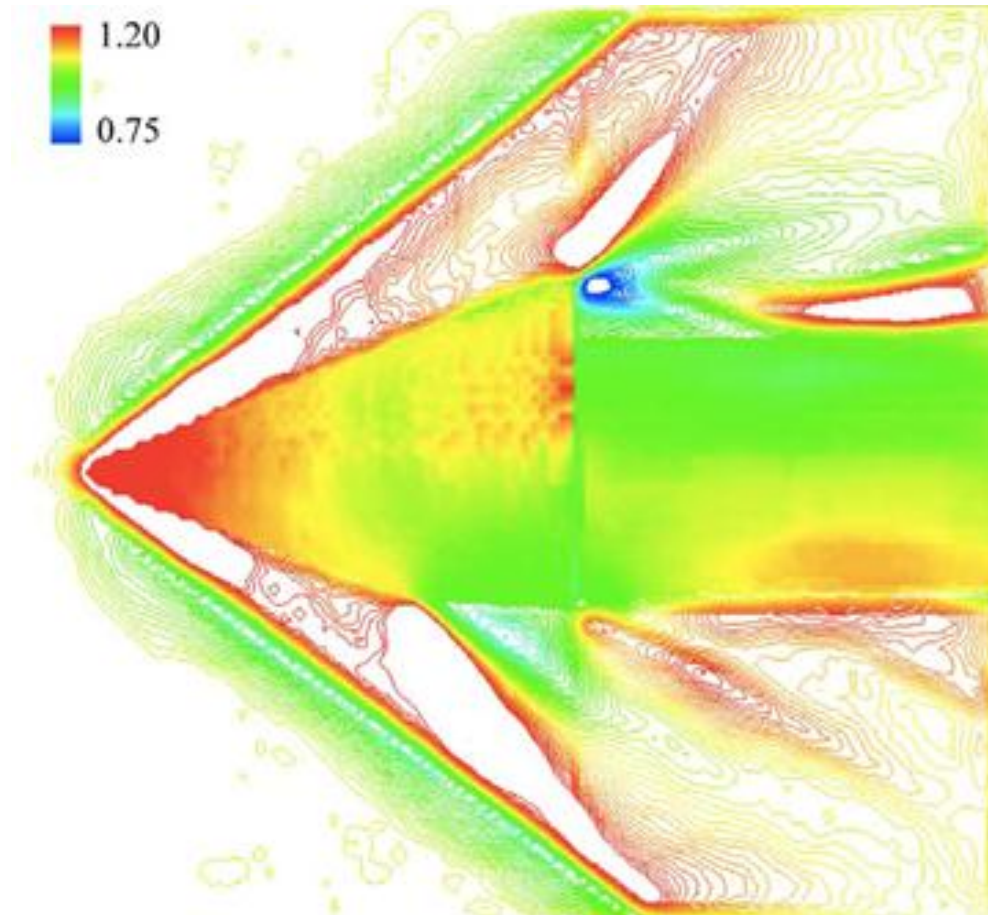
Dyed Smoke in vapor plume from a landing airplane.

Airplane through a cloud.



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.

3D-BOSS

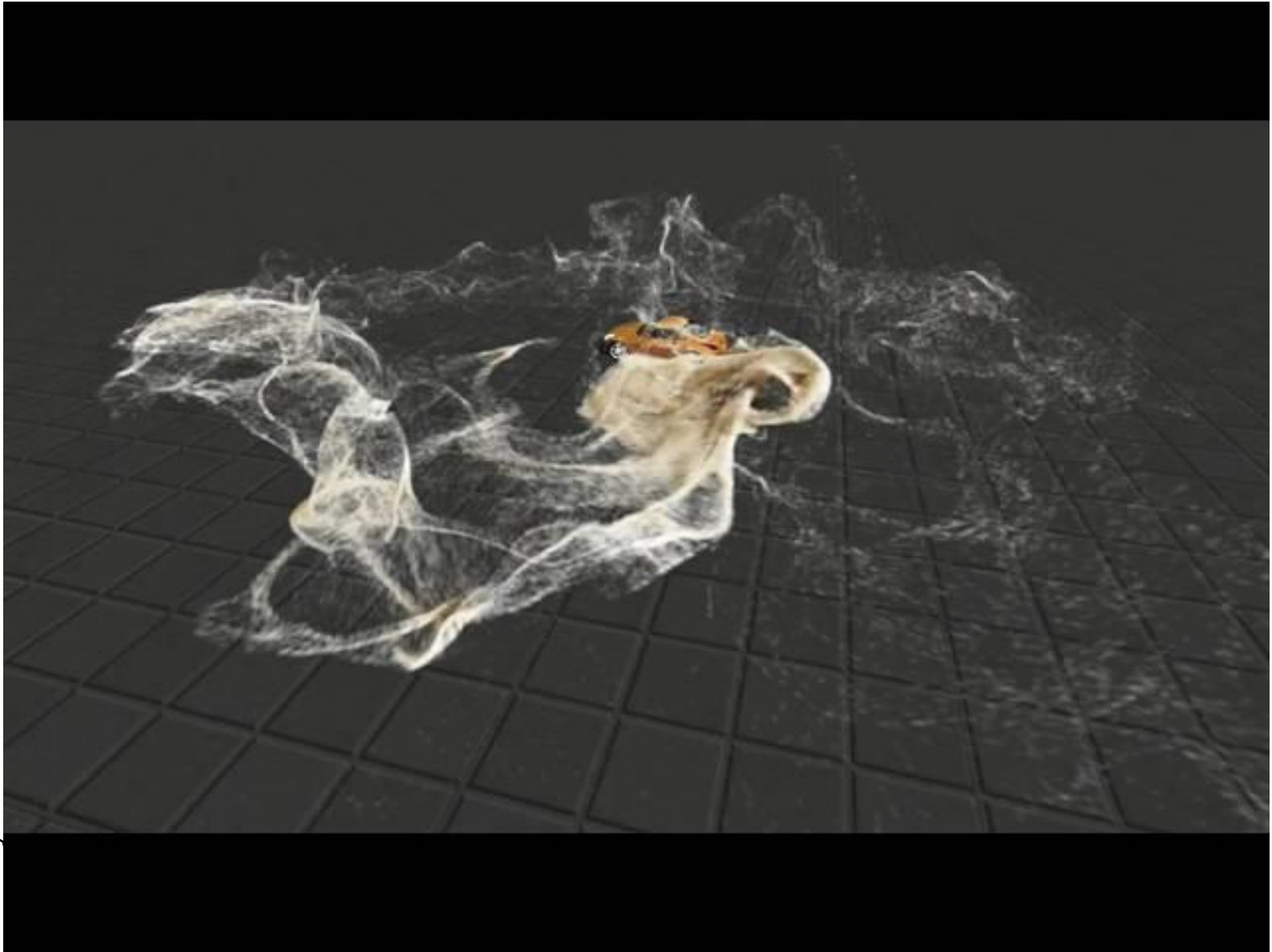
3-D Reference-Free Background-Oriented Schlieren

- Utilize stereoscopic 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



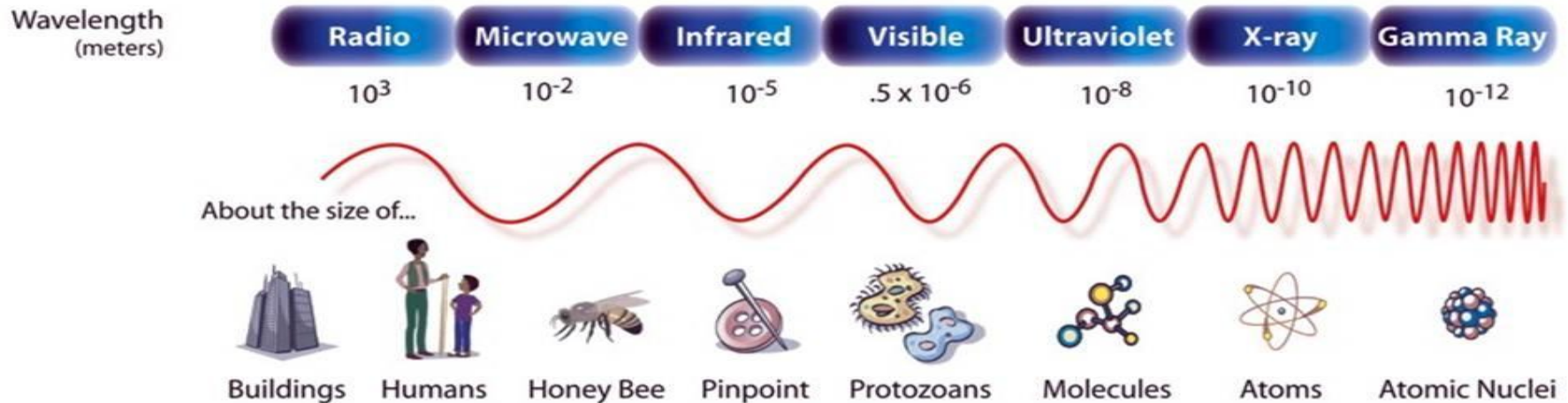
End Goal

Video by NVidia



Alternate Wavelength 3D-BOSS

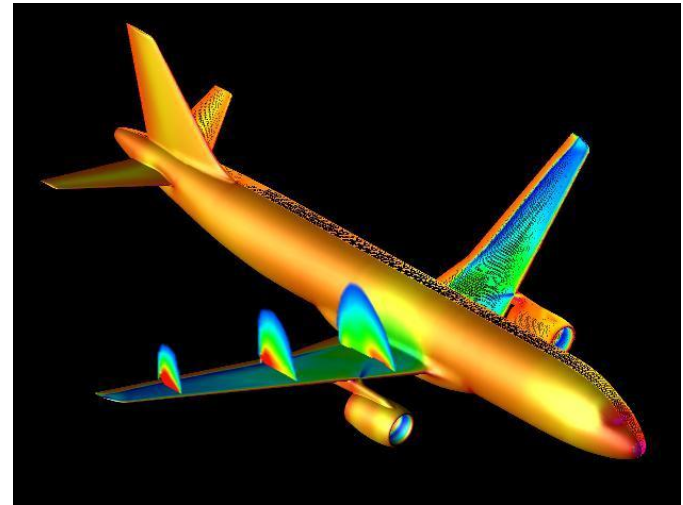
- Explore Schlieren imaging using non-visible wavelengths
- IR, Ultraviolet, microwave, etc.



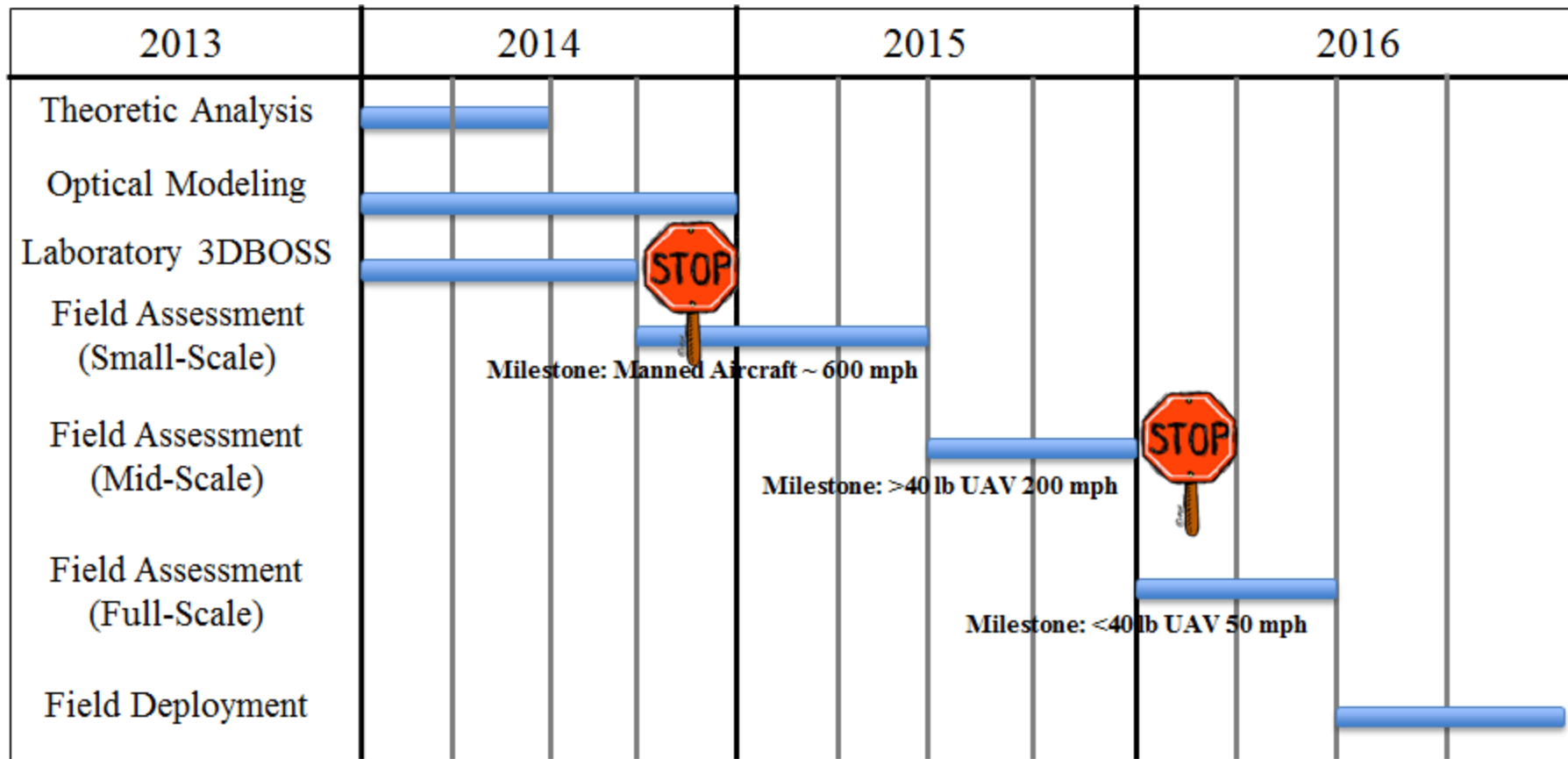
www.nasa.gov

Potential Issues

- Long distance imaging may prove very challenging
- Air pressure change from propellers and wings may be too subtle for detection



Milestones



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



MDS
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

World Impact

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



persianblog.ir



army.gov



wikimedia.com



cnn.com