Student Field Experiment Results using the MIT IAP 2011 Laptop Based Radar*

Presented at the 2011 MIT Independent Activities Period (IAP)

Gregory L. Charvat, PhD
MIT Lincoln Laboratory

28 January 2011

***This work is sponsored by the Department of the Air Force under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, conclusions and recommendations are those of the authors and are not necessarily endorsed by the United States Government.**

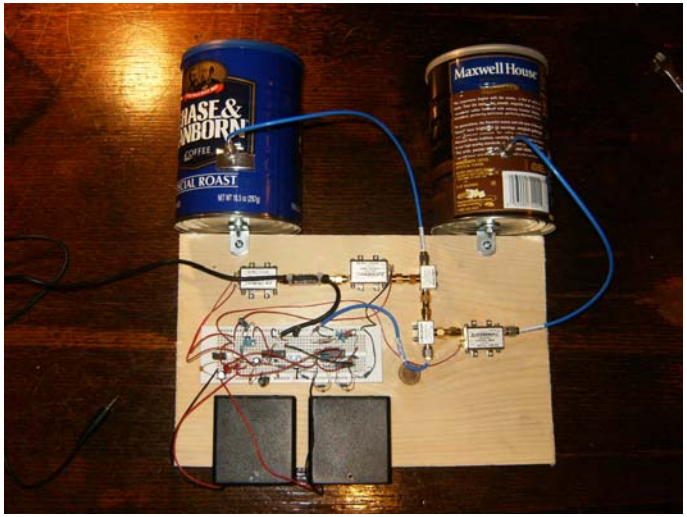
Outline

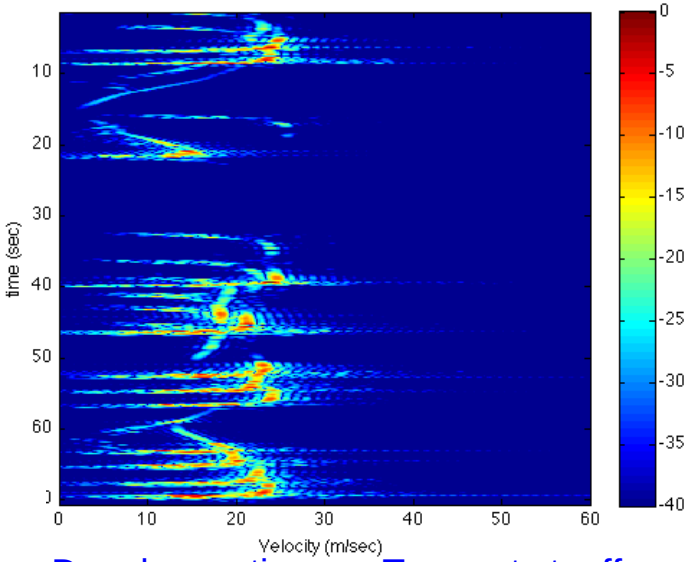
- Baseline of results from instructors

- Student Results:
  - Albert Wang, Michael Yu, and Joseph McCarter
  - Adam Bardagjy
  - Frank Yaul, Steve Levine, and Lili X. Cai
  - Fred Chen, Yan Li, and Ranko Sredojevic
  - Gustavo Goretkin and anonymous MIT student
  - Josh Spitzberg and Kristina Wong
  - Kate Williams, Spiros Mantzavinos, Galia Ghaza, and Eric Williams
  - Tony Kim, Nevada Sanchez, and Paresh Malalur
  - Walker Chan, Elaina Chai, and Michael Scarito

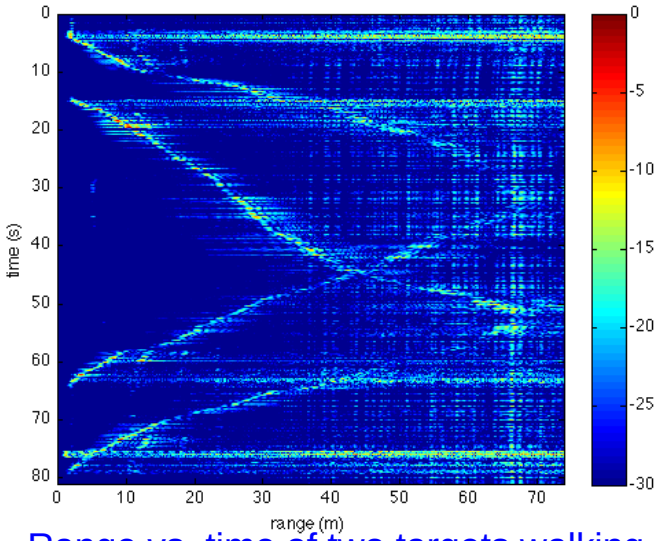
- Next steps
- Summary

Instructor's radar



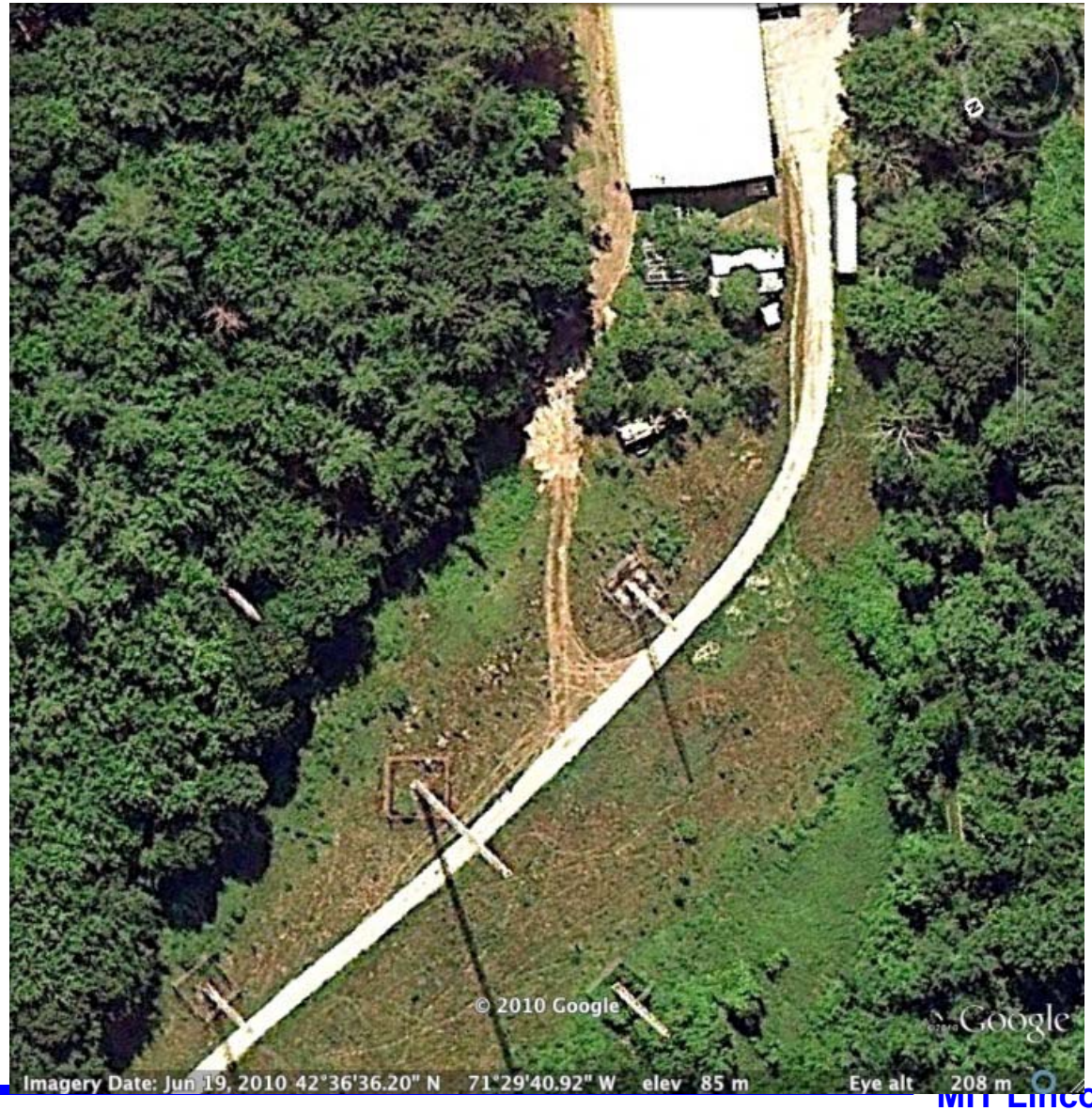


Doppler vs. time on Tremont st. off Newton corner.



Range vs. time of two targets walking through an open field into the woods.

Instructor's radar



Warehouse at MIT LL site in Westford MA.

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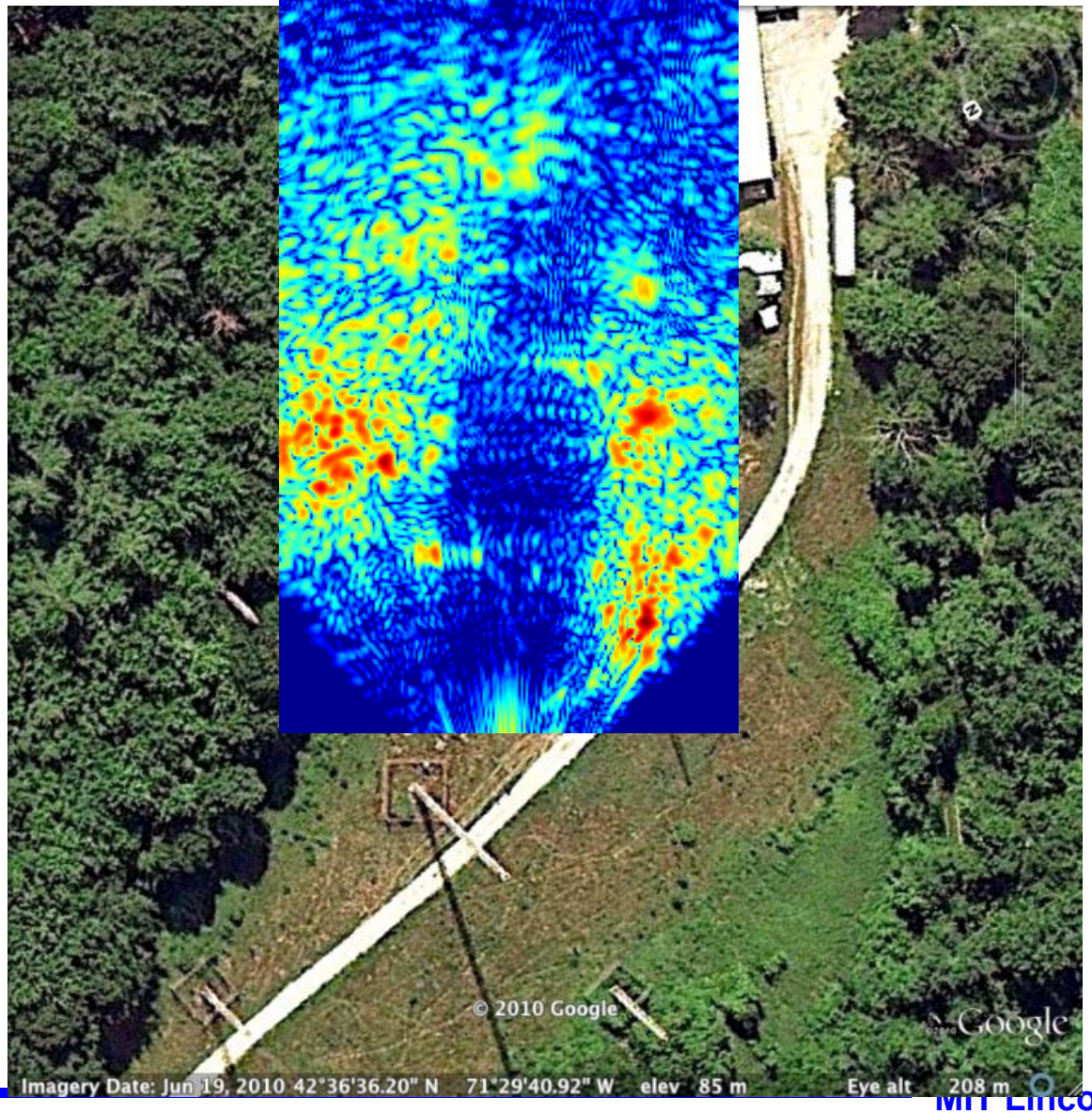
Instructor's radar



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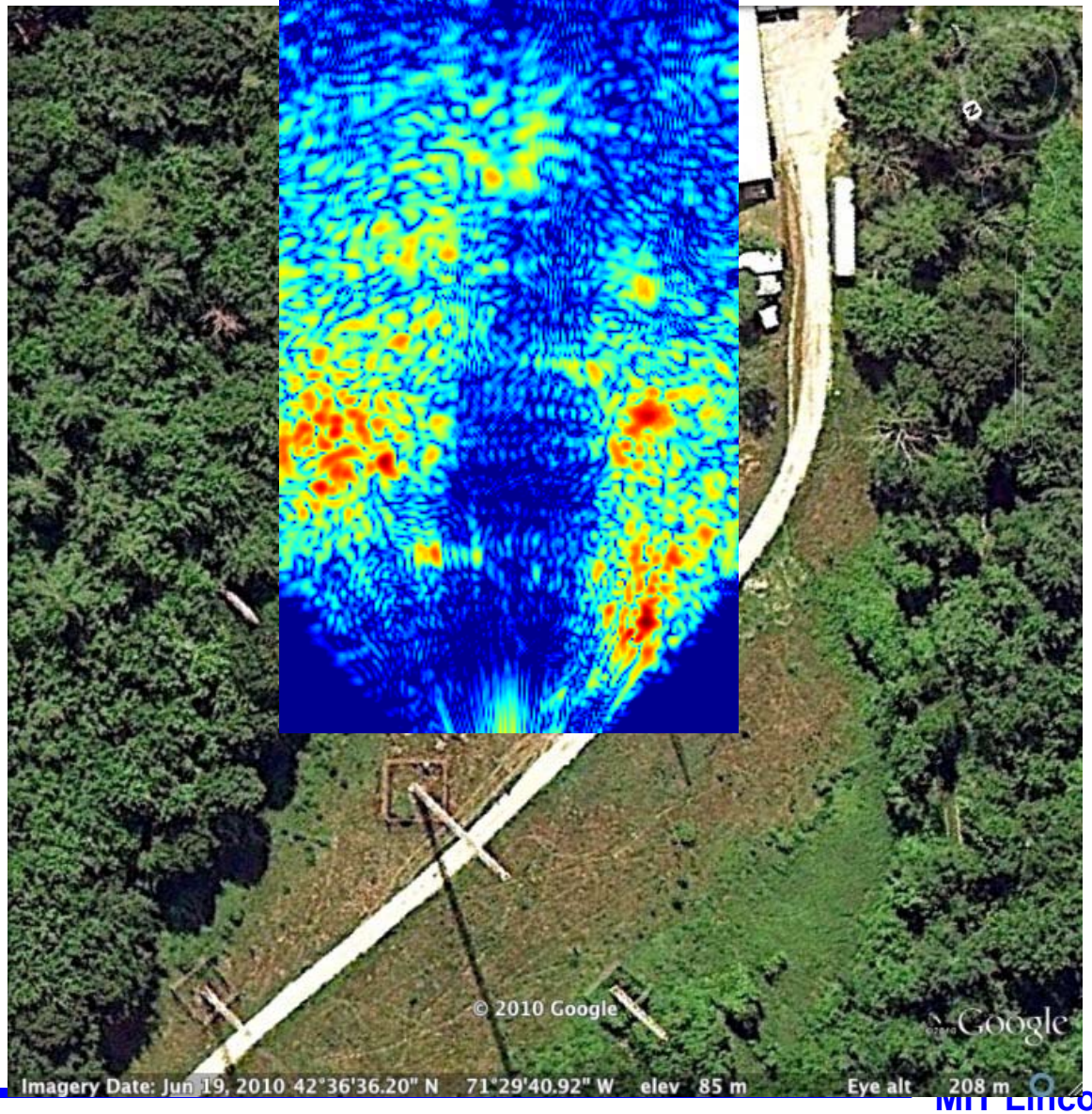

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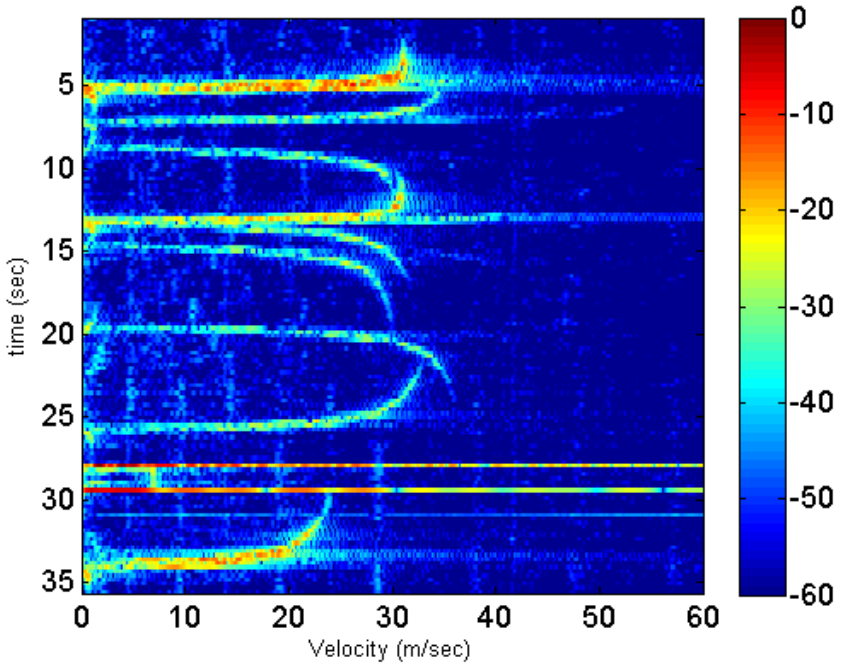
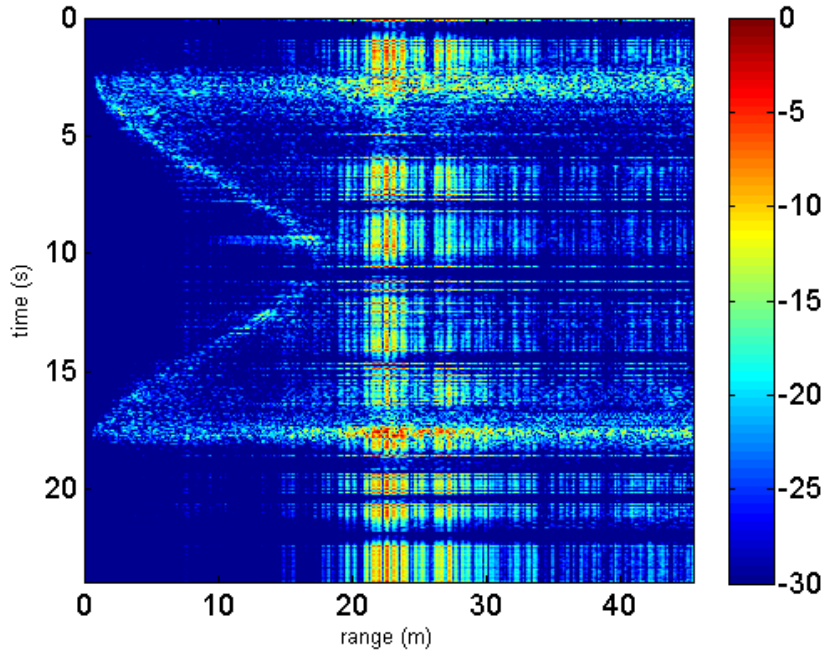
Albert Wang, Michael Yu, and Joseph McCarter



Doppler vs. time at Memorial dr. at Audrey St. towards Harvard bridge.



Range vs. time of Michael running down the basement of building 5.

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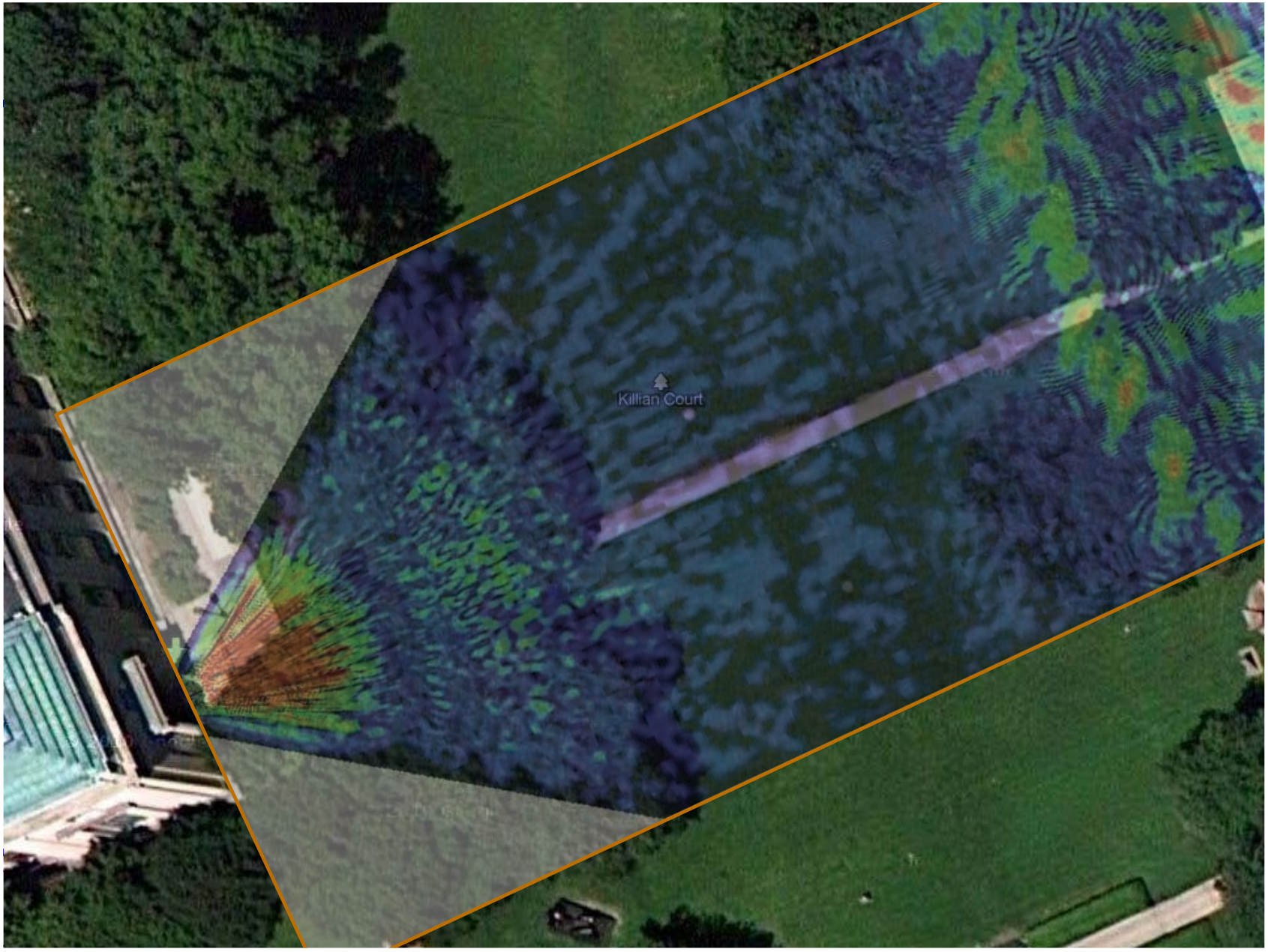

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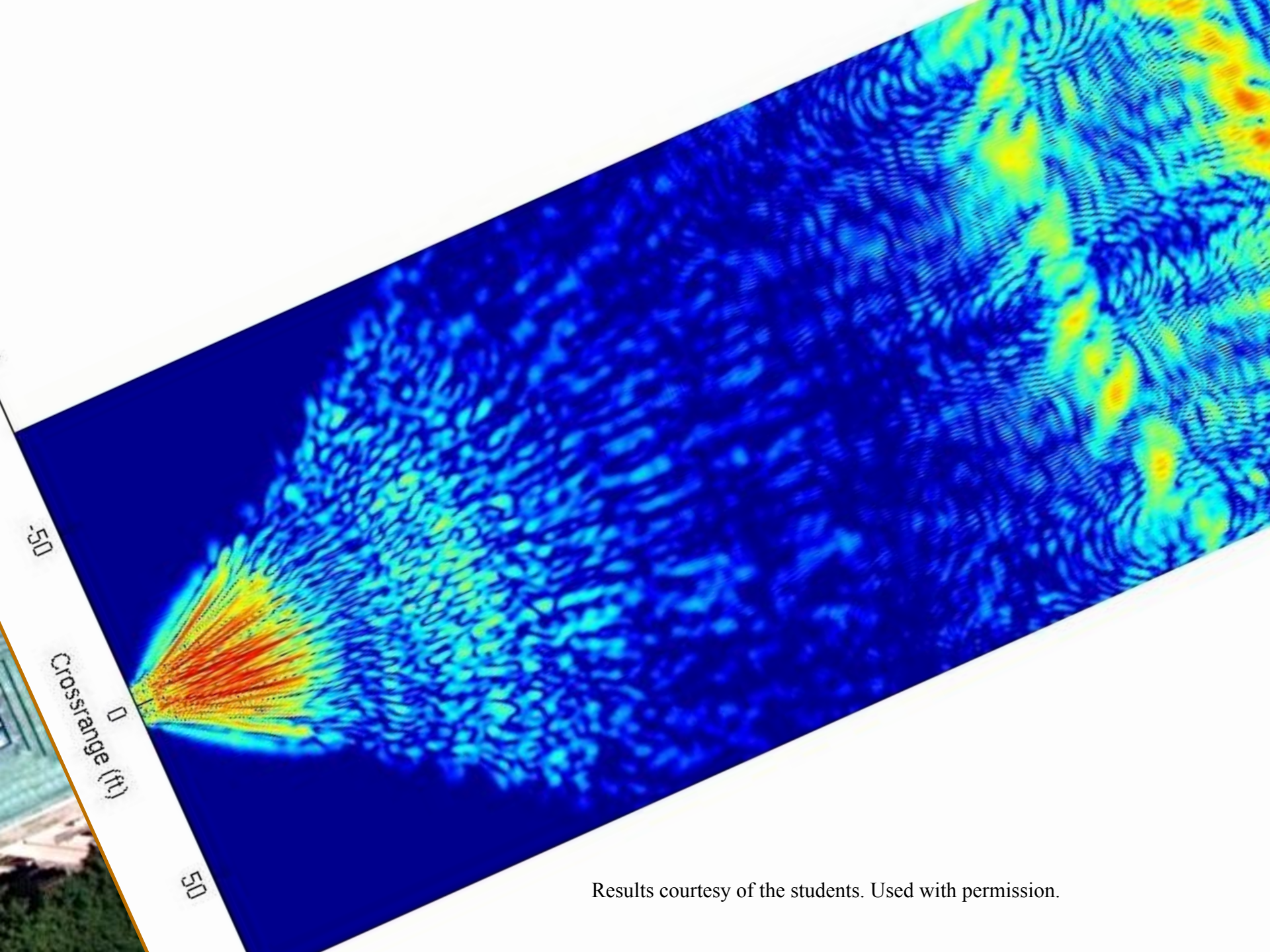

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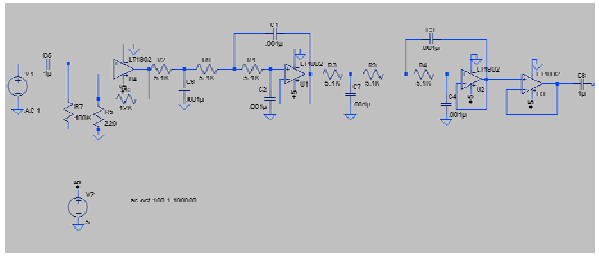
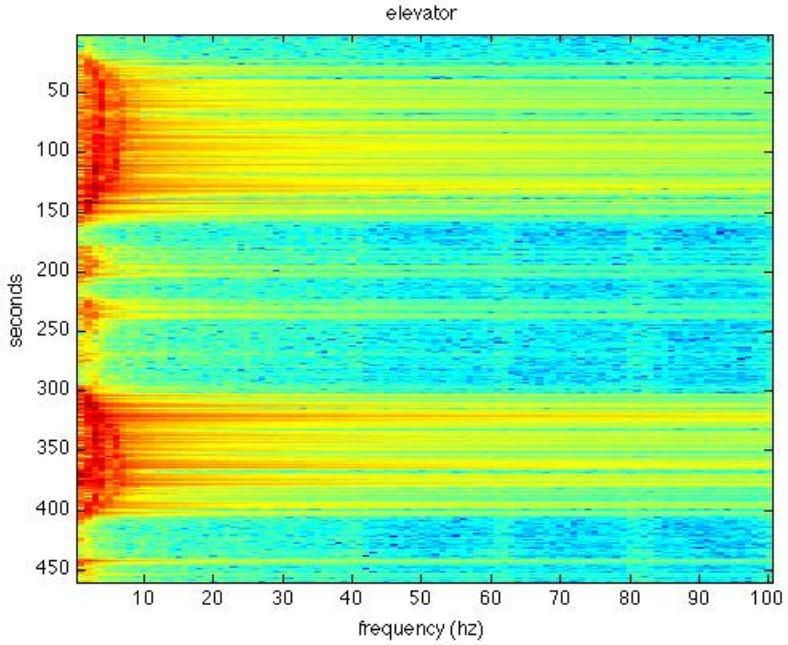
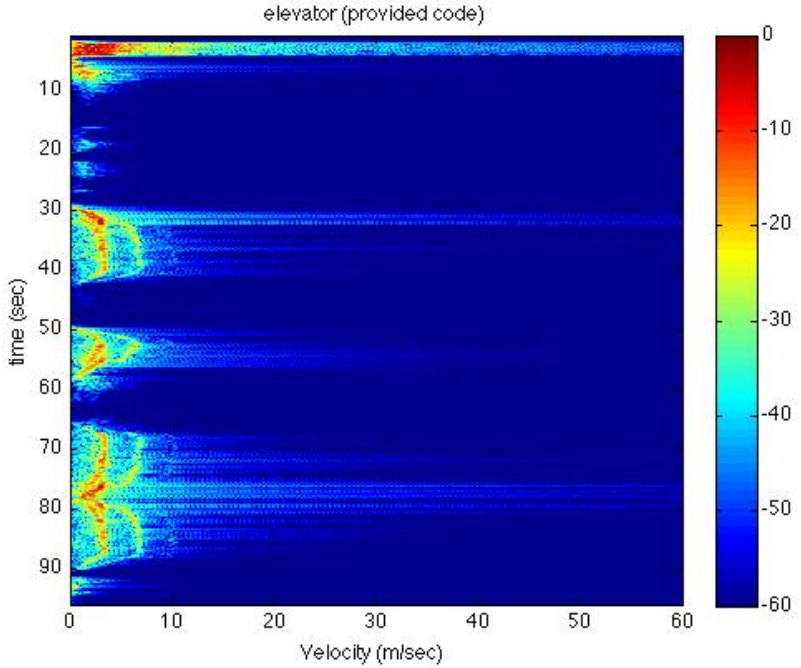
Adam Bardagjy



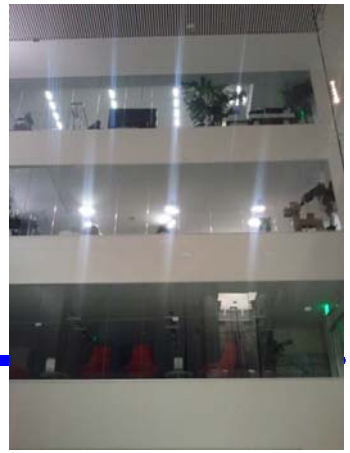
Innovation: new LPF, 6 pole, same number of components, but only ONE type of resistor and ONE type of cap.



Doppler vs. time of the elevator.



Range vs. time of the elevator.



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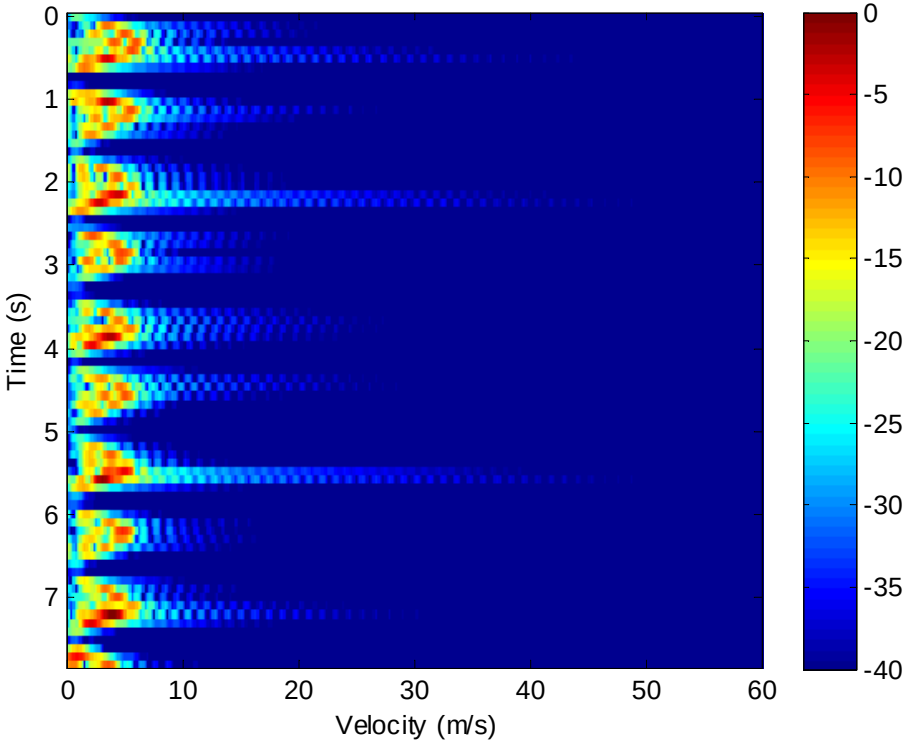
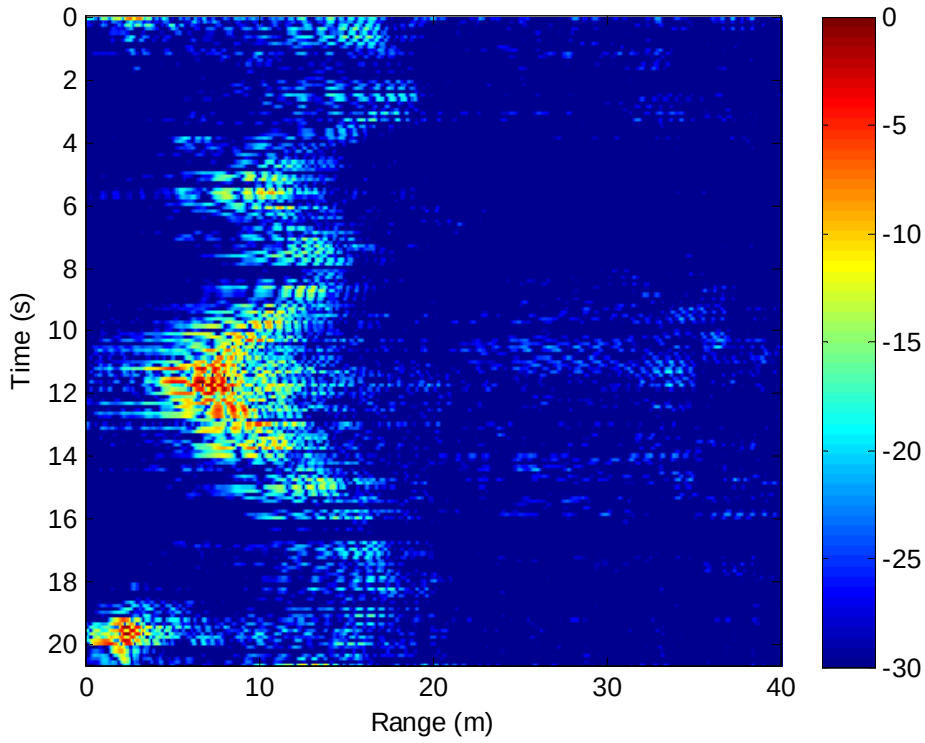
Frank Yaul, Steve Levine, and Lili X. Cai



Doppler vs. time of a pendulum.



Range vs. time of Frank walking in Lobby 7 with Tony Kim's clutter rejection algorithm.

Results courtesy of the students. Used with permission.

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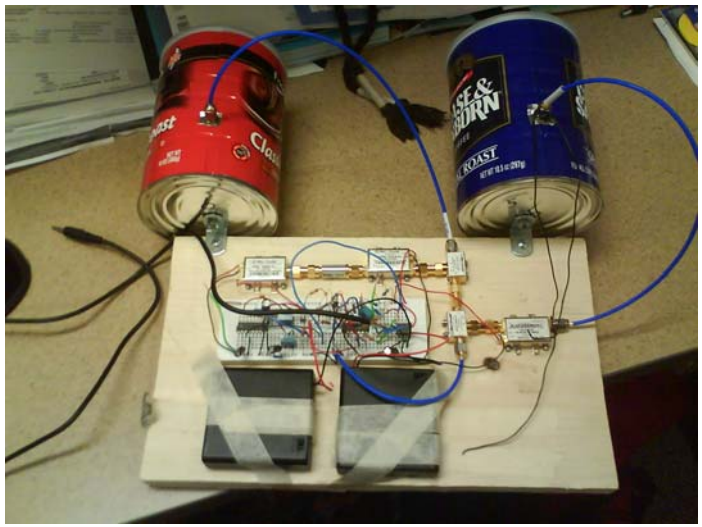
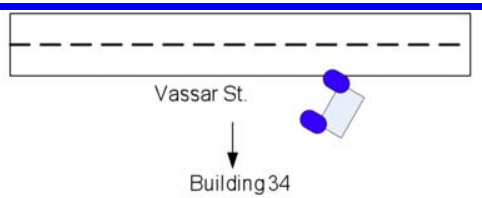
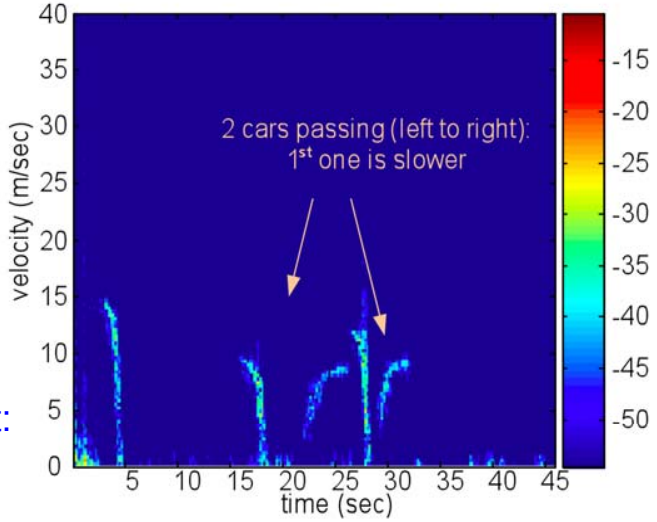
Fred Chen, Yan Li, and Ranko Sredojevic

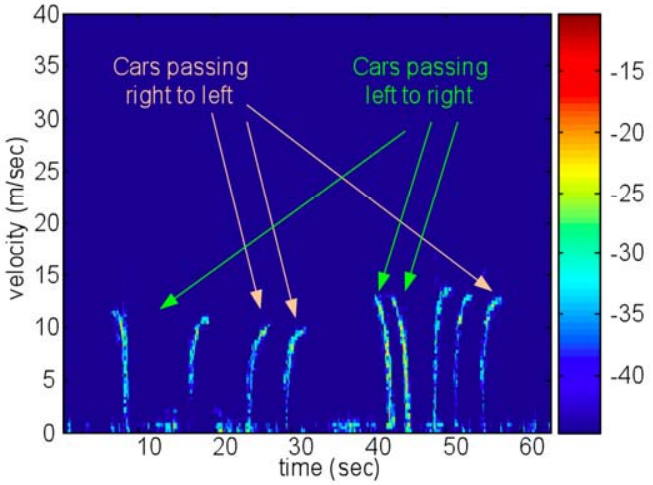
"Not necessarily a lot of time put into it, but lots of love ☺."





Doppler vs. time on Vassar Street:

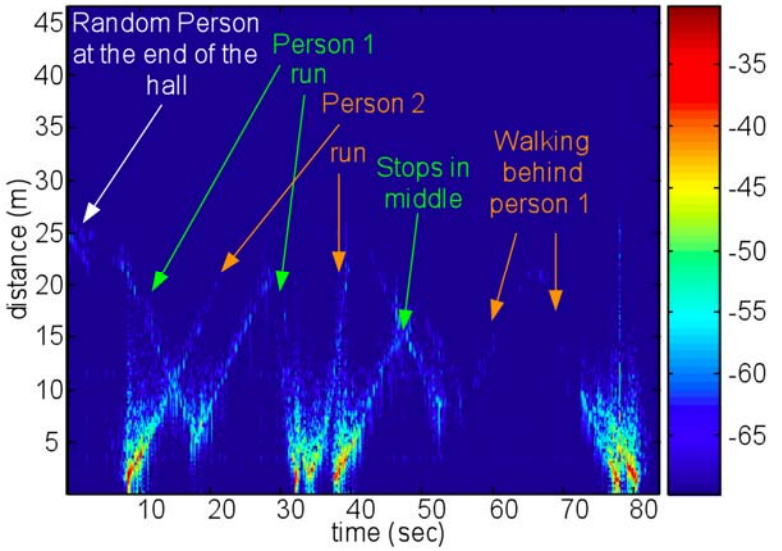




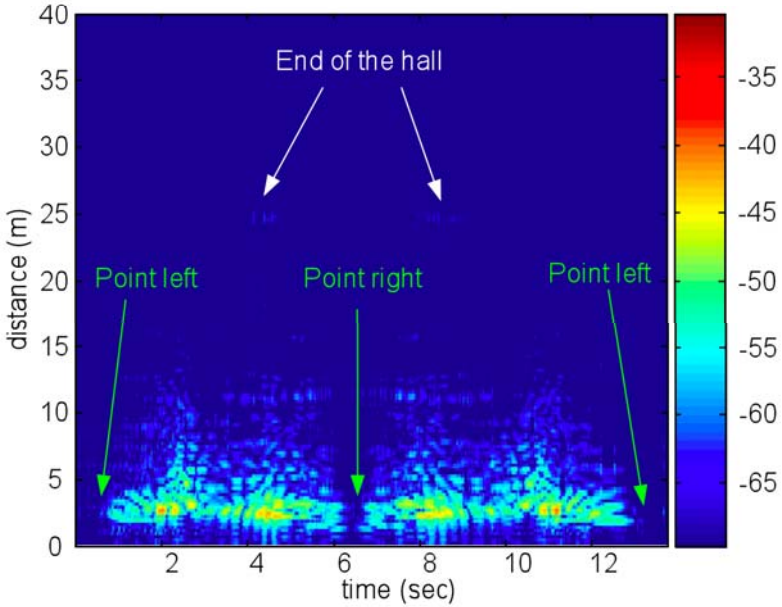
Results courtesy of the students. Used with permission.

Fred Chen, Yan Li, and Ranko Sredoievic

Range vs. time in hallway of building 38:



Radar placed on swivel chair and rotated CW then CCW:



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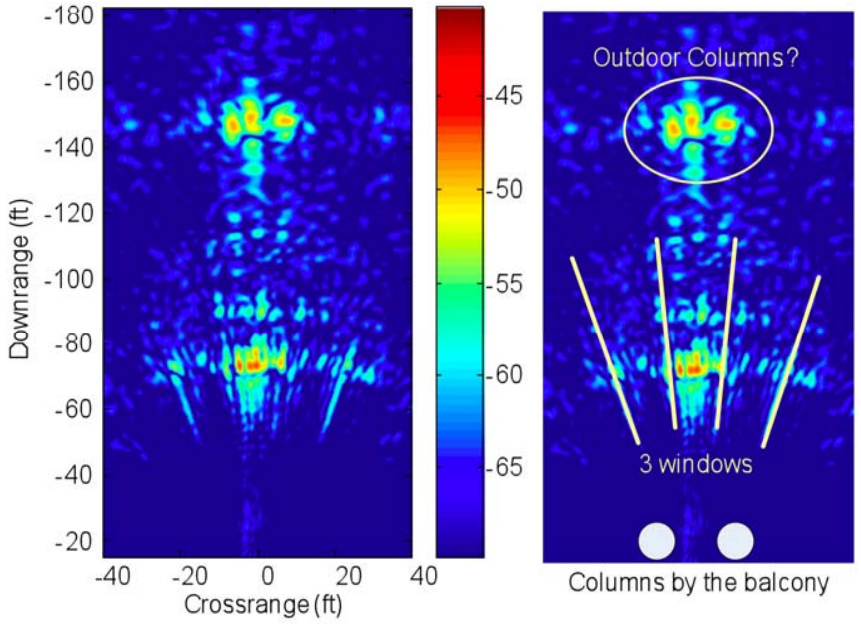
Fred Chen, Yan Li, and Ranko Sredojevic

SAR image of Lobl
from 2nd floor balcony:



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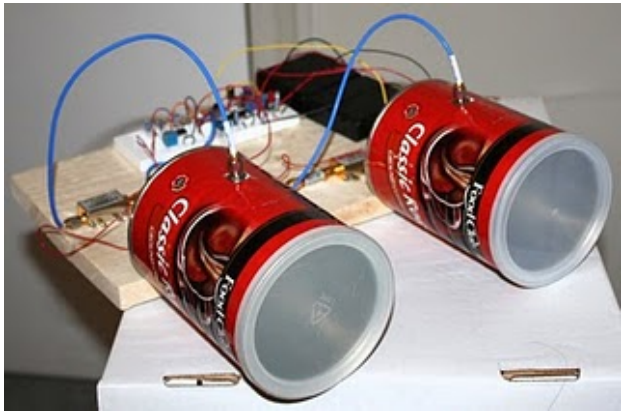
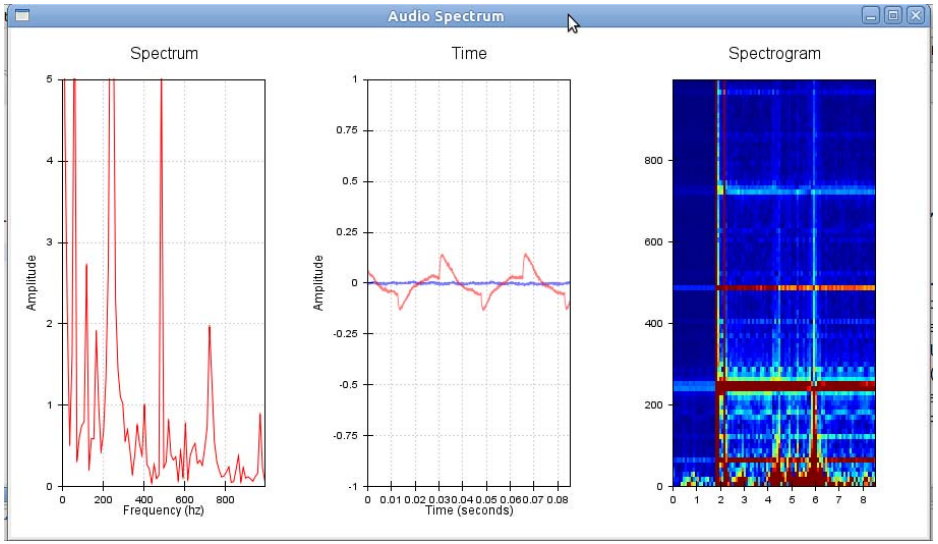
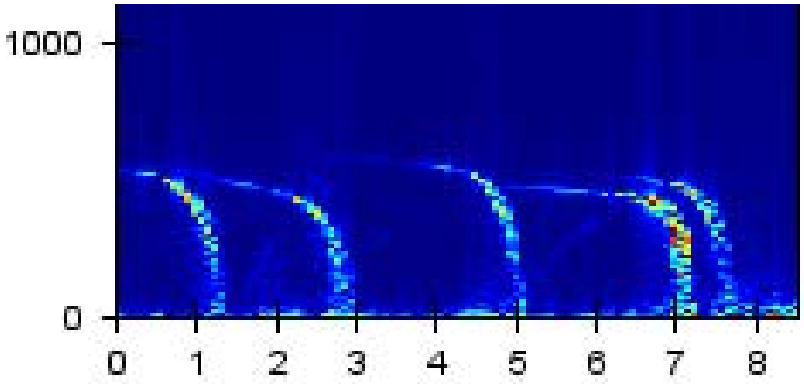




Innovation: Real-Time GUI



Doppler vs. time at corner of Memorial dr. at Ames st.

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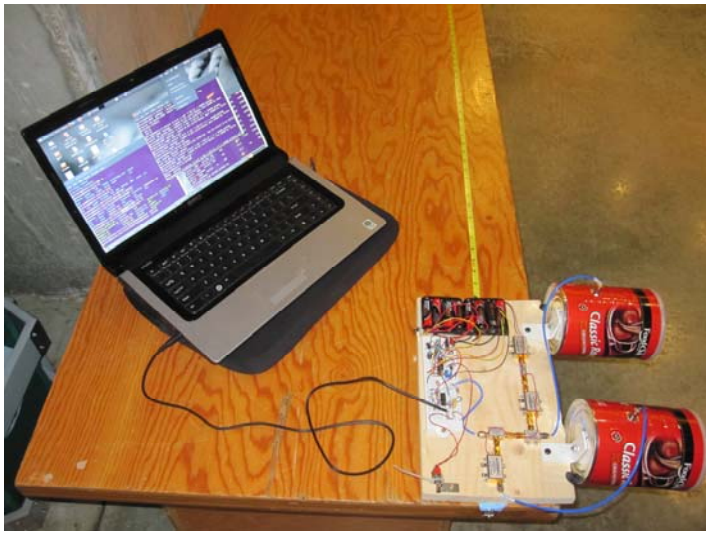
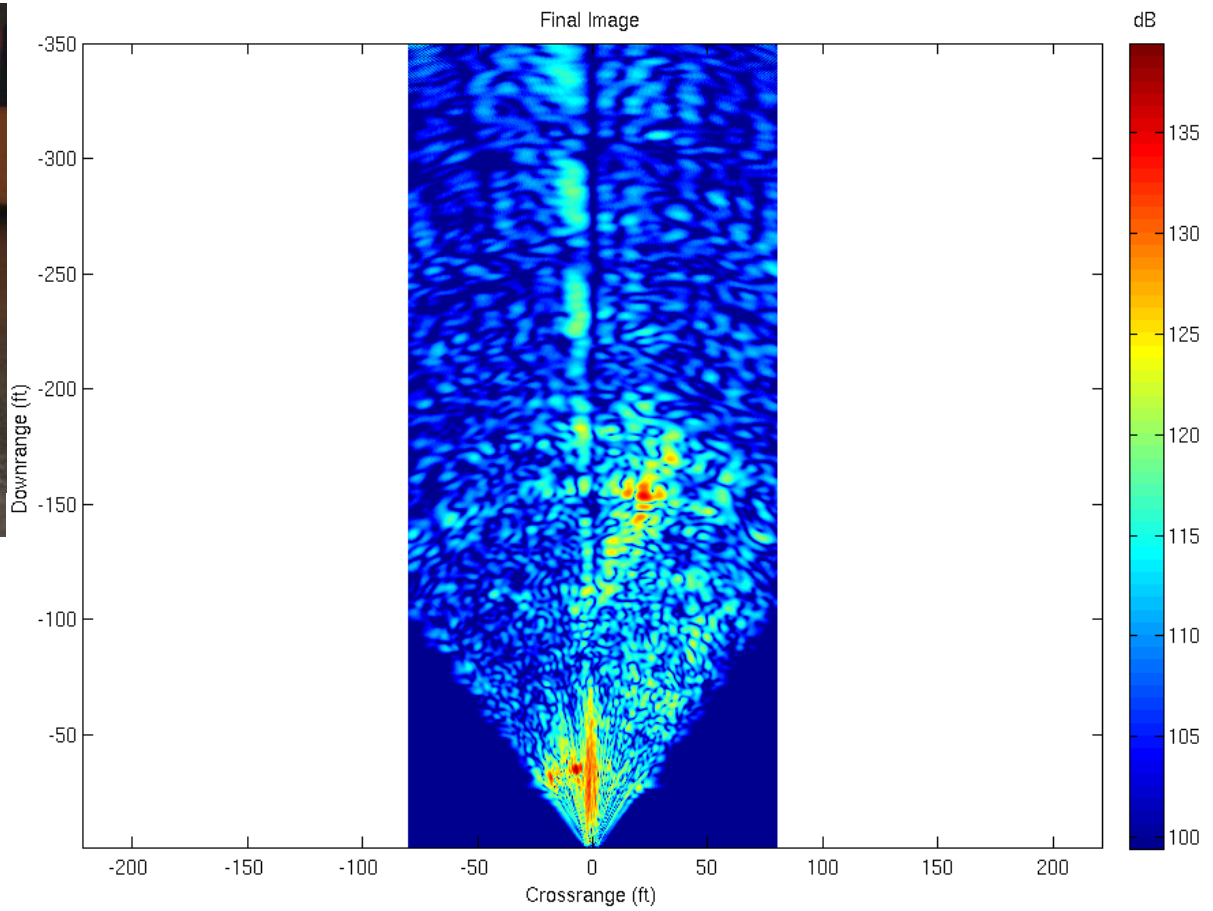
Gustavo Goretkin and anonymous MIT student





Inside Stata Center

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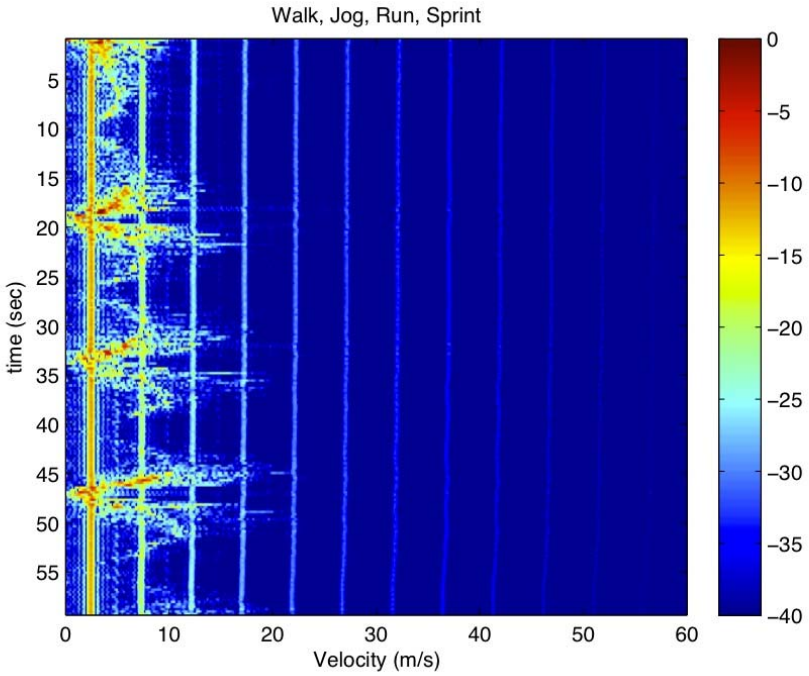
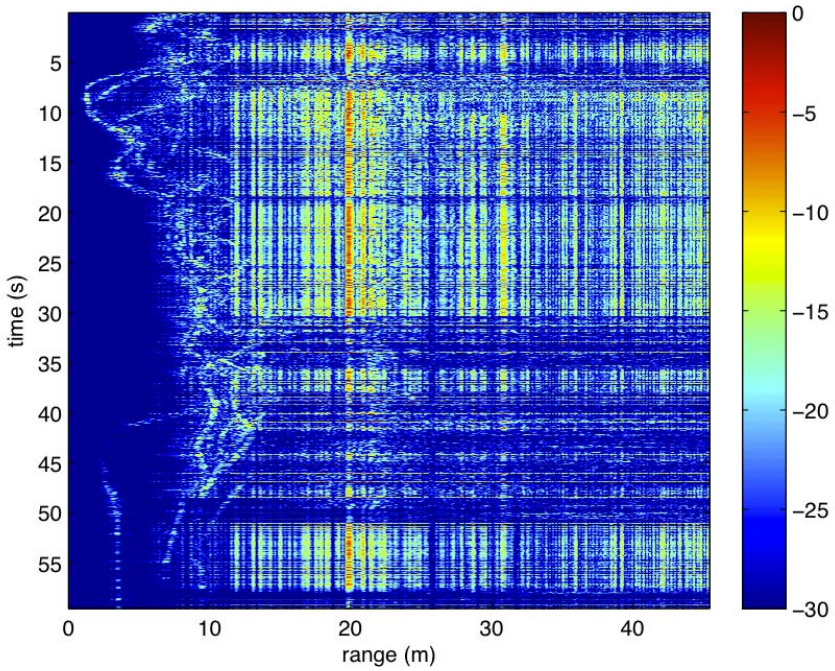


Doppler vs. time of walk, run, sprint.



Range vs. time of MIT Ultimate Frisbee club practice, 3-on-3 scrimmages.

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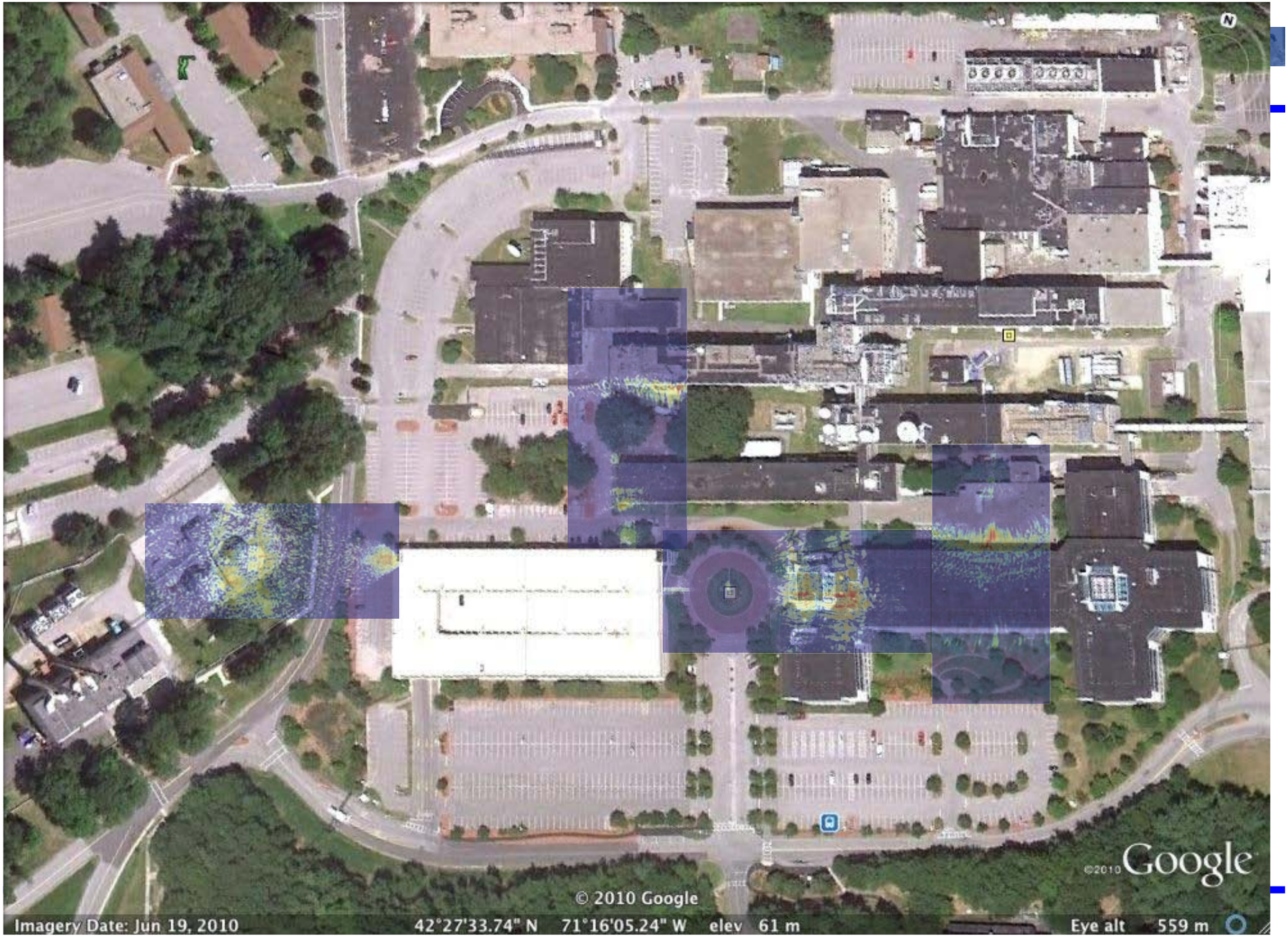

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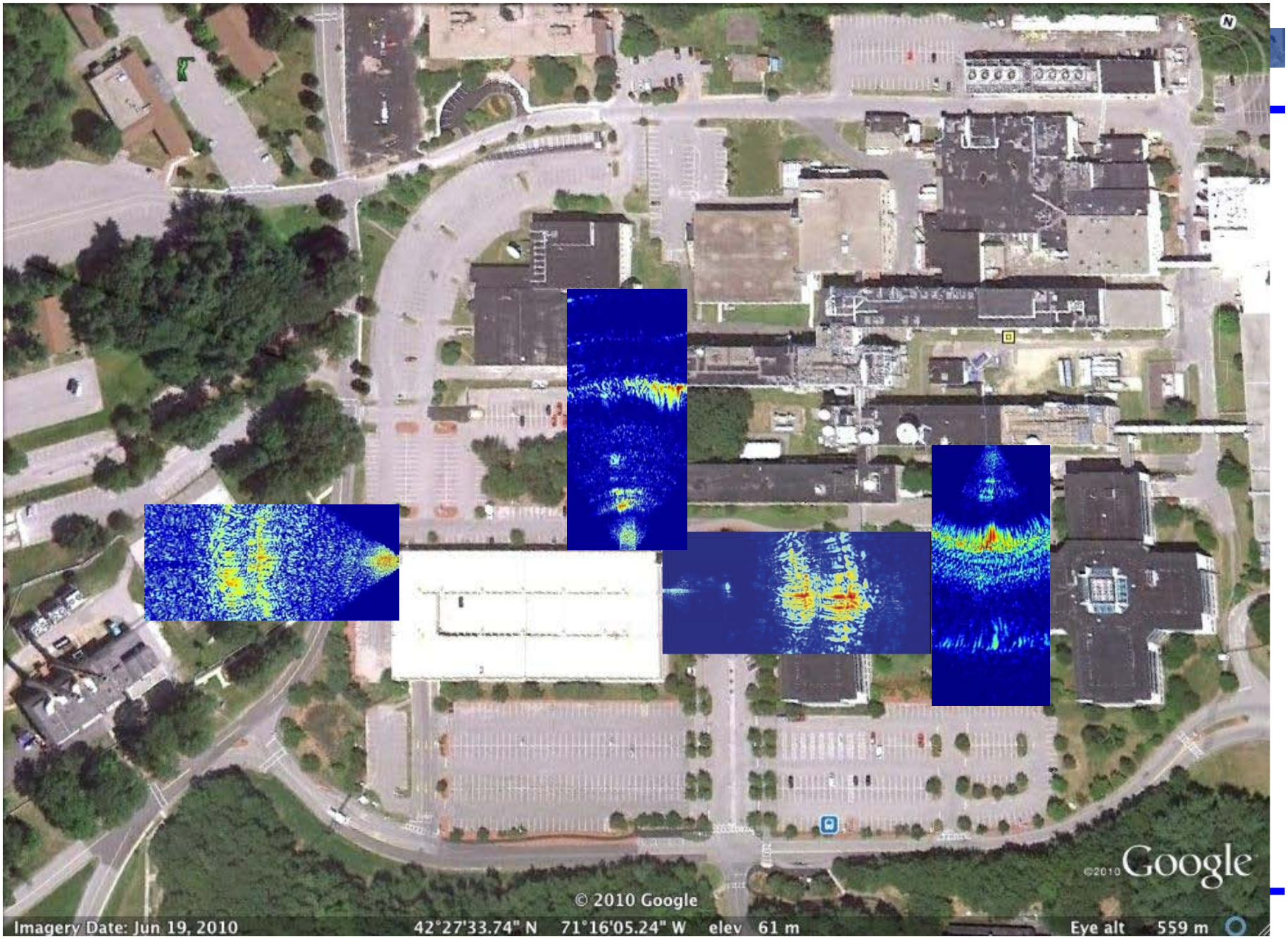

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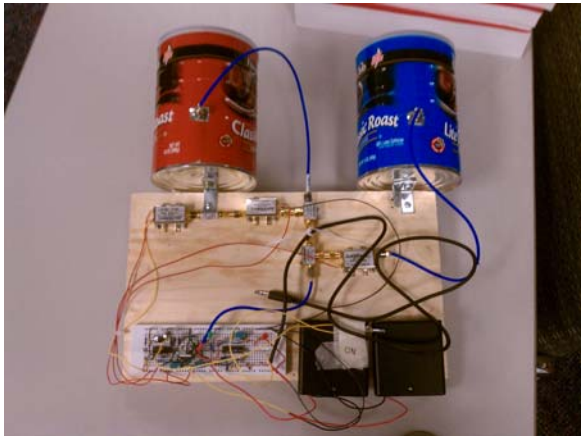
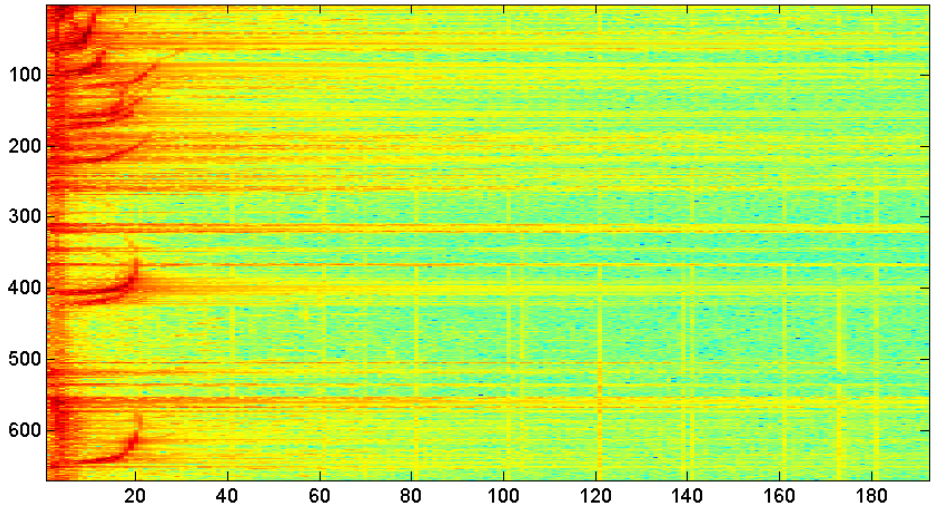
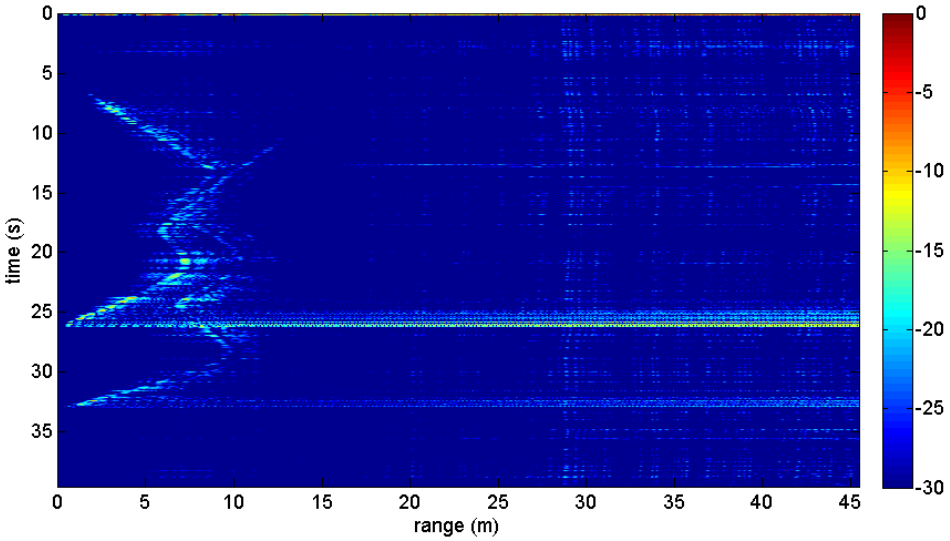
Kate Williams, Spiros Mantzavinos, Galia Ghaza, and Eric Williams



Doppler vs. time of traffic.



Range vs. time.



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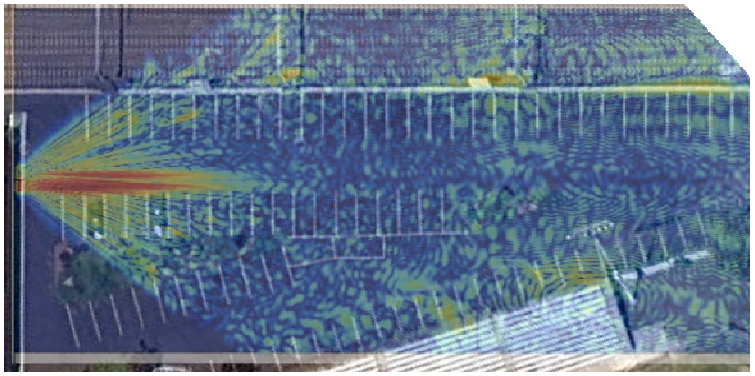

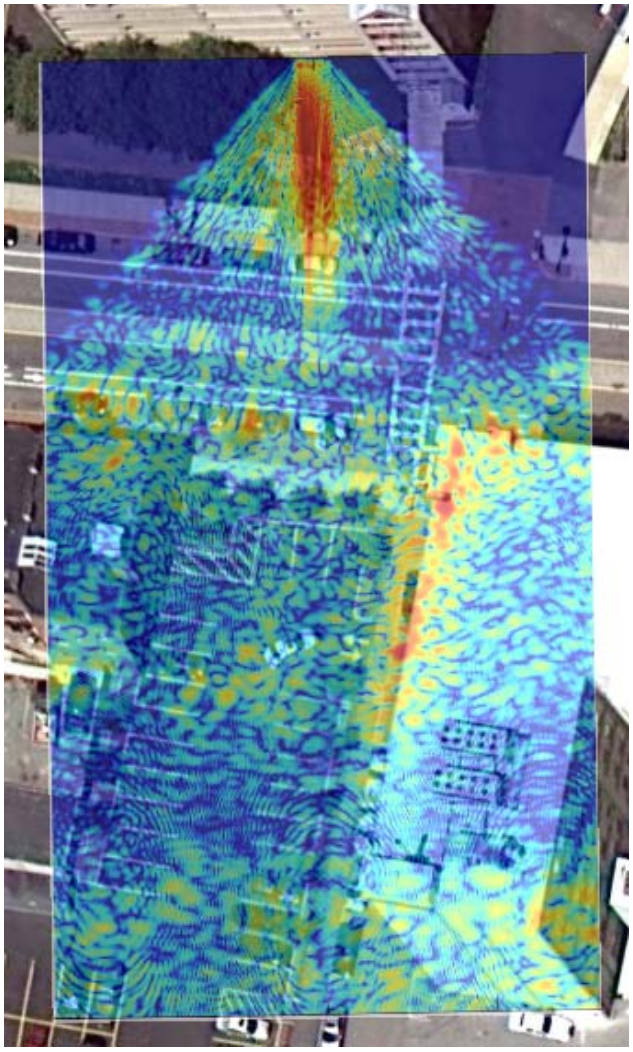

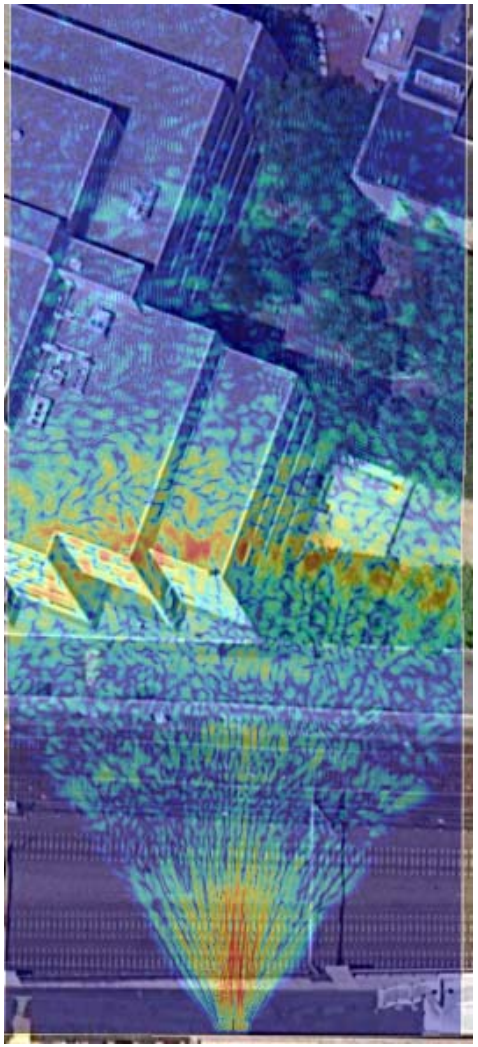

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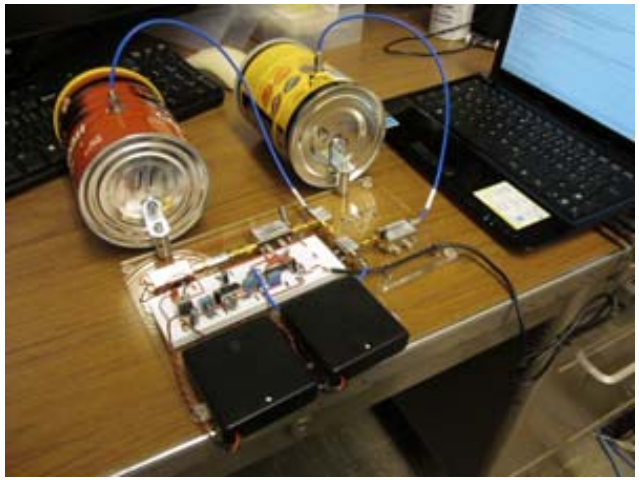
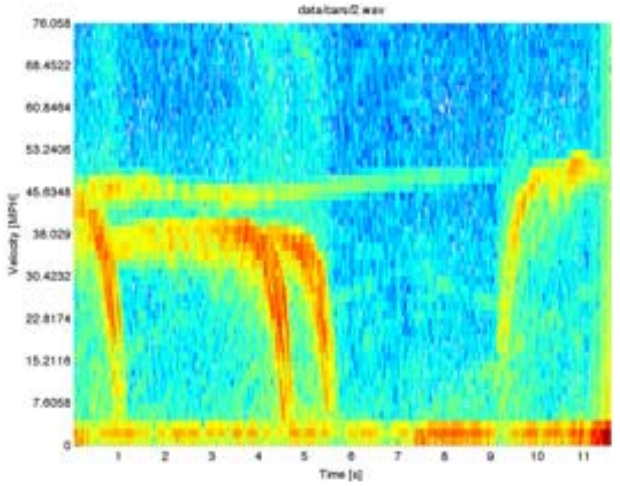
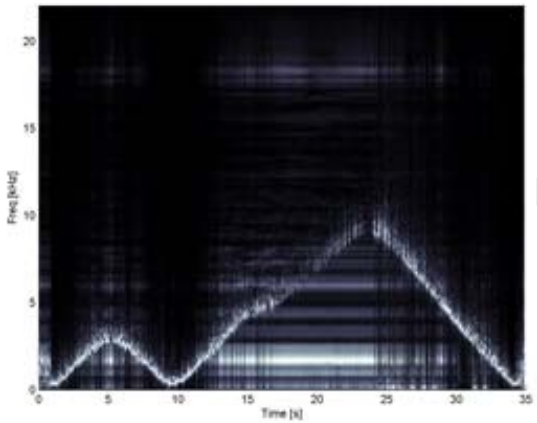
Tony Kim, Nevada Sanchez, and Paresh Malalur



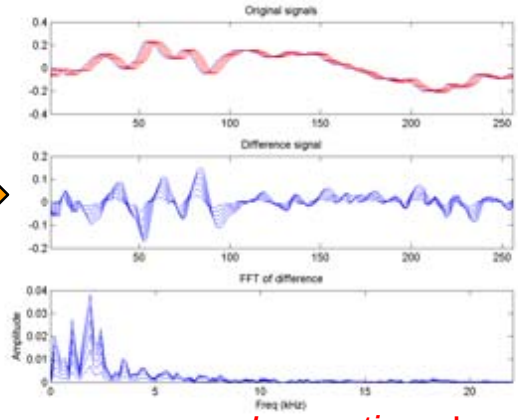
Innovation: Plexiglas radar chassis for improved ruggedness for use in field testing

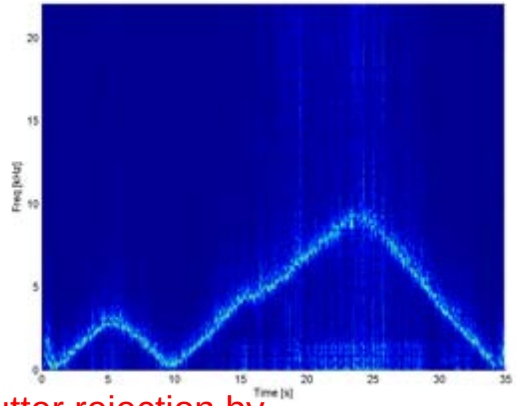


Doppler vs. time at Memorial dr. underpass.



Running down 2nd floor in building 26.

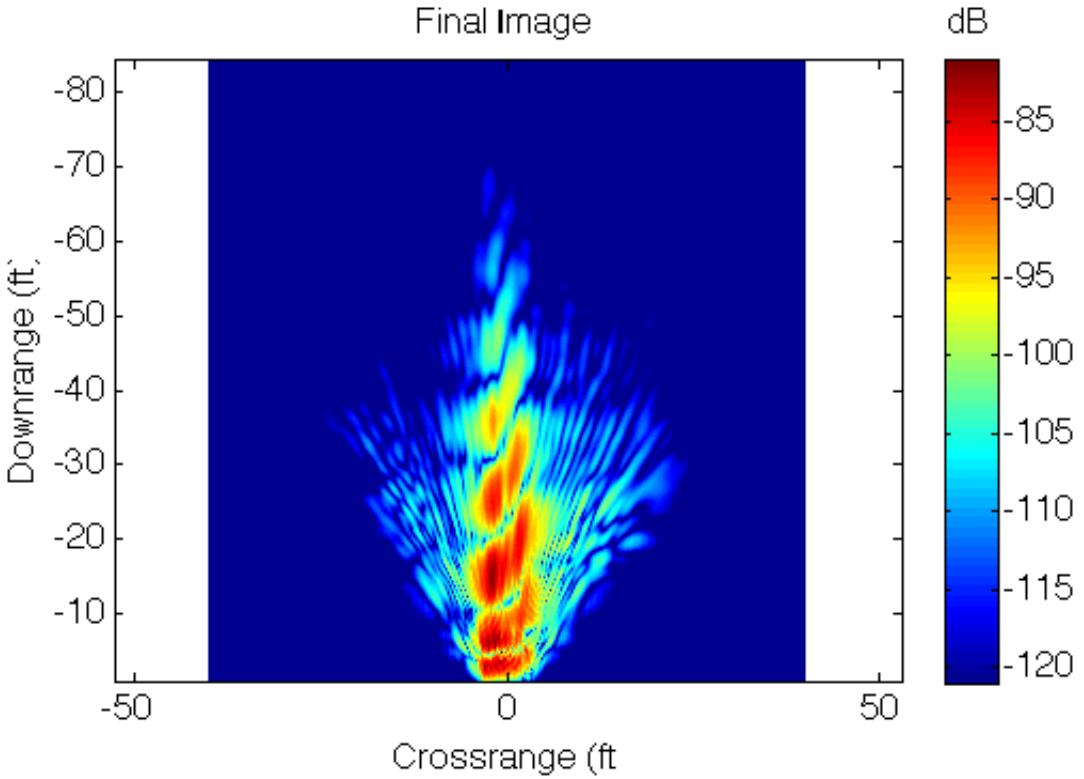


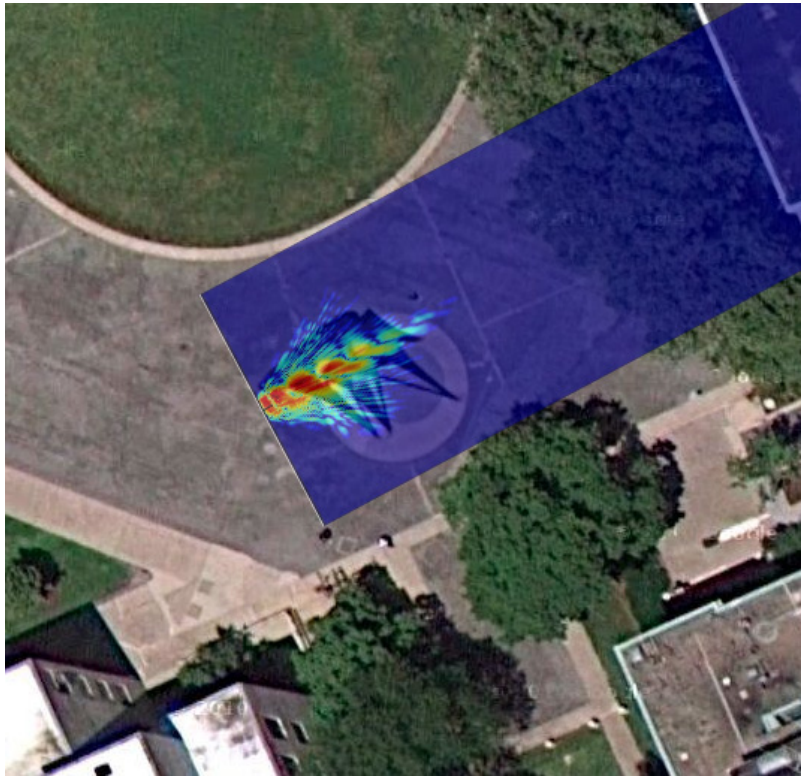


Innovation: Improved clutter rejection by subtracting amplitudes of range data to overcome trigger jitter.

Results courtesy of the students. Used with permission.

Tony Kim, Nevada Sanchez, and Paresh Malalur





Results courtesy of the students. Used with permission.

SAR image of the outdoor statue La Grand Voile (The Big Sail) by Alexander Calder.

Satellite map images © Google and GeoEye. Calder sculpture photo © MIT List Visual Arts Center
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Outline

- Baseline of results from instructors
- Student Results:
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  - Fred Chen, Yan Li, and Ranko Sredojevic
  - Gustavo Goretkin and anonymous MIT student
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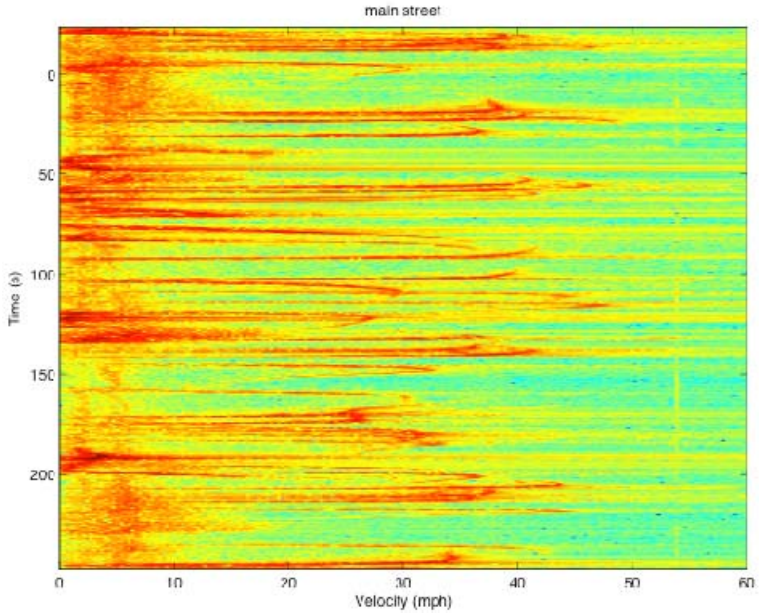
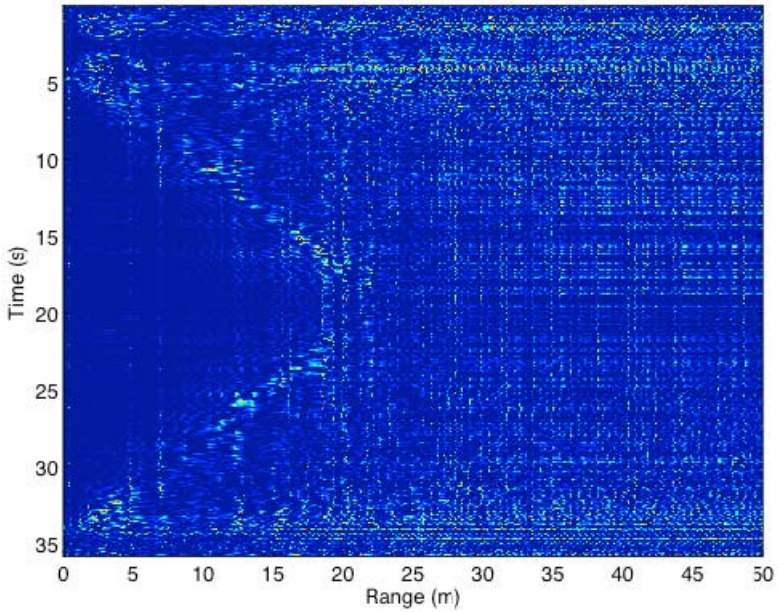
- Next steps
- Summary

Walker Chan, Elaina Chai, and Michael Scarito



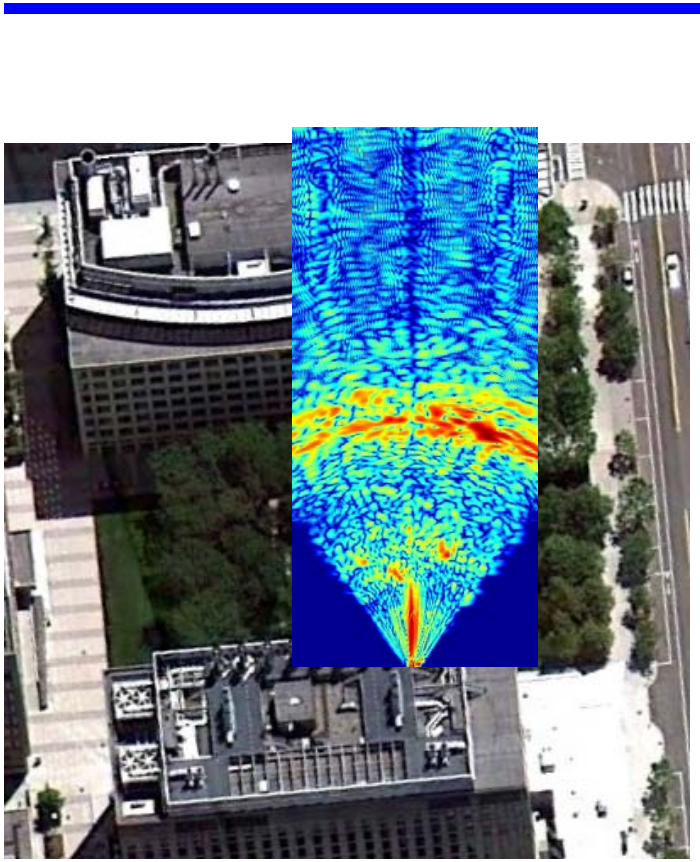
Doppler vs. time at 77 Mass Ave.

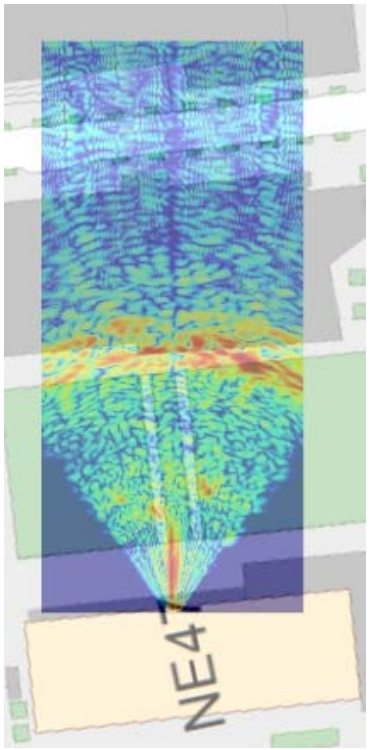


Running down 2nd floor in building 26.

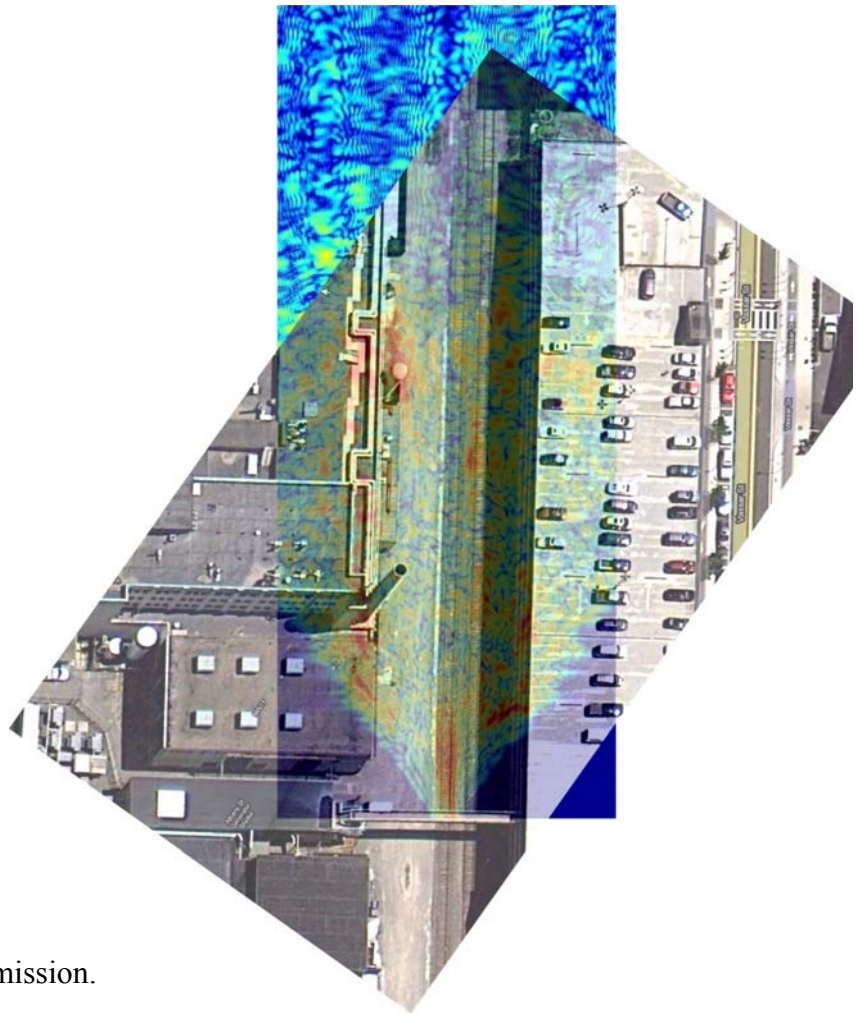
Results courtesy of the students. Used with permission.

Walker Chan, Elaina Chai, and Michael Scarito





Courtyard next to building NE47



Looking down the train tracks

Results courtesy of the students. Used with permission.

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Next steps: improve your radar

Make improvements in order of importance:

1. Proper data acquisition system with trigger
   - improved pulse-to pulse phase coherence
     - improves clutter rejection in range vs. time
     - improves SAR imagery
   - calibration possible
     - improve SAR resolution

2. Increase reliability by soldering analog circuits on to proto board

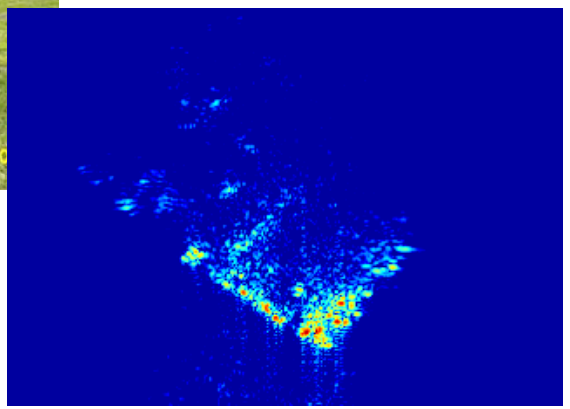
3. Increase reliability by building into metal or plastic chassis

Next steps: build a wider bandwidth or higher frequency radar

- Use more bandwidth to improve range resolution
- Increase frequency to improve cross-range resolution
- Mount on to automated rail for increased cross-range positioning accuracy
  - less difficult to make SAR image
  - increases 'funness' level

Feasible UWB imaging system:

Why was I pulled over?

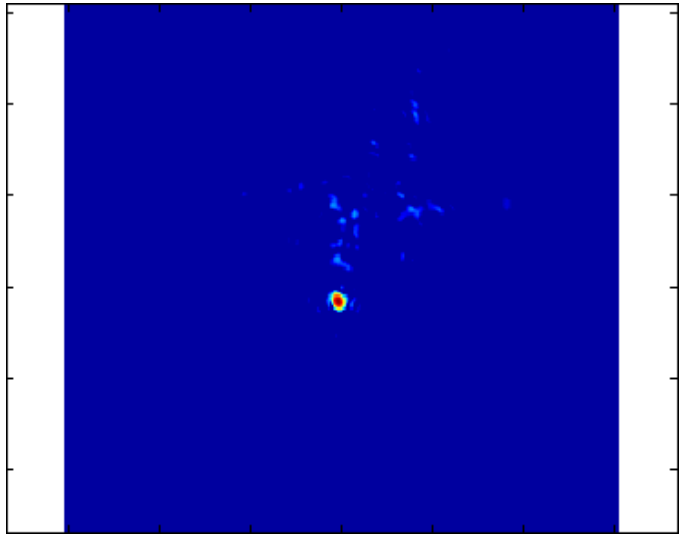


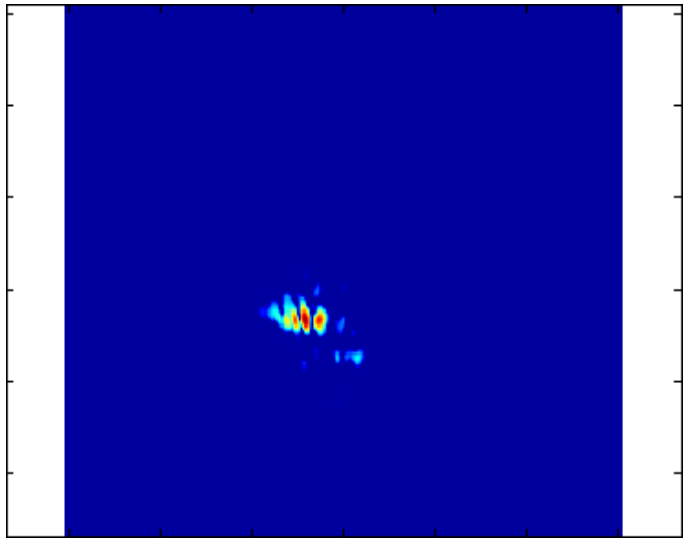
5.0 Mustang on radar

Next steps: build a phased array radar

Phased array radar built in garage:

Phased array radar built at Lincoln Laboratory:

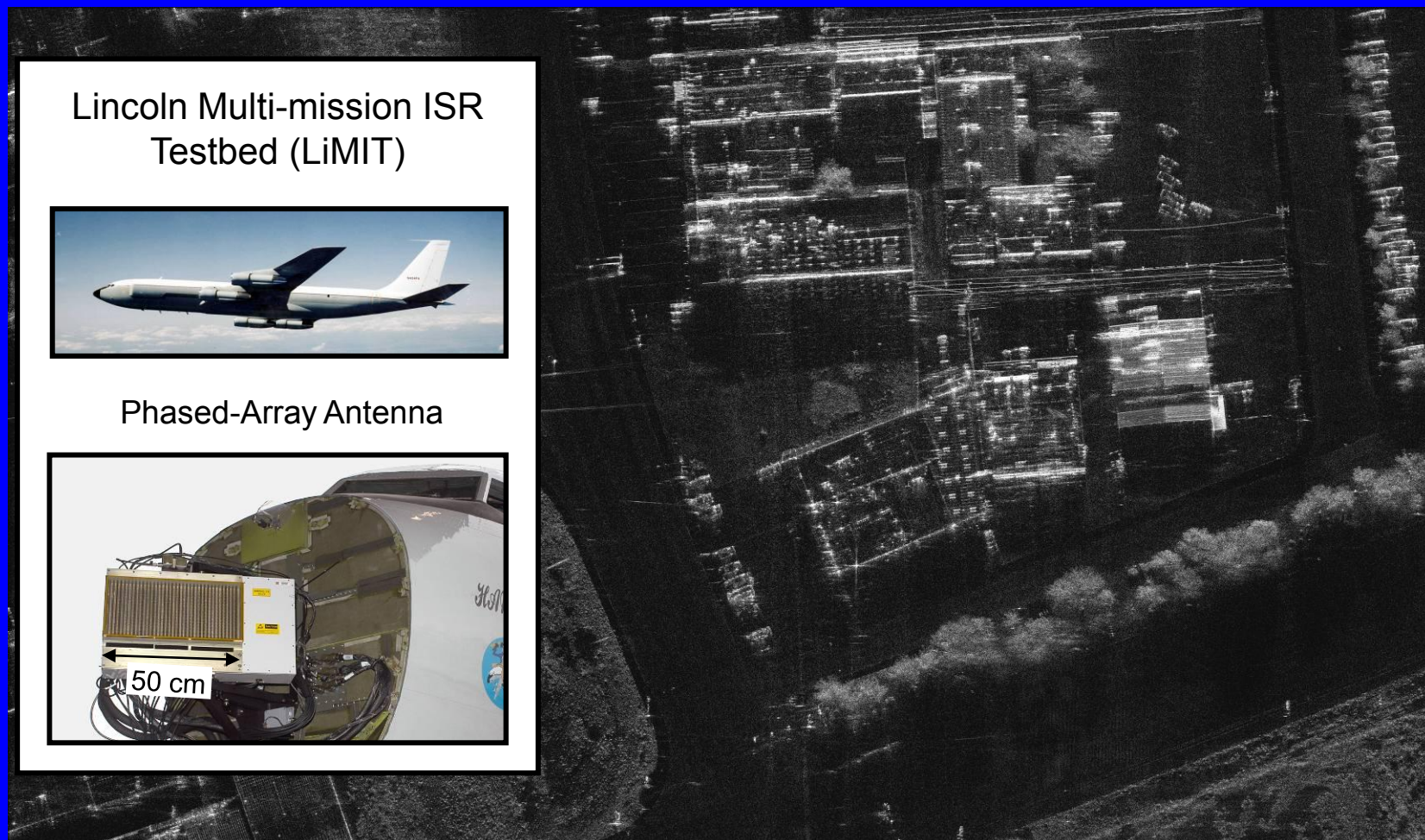




Next Steps: Work at Lincoln Laboratory on systems like LiMIT

Sierra Vista, AZ, August 18, 2005

160 m Range cutout (400 m swath)



260 m Cross Range cutout (2 km swath)

MIT Lincoln Laboratory

G. R. Benitz, 'Synthetic Aperture Radar (SAR),' MIT Lincoln Laboratory, 2007.

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Summary

- Course objective: generate interest in radar design
  - Abstract and difficult concept made to be fun
  - Lectures at a high level to keep things interesting:
    - history of radar
    - RF design
    - antennas
    - pulse compression
    - SAR imaging
  - Continuous engagement, make actual radar system
  - Field experiments, results from 9/9 groups:
    - doppler vs. time
    - range vs. time
    - SAR imaging
- Long-term recruiting and increased campus collaboration
- Course to Opencourseware site
  - share with all students interested in radar
  - share our concept of interactive learning with greater DoD

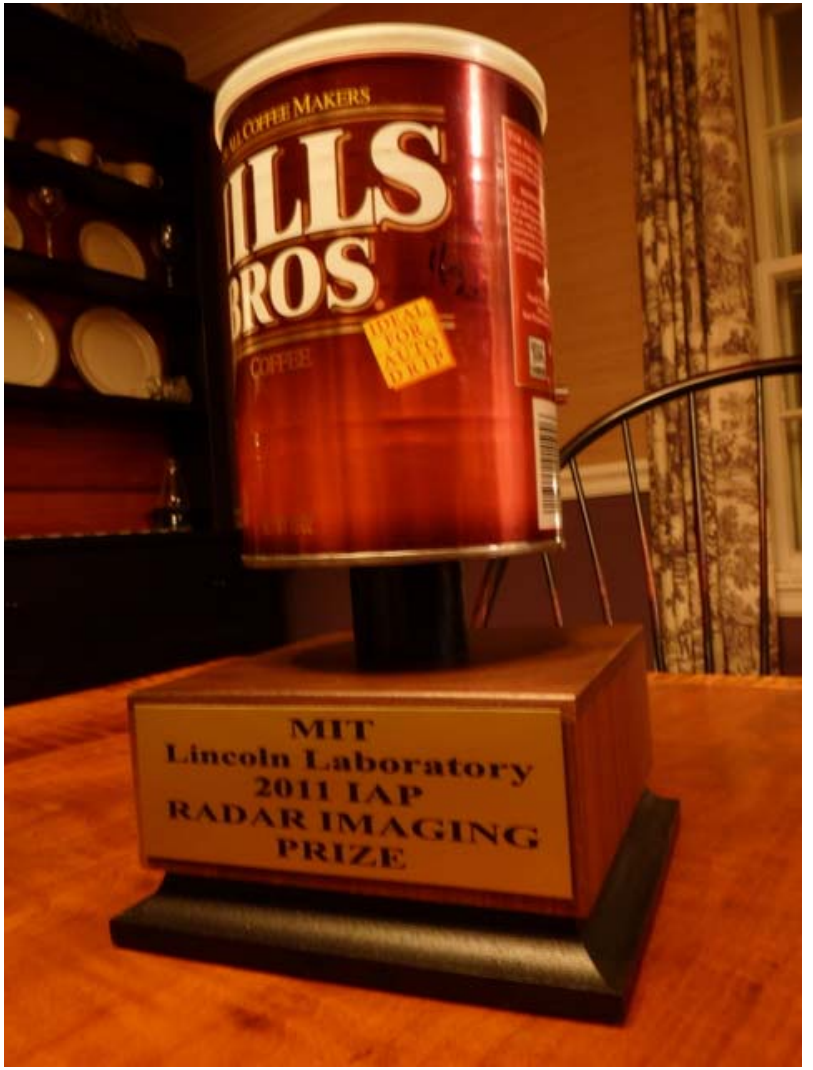
Prestigious Award Ceremony Time!

For the best radar image made using coffee cans.

The Stanley Cup of Radar Awards!

Who gets the Cup?

Winning team: Tony Kim, Nevada Sanchez, and Paresh Malalur



MIT OpenCourseWare
http://ocw.mit.edu

Resource: Build a Small Radar System Capable of Sensing Range, Doppler, and Synthetic Aperture Radar Imaging

Dr. Gregory L. Charvat, Mr. Jonathan H. Williams, Dr. Alan J. Fenn, Dr. Steve Kogon, Dr. Jeffrey S. Herd

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