Engineering Research Center for
CASA
Collaborative Adaptive Sensing of the Atmosphere

What is the ERC ?
Why is it important to me?
How might I get involved?

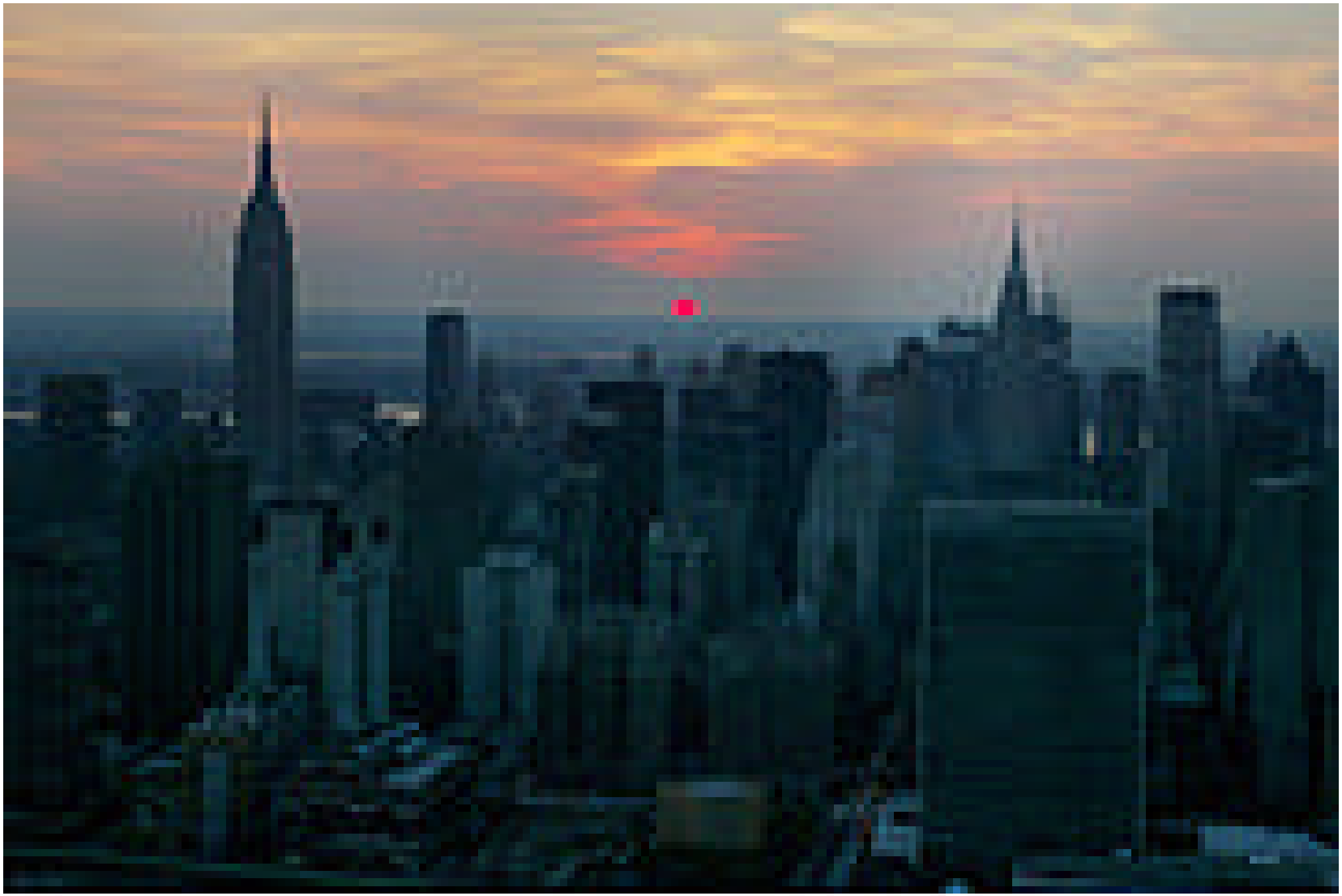
David McLaughlin
University of Massachusetts at Amherst

University of Massachusetts at Amherst

ECE Department Freshman & Sophomore Seminar

December 1, 2003

NSF



Sunset during blackout
Sunset over Manhattan during blackout, Aug. 14, 2003.
Vincent Laforet/The New York Times Photo Archives


POWER OUTAGES
Ottawa
Plattsburgh
Toronto
Syracuse
Utica
Albany
Detroit
Buffalo
Rochester
Hartford
New York
Cleveland
MSNBC

August 13, 14 Blackout

- How do we engineer complex systems that don't shut down?
- What are the technologies involved?
- Is this an ECE problem? A business problem? A software problem? An ME problem? An "end-user" problem?
- ***How do we educate tomorrow's engineers to engineer such systems?***

Tomorrow's Engineers

- **will**
  - work with many types of users to design their systems
  - deal with complexity and uncertainty
  - need strong fundamental background, but they …

- **will not** be expert in all the technologies they will encounter. Therefore, they will need to effectively
  - work across disciplinary boundaries
  - work in diverse teams

- **will be leaders**

- **are today's engineering students.**

The ERC is an Engineering Research Center created by a major, highly competitive research grant from the National Science Foundation.

ERC's *exist* to educate students about engineered systems by tackling society's tough technological problems.

Our ERC – CASA – is about students working with professors, industry partners, and "end-users" to engineer an entirely new way to detect & predict tornadoes and other atmospheric hazards.

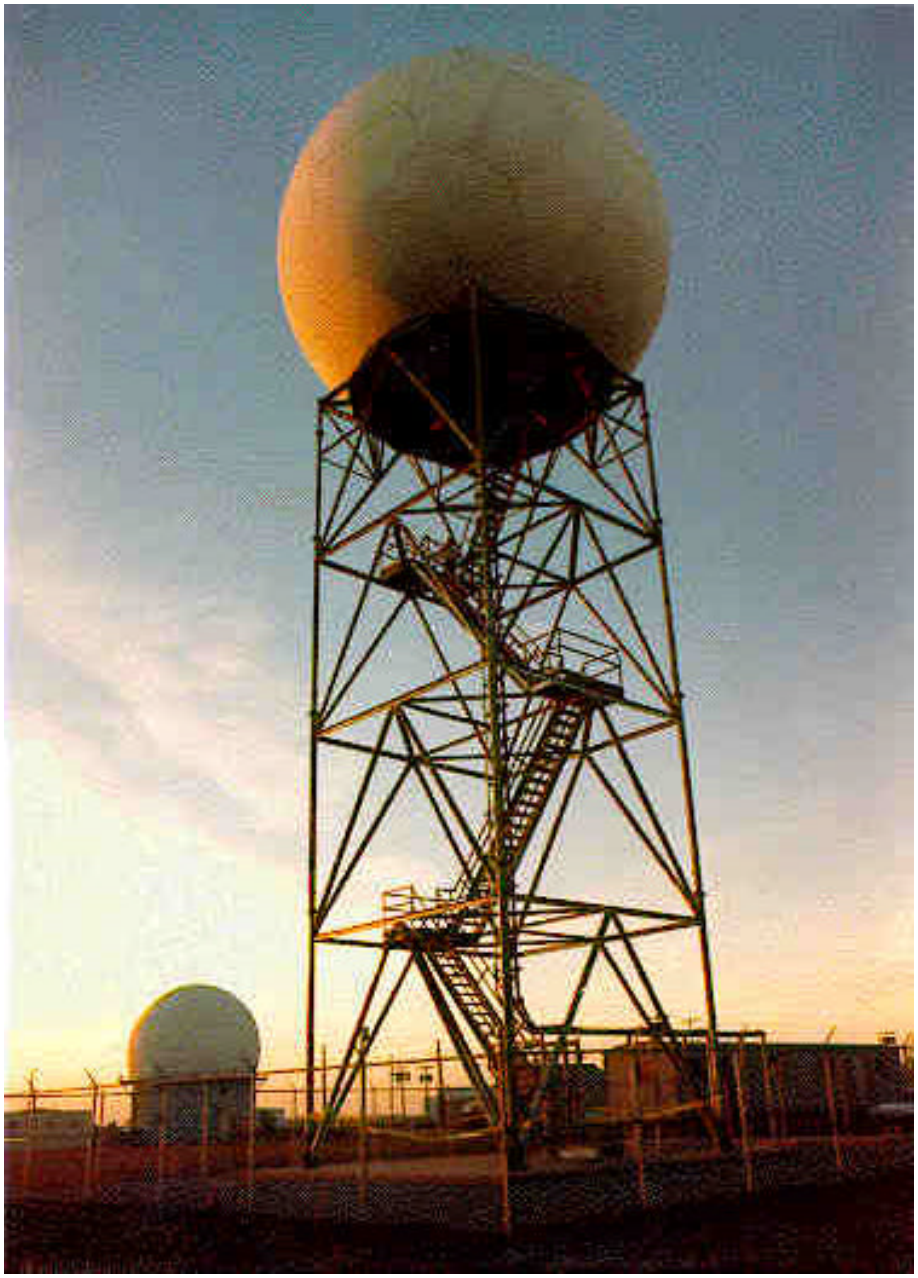

GREYHOUND


Texas Medical Center

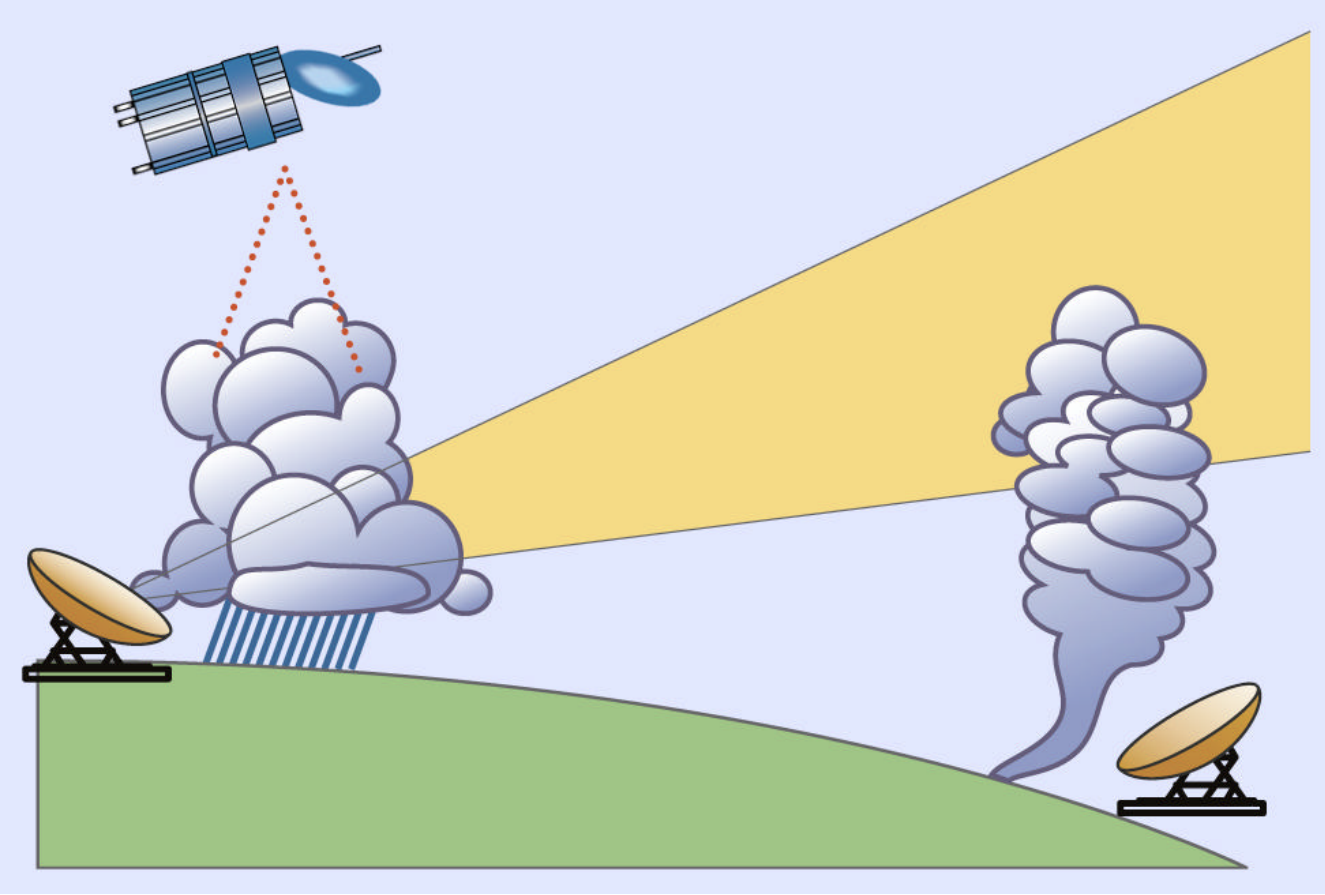
NEXRAD Installation

8.5 meter antenna
10 meter radome
500 kW transmitter

138 installations across US



Lower Troposphere is grossly unobserved today



Earth curvature effects prevent 72% of the troposphere below 1 km from being observed

WSR-88D Facility Damage
in Northern Taiwan 1996

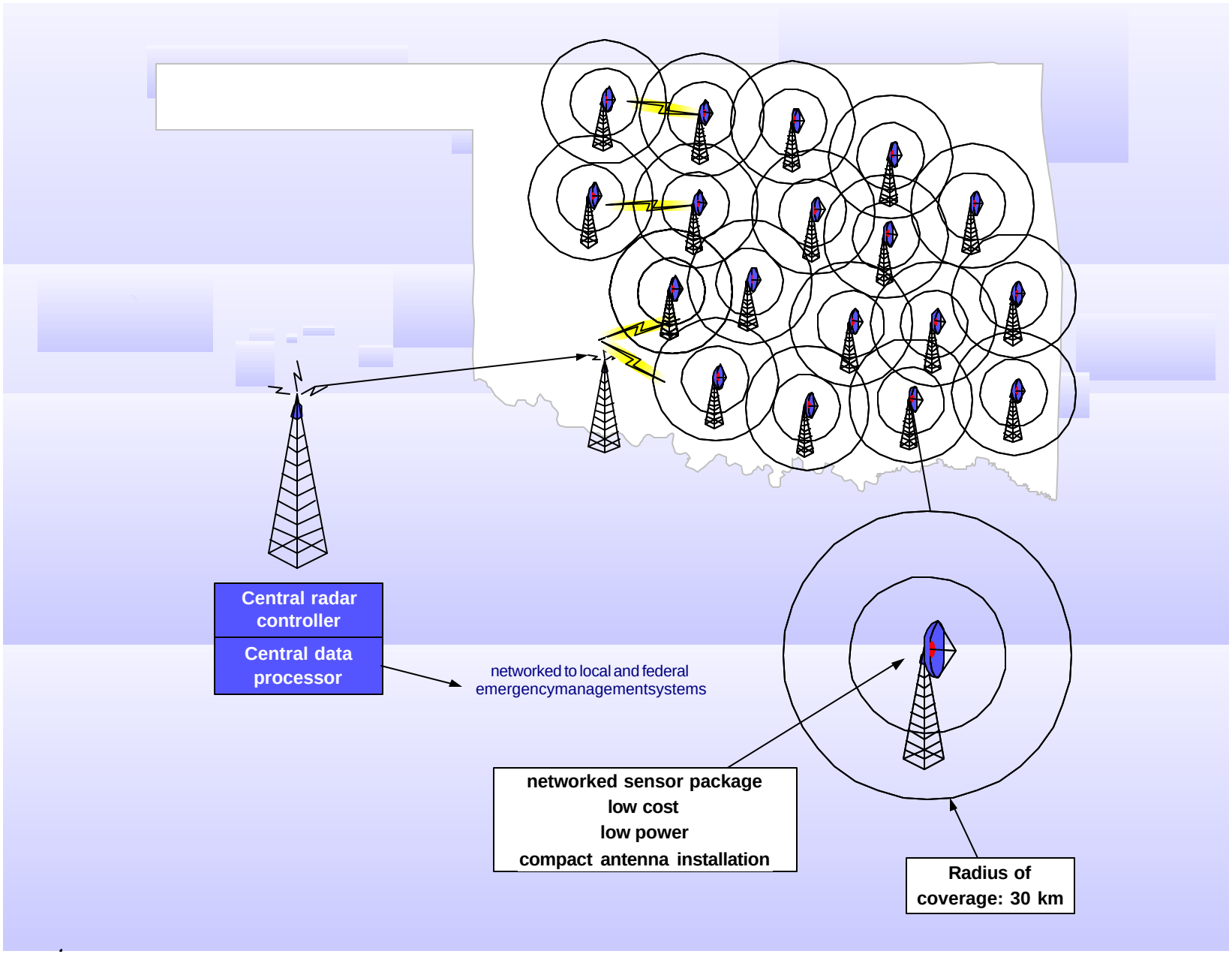
Catastrophic Failure of Single-Point Sensor

Source: NCAR Web Site
http://www.scd.ucar.edu/vg/Herb/herb.html

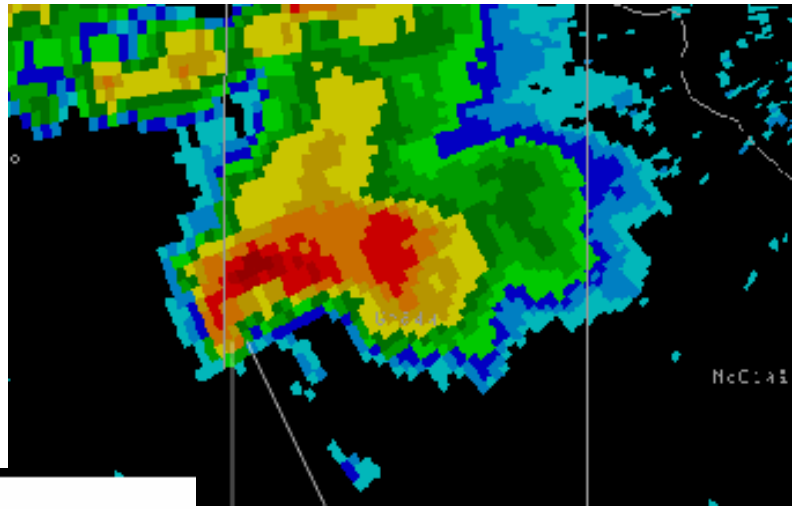
Today's system

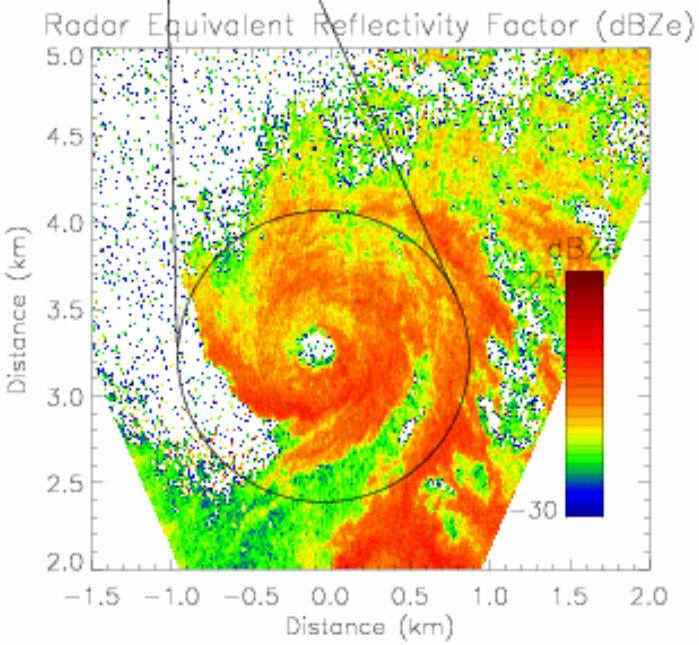
- Can't see down low
  - Can't accurately detect tornadoes (80% false alarms!)
  - Can't quantitatively measure rainfall
  - Can't describe in detail what's happening when a hurricane makes landfall
- Is subject to catastrophic single-point failure.

NetRad


Central radar controller
Central data processor
networked to local and federal emergencymanagementsystems
networked sensor package
low cost
low power
compact antenna installation
Radius of coverage: 30 km

May 3, 1999 Tornado Outbreak in Oklahoma



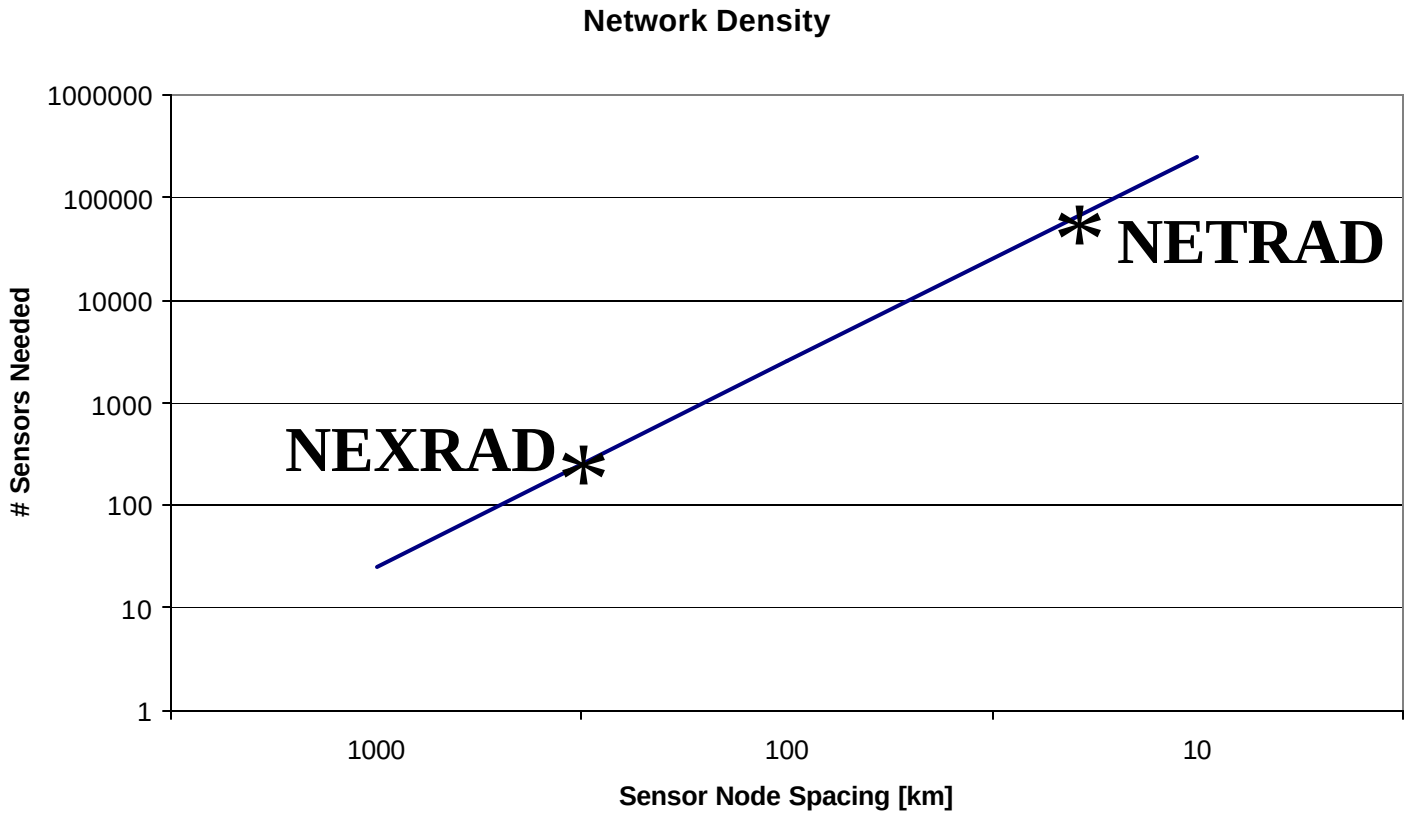


Sparse Network

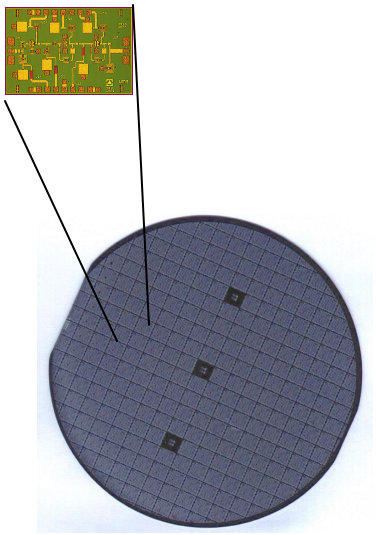
- **Large, expensive sensors**
- **Power tubes**
- **Mechanical scanning**

Dense Network

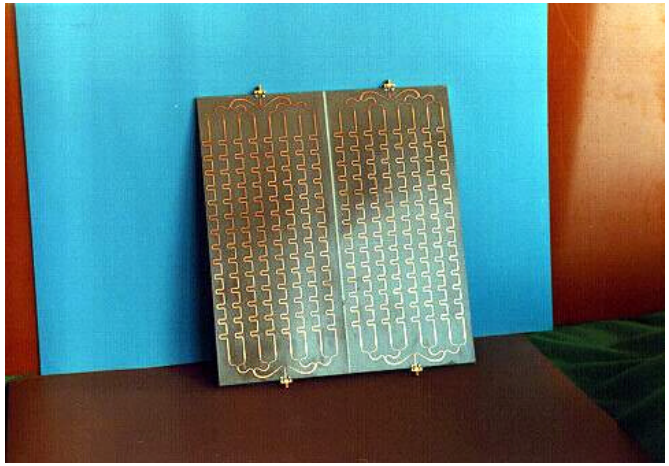
- **Small, inexpensive sensors**
- **Solid State**
- **Electronic scanning**



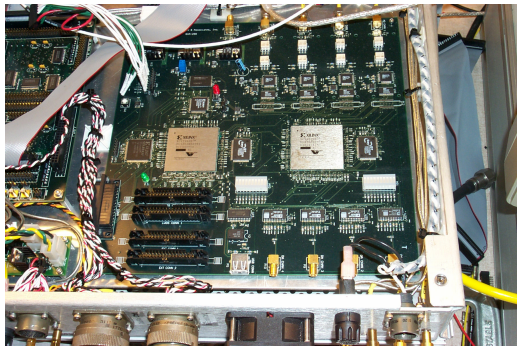
Enabling Sensor Component Technologies



Low-Cost Monolithic Microwave IC's. ("A common manufacturing base for dual-use applications," Fallon et al, M/A-Com, NRC Report on Commercial and Military Manufacturing, NRC, 2002.)

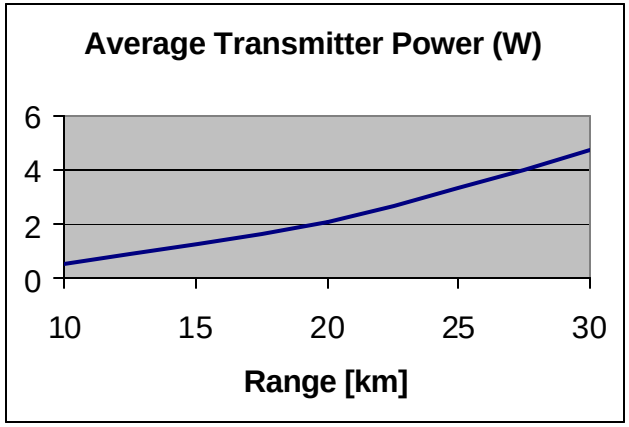


Microstrip patch antenna arrays

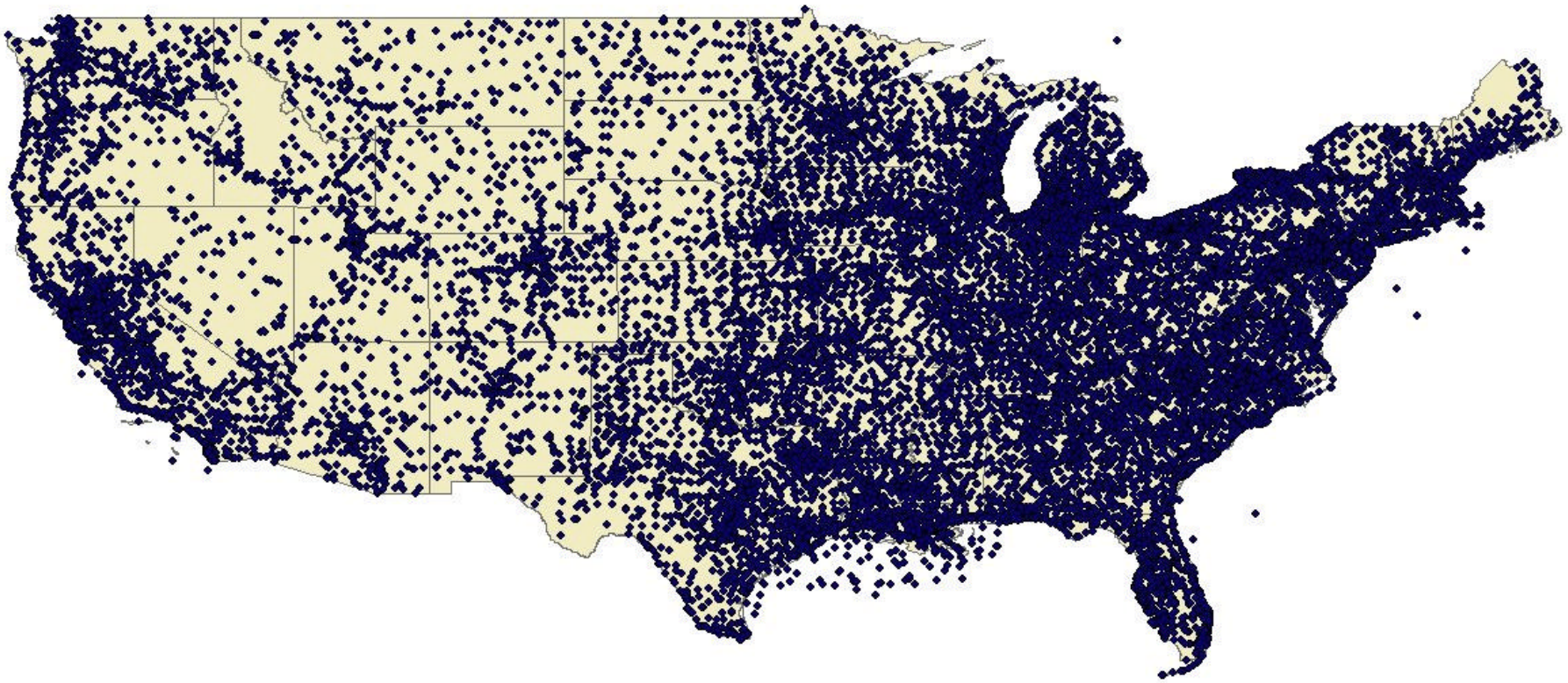


High-performance embedded processors Based on reconfigurable FPGA's

NETRAD System Parameters and Specifications		
Operating frequency	10.0	GHz
Antenna diameter	1	meter
Antenna beamwidth	1.7	deg
Noise figure	5	dB
System loss	4	dB
Maximum Height	3,000	meter
Update time	60	seconds
Range resolution	100	meter
CHIRP Gain	20	
Pulse integration gain	20.8	
Azimuth resolution (at 14 km range)	424	meter
Sensitivity (min dBz at 0 dB SNR)	0.0	dB



FCC Cellular Database -- 20,455 sites



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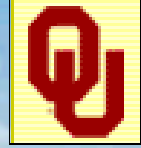
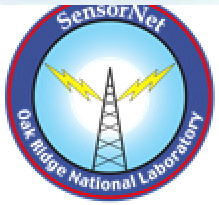
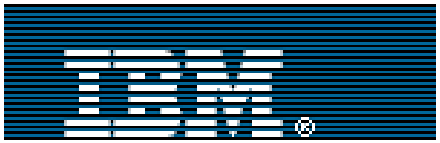
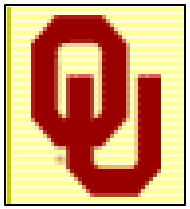








Average Number of Tornadoes per Year

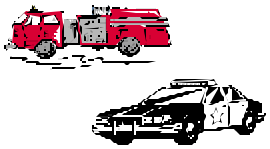
24 Tornadoes Per Year Over NETRAD Domain

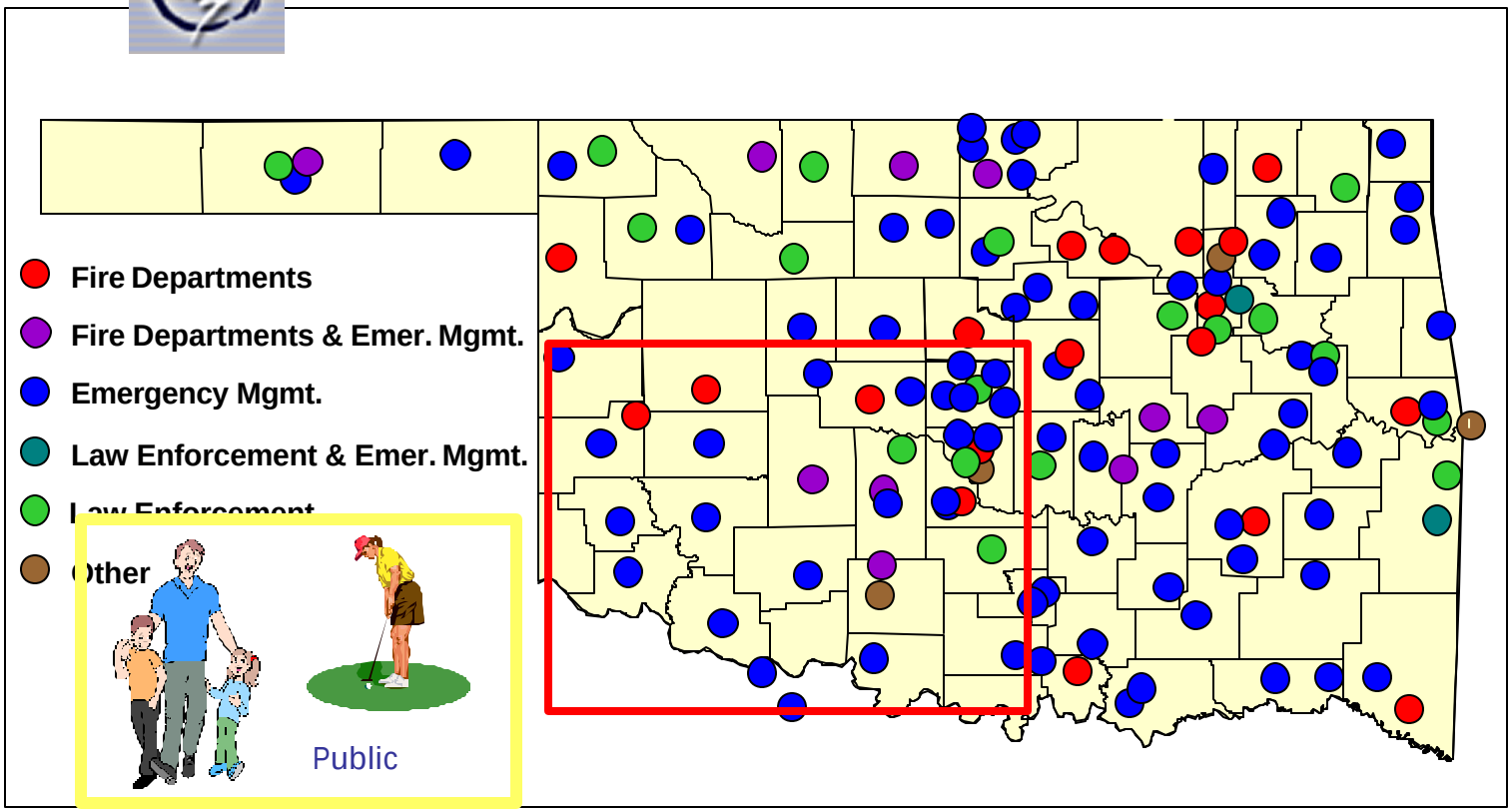
KEY

Average number of tornadoes per year per 10,000 square miles

- Fewer than one
- One
- Three
- Five
- Seven
- Nine

Direct Connection to Emergency Management

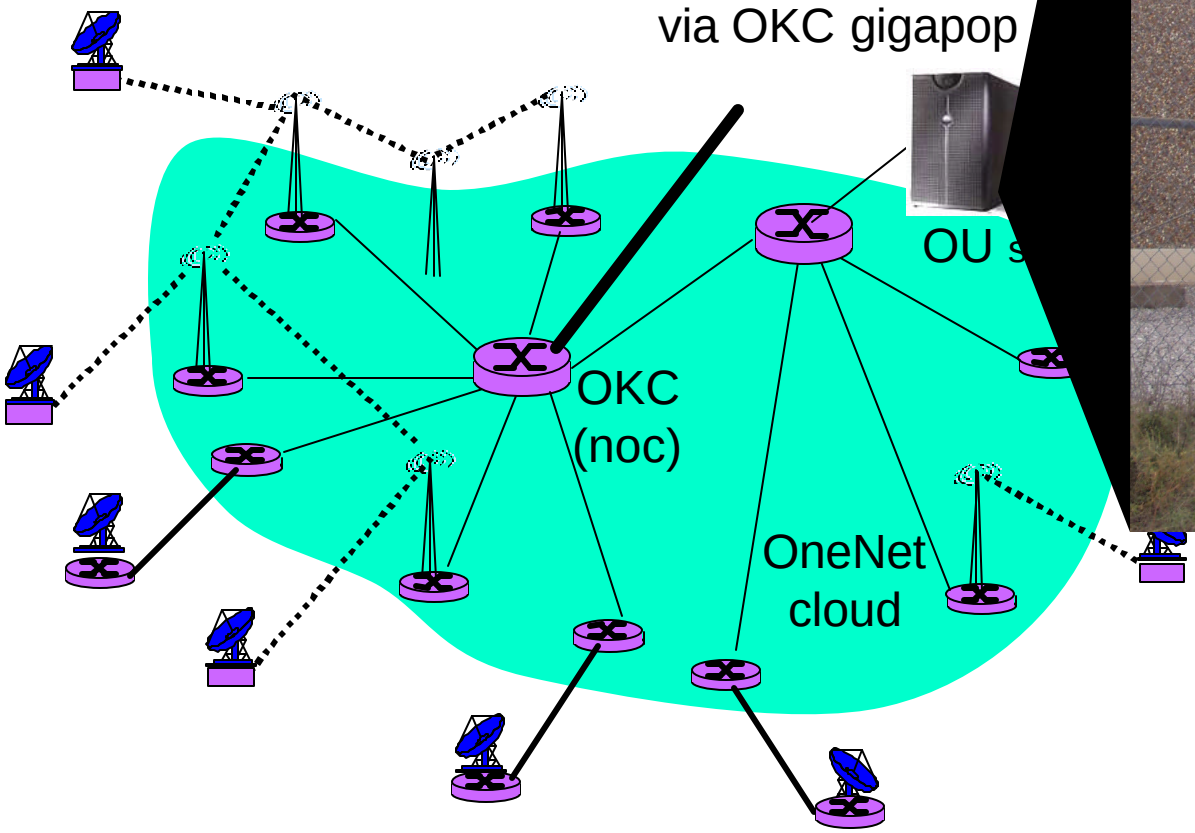




INNOVATIONS IN AMERICAN GOVERNMENT

STOCKHOLM.CHALLENGE

Network control and data dissemination…



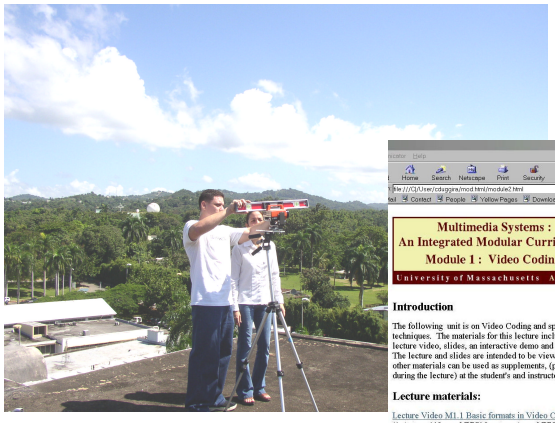
Fractional T1 (100K)
via existing OneNet
clients (e.g.,, school)

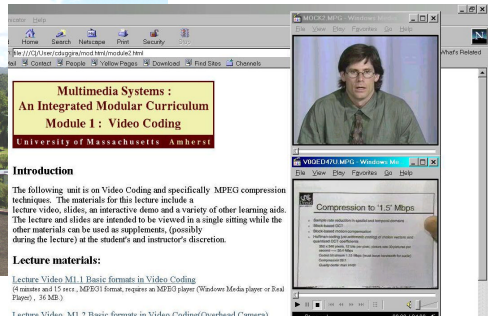
Texas Medical Center Test Bed

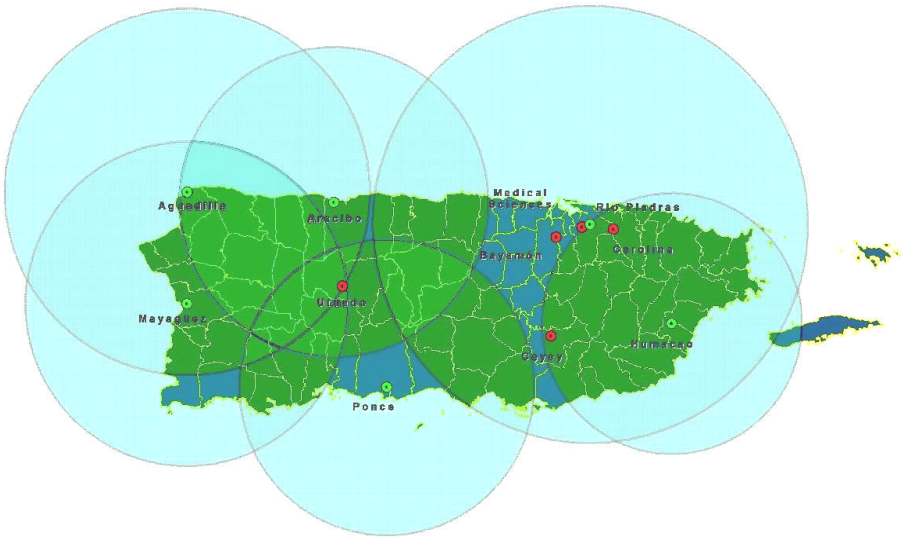
Emergency Response - TMC

- Flood Doors
- Flood Gates
- Facility Entrances
- Communications
- Operations
- Training

Puerto Rico Test Bed







- ***Student Designed Test Bed***

- Collaborate National Weather Service @ San Juan

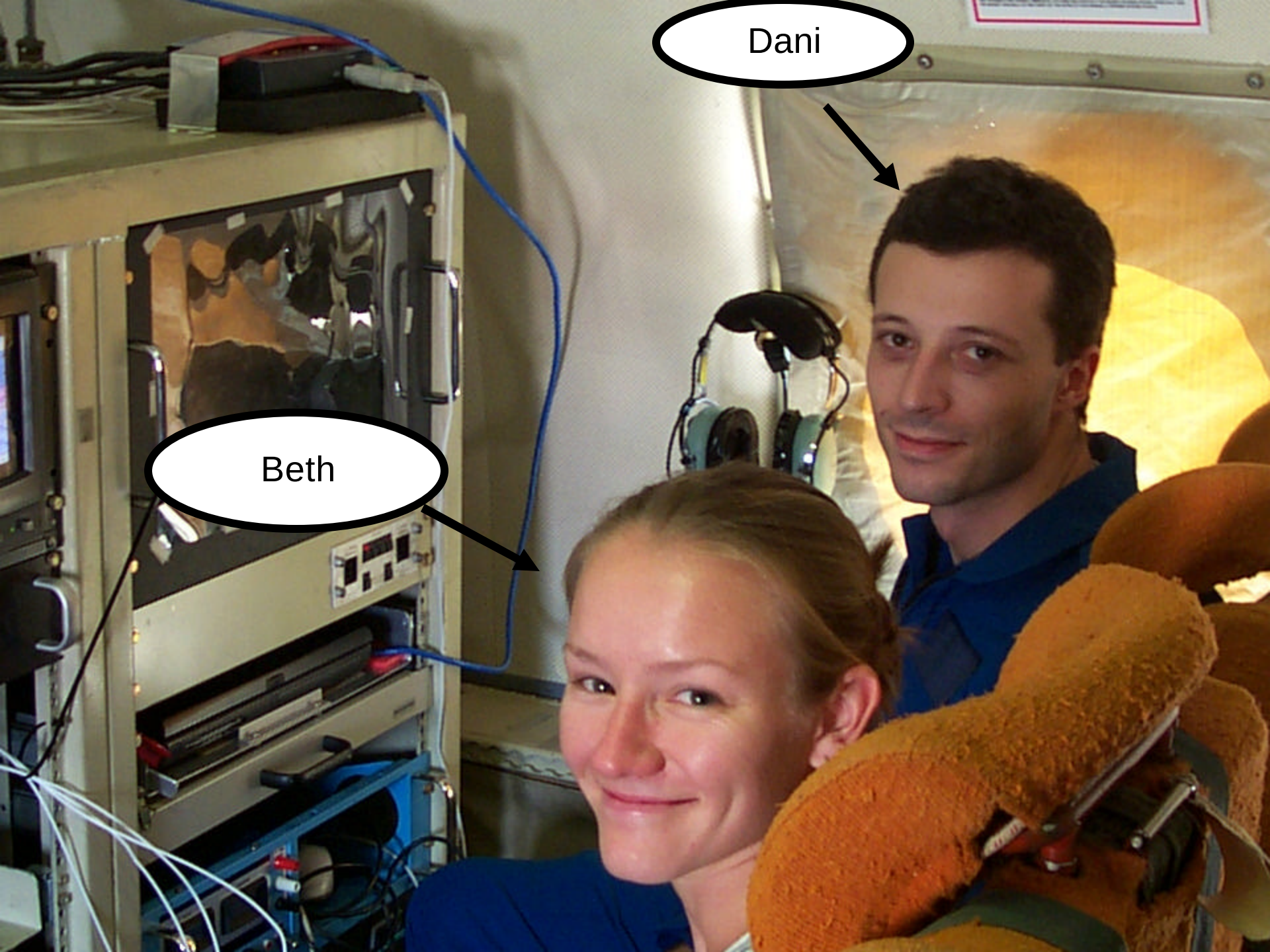
- Integrate other end-users such as Emergency Management and Planning.


Brian

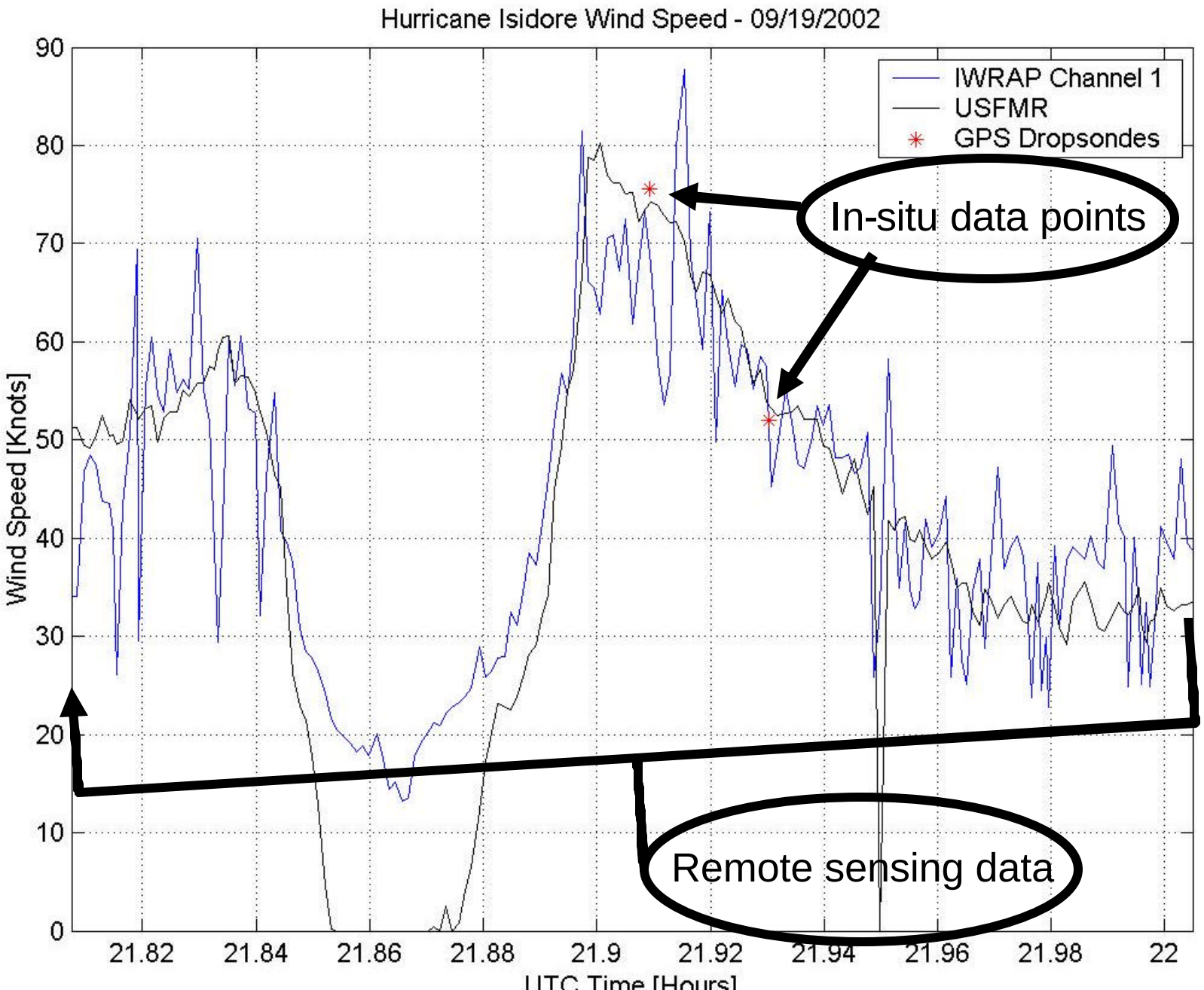

DOPPLER RADAR AND WEATHER OBSERVATIONS


NOAA HURRICANE HUNTER
“Miss Piggy”


19 08 2002 11:29


Dani
Beth


N43RF
UNITED STATES DEPT OF COMMERCE


Hurricane Isidore Wind Speed - 09/19/2002
IWRAP Channel 1
USFMR
GPS Dropsondes
In-situ data points
Remote sensing data
Wind Speed [Knots]
UTC Time [Hours]
0
10
20
30
40
50
60
70
80
90
21.82
21.84
21.86
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21.9
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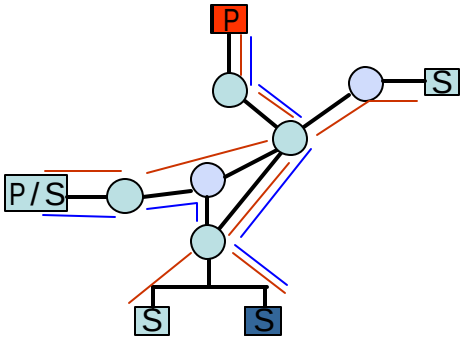
21.94
21.96
21.98
22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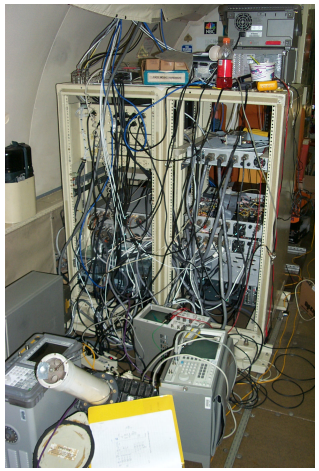

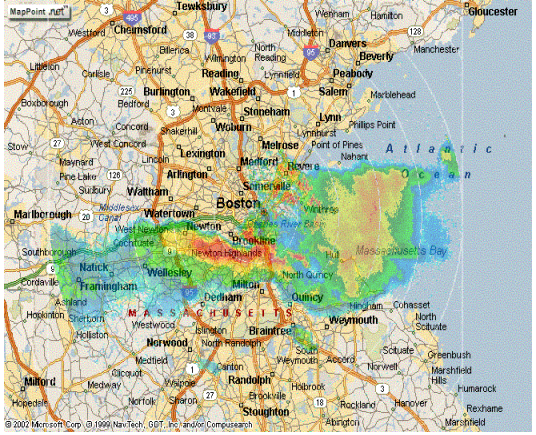
MapPoint .net
Tewksbury
Chelmsford
Danvers
Beverly
Peabody
Salem
Burlington
Wakefield
Stoneham
Woburn
Lynn
Melrose
Lexington
Medford
Arlington
Somerville
Boston
Watertown
Newton
Brookline
Wellesley
Natick
Framingham
Milton
Quincy
Weymouth
Braintree
Norwood
Randolph
Stoughton
Milford
Atlantic
Ocean
Massachusetts Bay
MASSACHUSETTS
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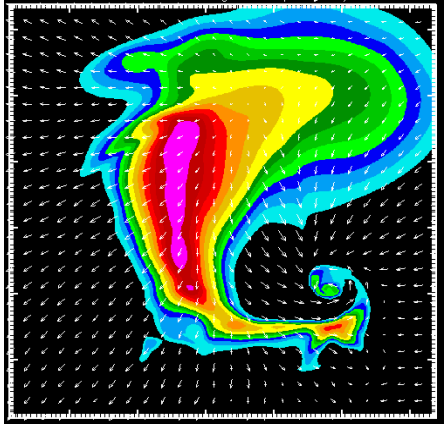
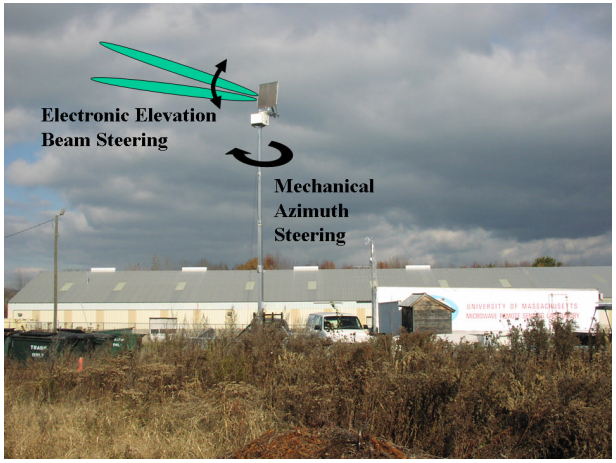



UNIVERSITARIO DE MAYAGUEZ

Join us!


Electronic Elevation
Beam Steering
Mechanical
Azimuth
Steering


UNIVERSITY OF MASSACHUSETTS

What is the ERC ?
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- Contact Asst. Dean Kathleen Rubin for information about CASA's Research Experience for Undergraduates (REU) program.
- http://www.casa.umass.edu

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touching people's lives...

… vastly improving our ability to detect, understand, and predict severe storms and other atmospheric and airborne hazards

… saving lives/property, providing economic benefits through improved warning and response

… diverse education, outreach

… industrial opportunities, commercial development