Engineering Research Center for
Collaborative Adaptive Sensing of the Atmosphere

Concepts and Characteristics of CASA Radar System


University of Massachusetts Amherst


University of Oklahoma

Colorado State University


University of Puerto Rico Mayagüez

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CASA (Collaborative Adaptive Sensing of the Atmosphere)

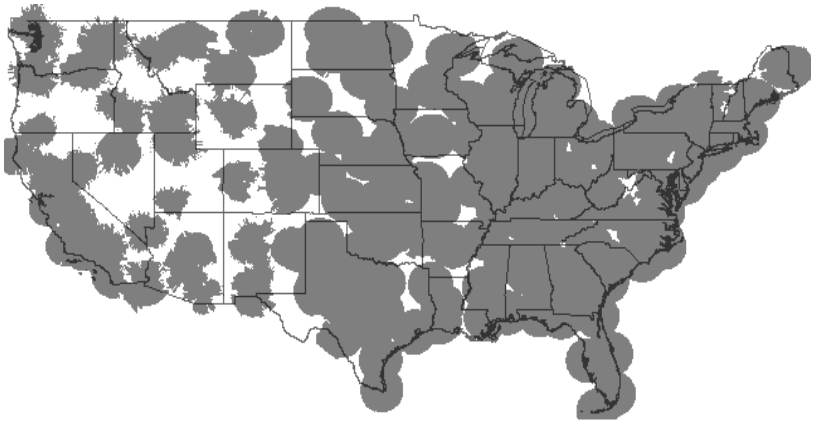
SHORT-WAVELENGTH TECHNOLOGY AND THE POTENTIAL FOR DISTRIBUTED NETWORKS OF SMALL RADAR SYSTEMS

BY DAVID MCLAUGHLIN, DAVID PEPYNE, V. CHANDRASEKAR, BRENDA PHILIPS, JAMES KUROSE, MICHAEL ZINK, KELVIN DROEGEMEIER, SANDRA CRUZ-POL, FRANCESC JUNYENT, JERALD BROTZGE, DAVID WESTBROOK, NITIN BHARADWAJ, YANTING WANG, ERIC LYONS, KURT HONDL, YUXIANG LIU, ERIC KNAPP, MING XUE, ANTHONY HOPF, KEVIN KLOESEL, ALFRED DEFONZO, PAVLOS KOLLIAS, KEITH BREWSTER, ROBERT CONTRERAS, BRENDA DOLAN, THEODORE DJAFERIS, EDIN INSANIC, STEPHEN FRASIER, AND FREDERICK CARR

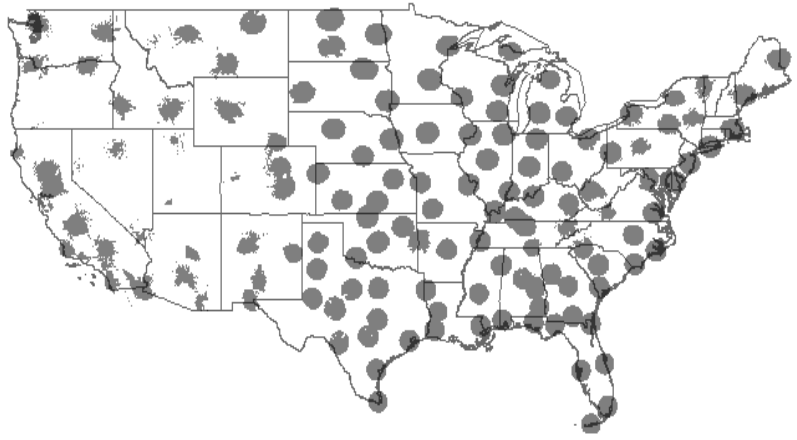
Dense networks of small radars—unlike today's large installations—can defeat Earth curvature blockage, thus providing more low-altitude data and meeting the diverse needs of end users.

BAMS 2009

Why CASA?
Current US Weather Surveillance Network



Coverage at 3 km

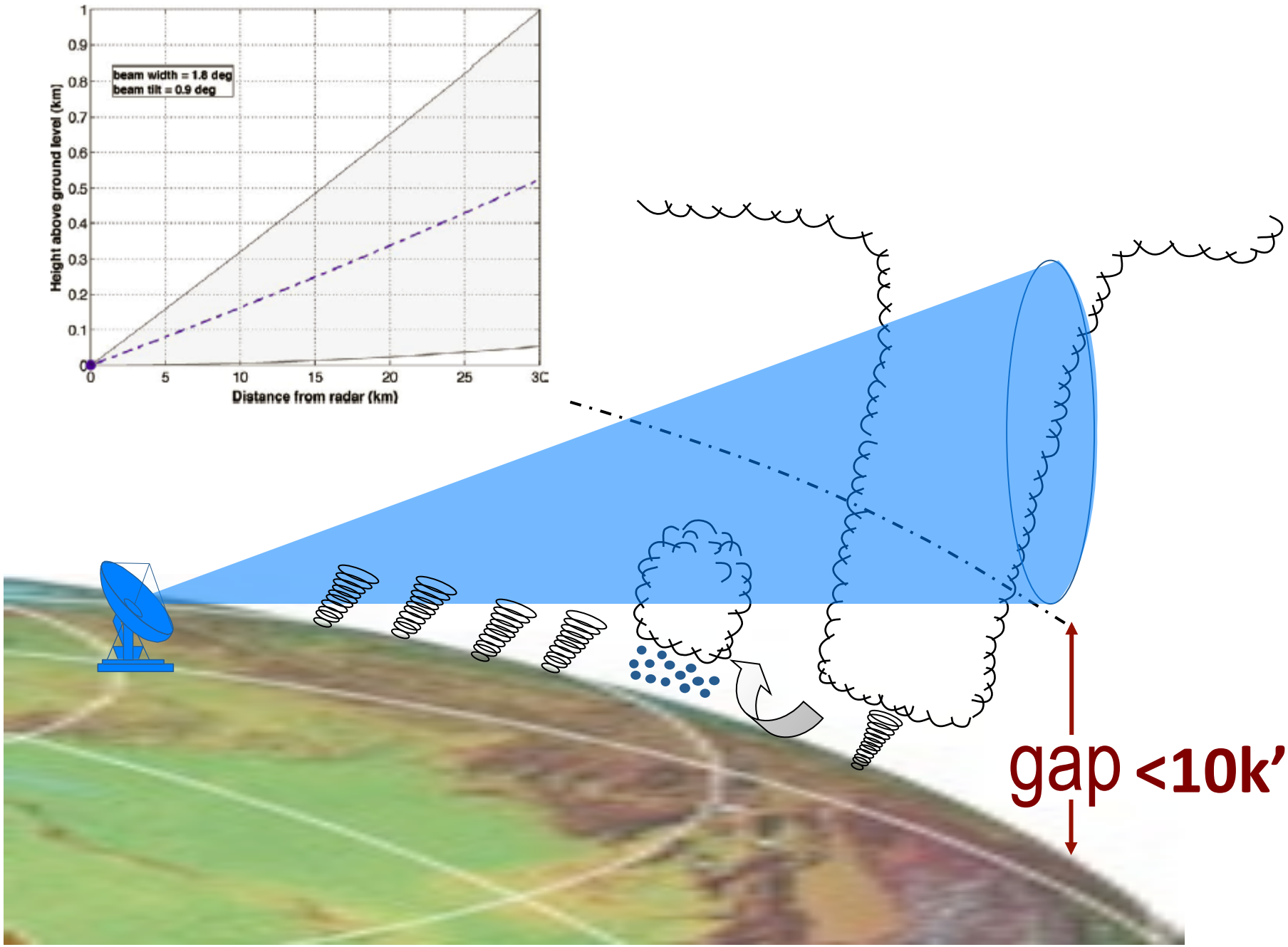


Coverage at 1 km

Characteristics:

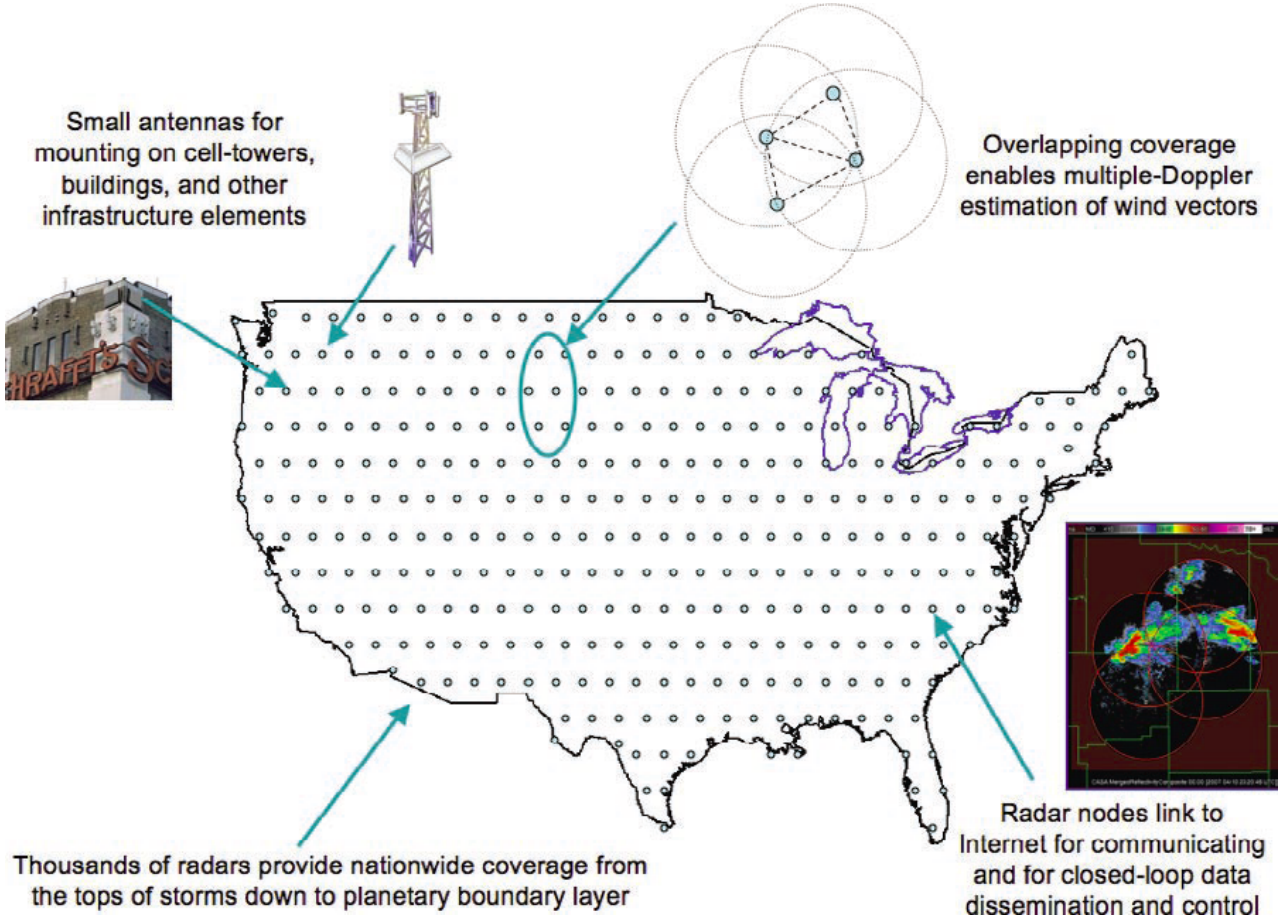
- $10M [US] per radar
- Doppler, Dual-pol

- Network <u>does not</u>:
  - View below 2-3 km owing to radar spacing
  - Provide high resolution (1 minute, low-altitude, hundreds of meter) measurements for local needs.


beam width = 1.8 deg
beam tilt = 0.9 deg
Height above ground level (km)
Distance from radar (km)
gap <10k'

CASA – Concept

- Close spacing
  - 30 km vs. 230+ km
- Short-wavelength
  - X-band vs. S-band
- Low-power
  - 10’s Watts
- Low cost
  - $200k US
- Low infrastructure



CASA IP-1
Four Radar Testbed

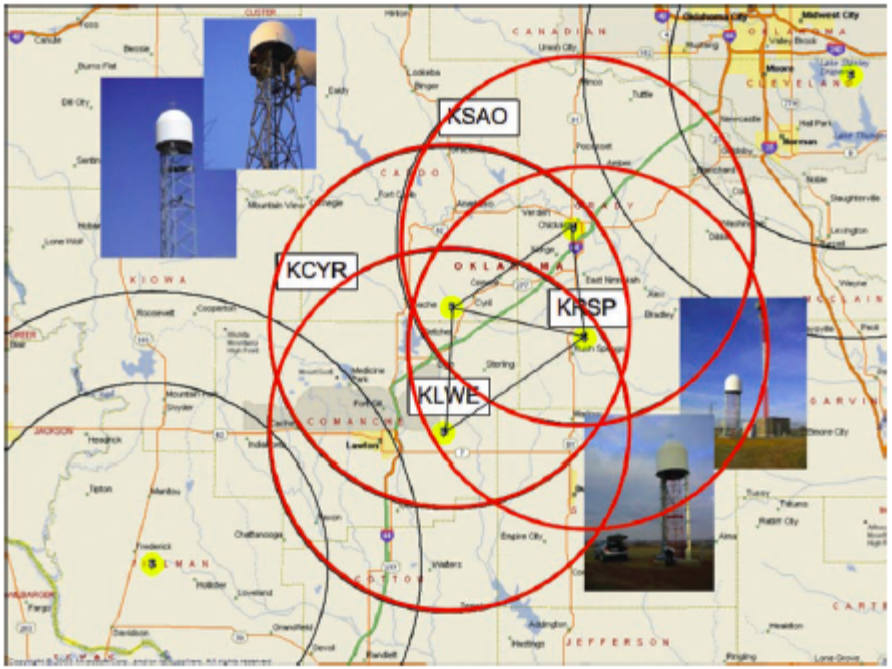
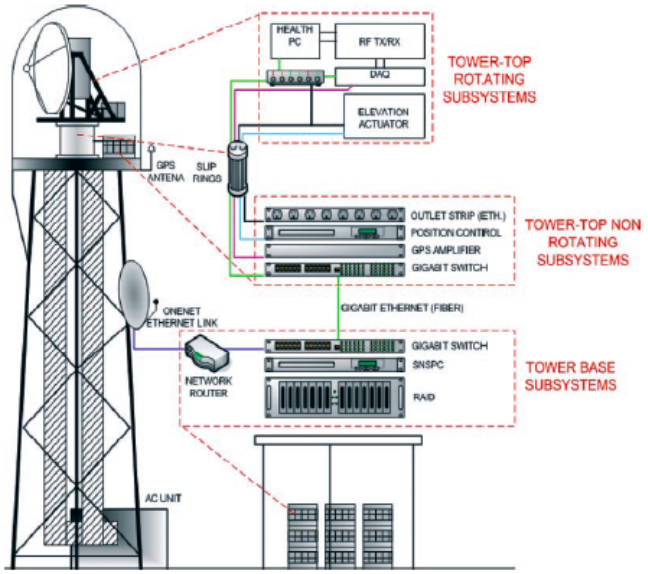


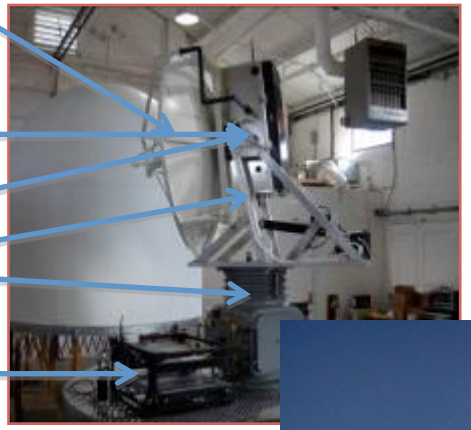
FIG. 7. Map of the CASA IP1 test bed in southwestern Oklahoma showing the radar sites and 40-km range rings. Also shown are the NEXRAD radars at (bottom left) Frederick (KFDR) and (top right) Twin Lakes (KTLX). The rings around the NEXRAD radars are at 40 and 60 km, respectively.



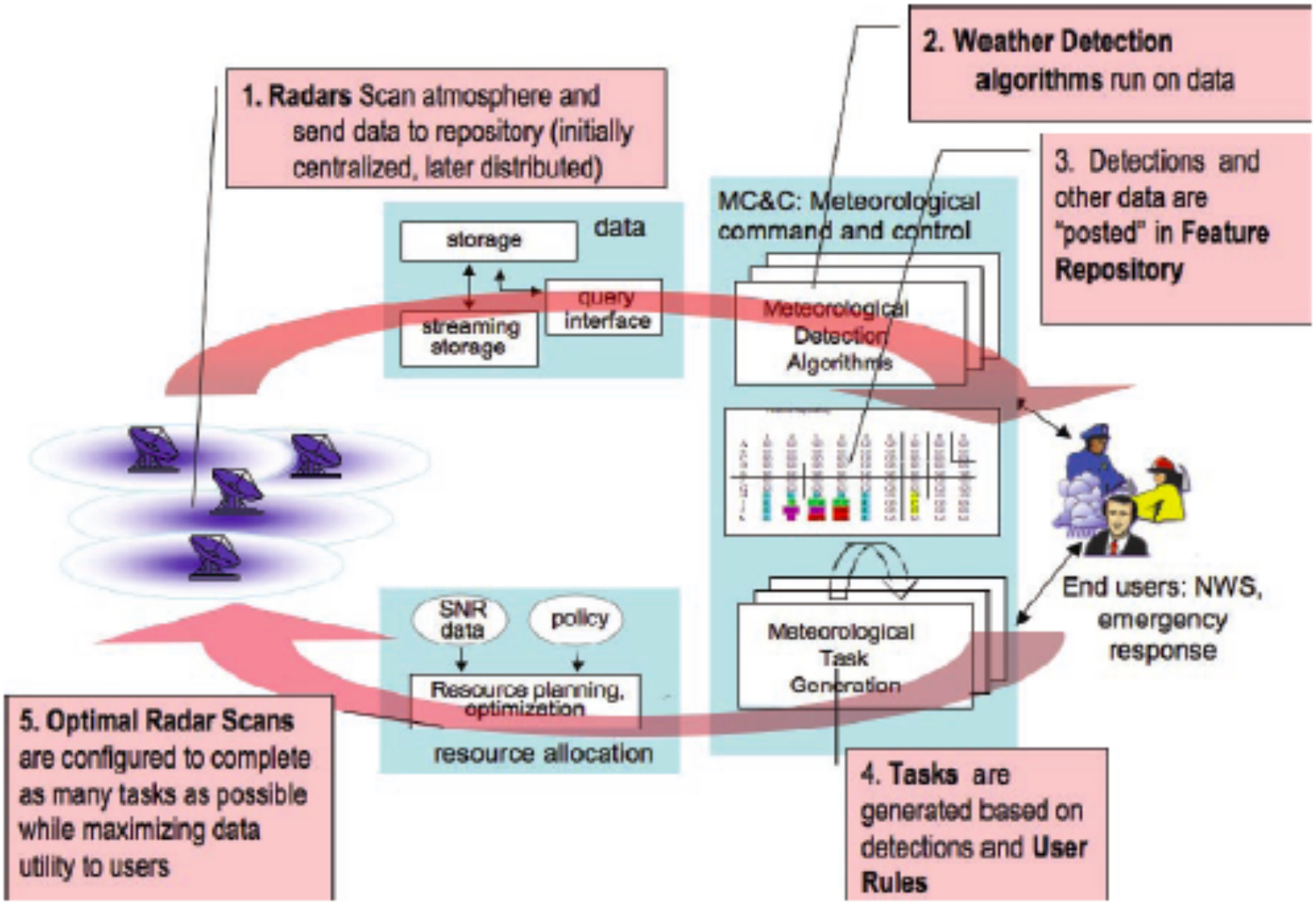
CASA Mechanical Scan Radar Systems

Components

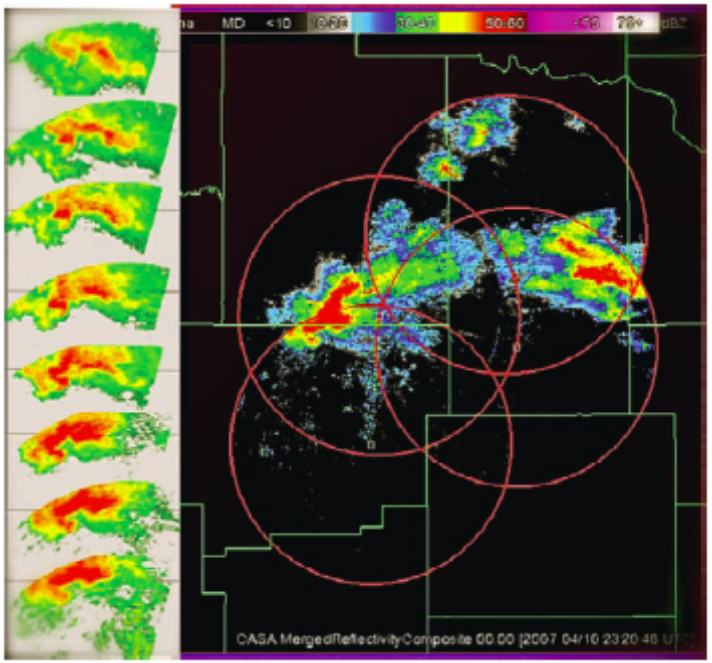
- Antenna
- Radome
- Tower (8m)
- Data Acq.
- Transceiver
- El Positioner
- Az Positioner
- Platform, frames
- Computers, storage
- HVAC



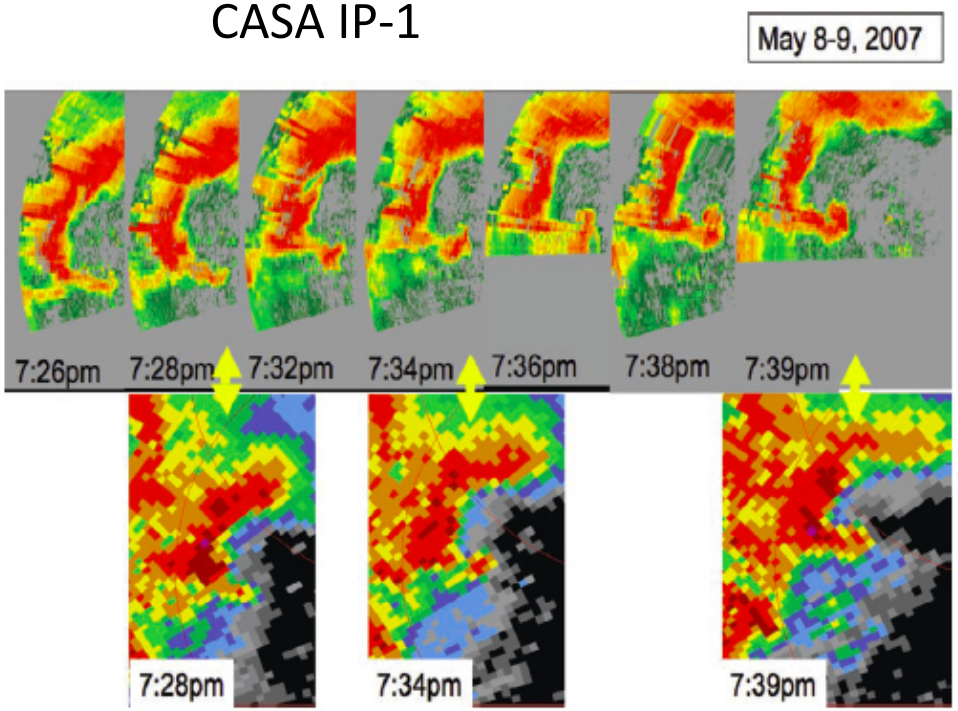
~%200 K; 25K/yr maintenance


1. Radars Scan atmosphere and send data to repository (initially centralized, later distributed)
2. Weather Detection algorithms run on data
3. Detections and other data are "posted" in Feature Repository
data
storage
query interface
streaming storage
MC&C: Meteorological command and control
Meteorological Detection Algorithms
Meteorological Task Generation
End users: NWS, emergency response
SNR data
policy
Resource planning, optimization
resource allocation
4. Tasks are generated based on detections and User Rules
5. Optimal Radar Scans are configured to complete as many tasks as possible while maximizing data utility to users

CASA IP-1 Network

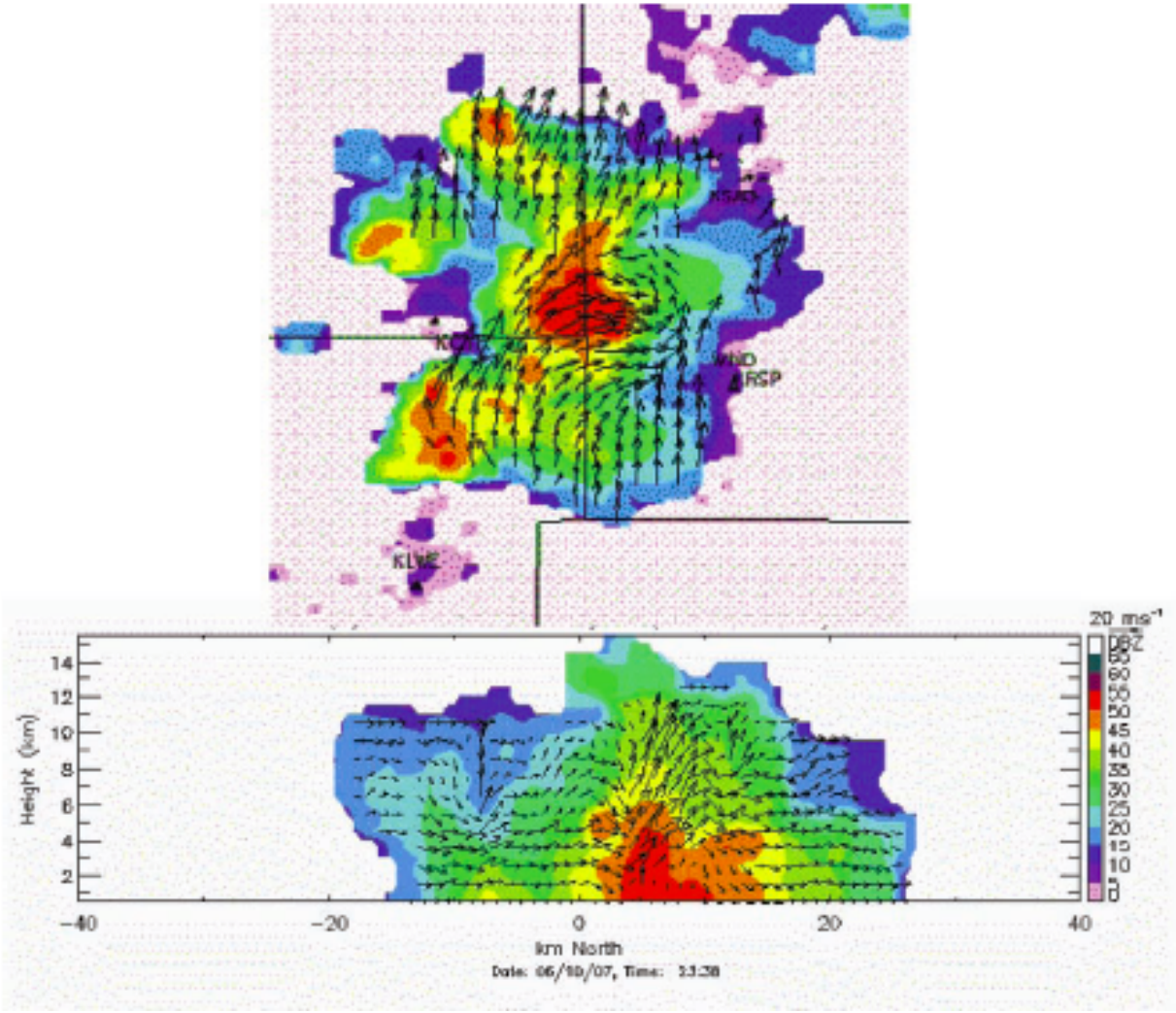


CASA IP-1

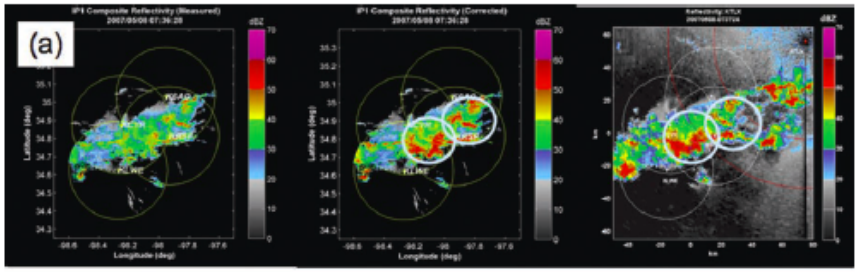


WSR-88D (Frederick KFDR)

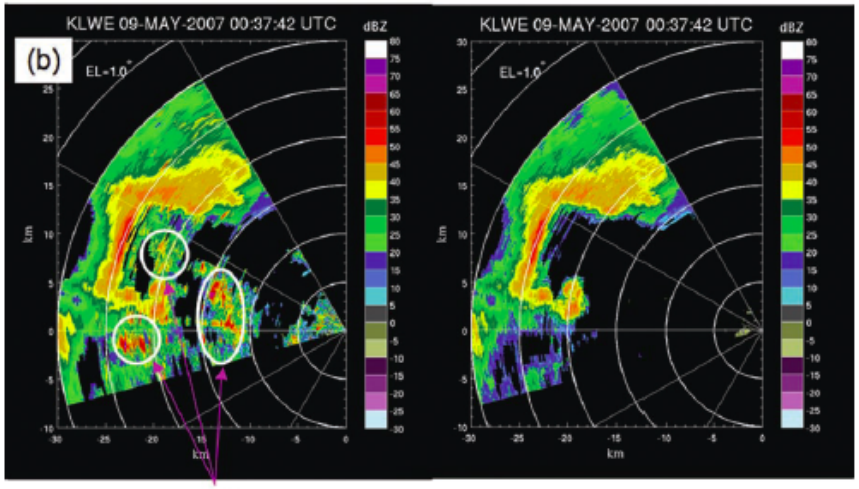
Multi-Doppler Analysis



Ground Clutter and Attenuation Corrections



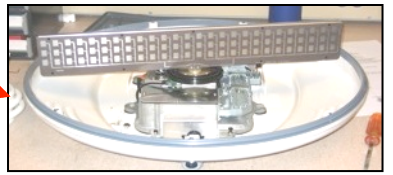
IP1 measured Z | IP1 corrected Z | KTLX measured Z

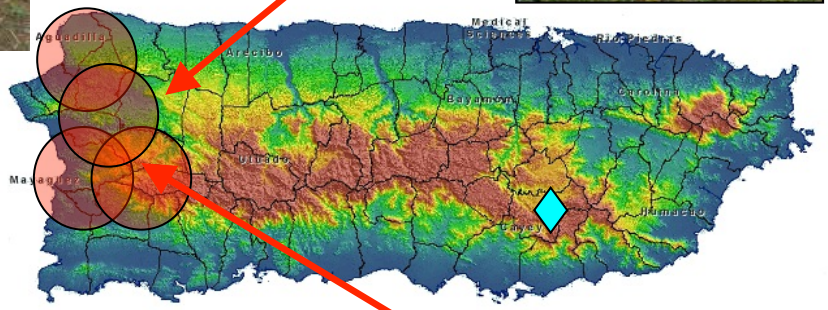


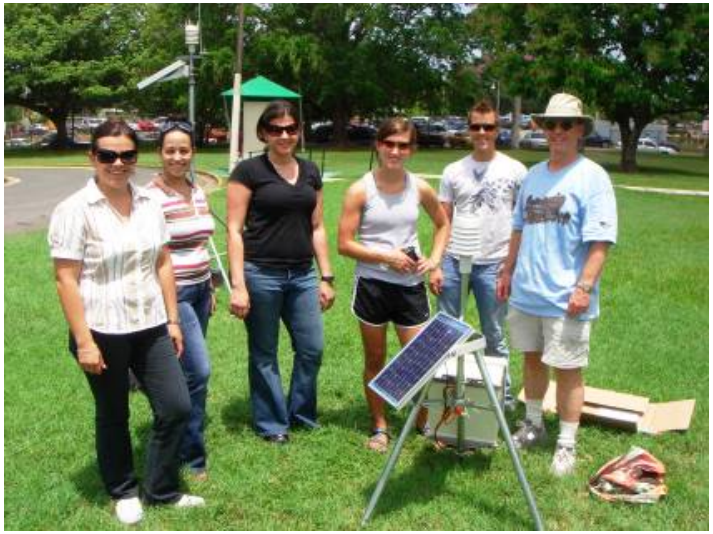
Ground clutter

Student Test Bed

Off-the-Grid Radar
First node being tested at UMass

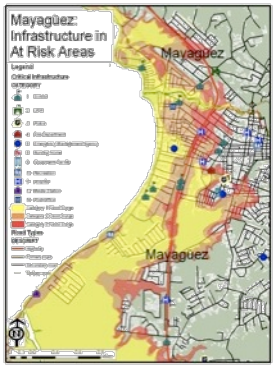






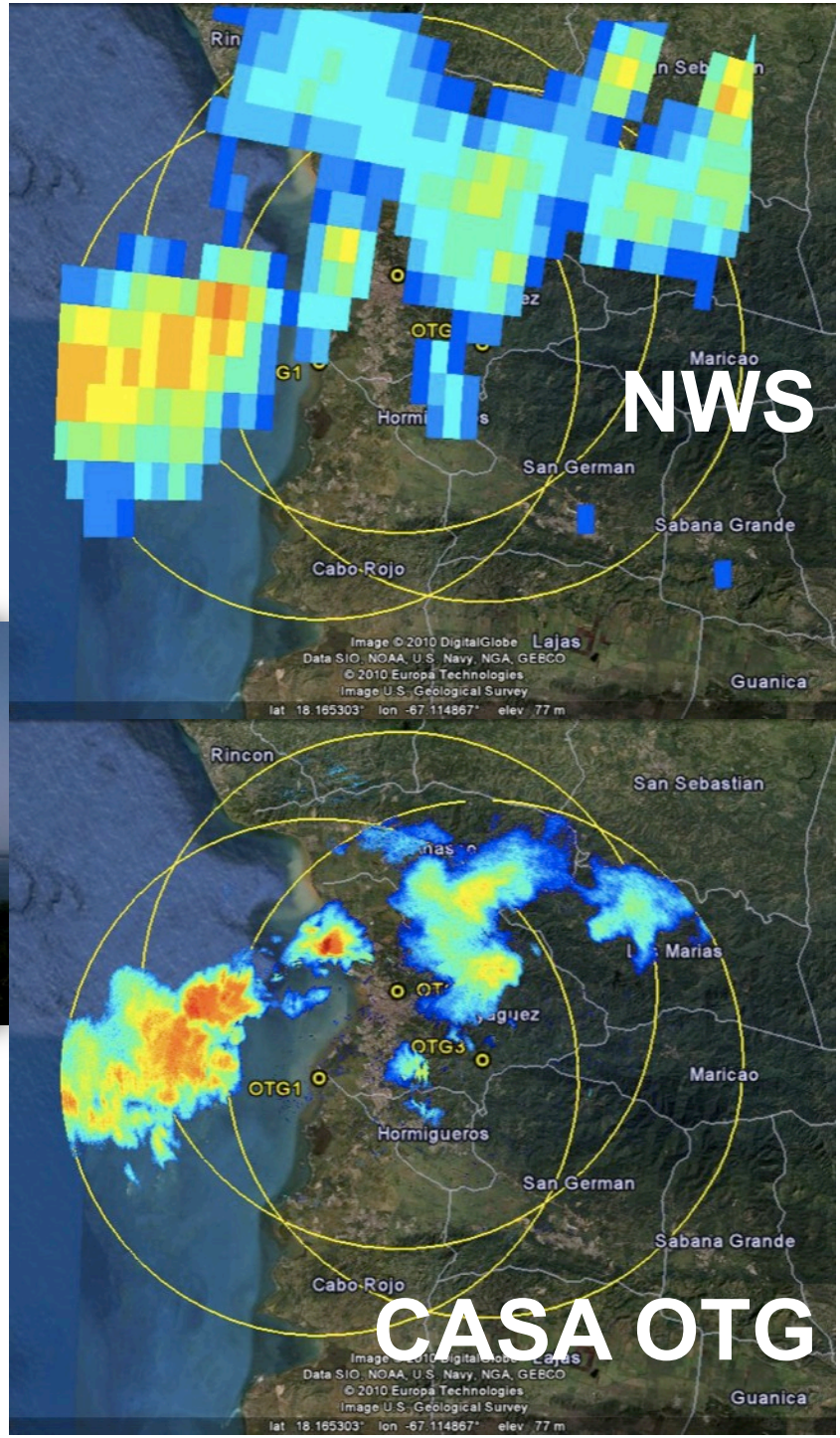
OTG-Solar powered and wireless communication

Siting based on Disaster Vulnerability Model



Modified off-the-shelf marine radars

OTG
Solar powered and wireless communication



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CASA DFW
Urban Demonstration Network

Brenda Philips, V. Chandrasekar,
Fred Carr, Molly Thoerner, Tim McClung,
Curtis Marshall, Apoorva Bajaj


University of Massachusetts Amherst


University of Oklahoma

Colorado State University


University of Puerto Rico Mayaguez

CASA is primarily supported by the Engineering Research Centers Program of the National Science Foundation under NSF award number 0313747.

Goals

1. Operate DFW Test Bed as "living lab" for high resolution, urban, end-to-end warning systems.

2. Demonstrate quantifiable value of CASA systems
   - Sensors, products, processes, users, impacts
   - Atmospheric sciences, radar met, integrated warning systems, networking, hazardous decision-making, social science, economics.
   - Network-of-networks

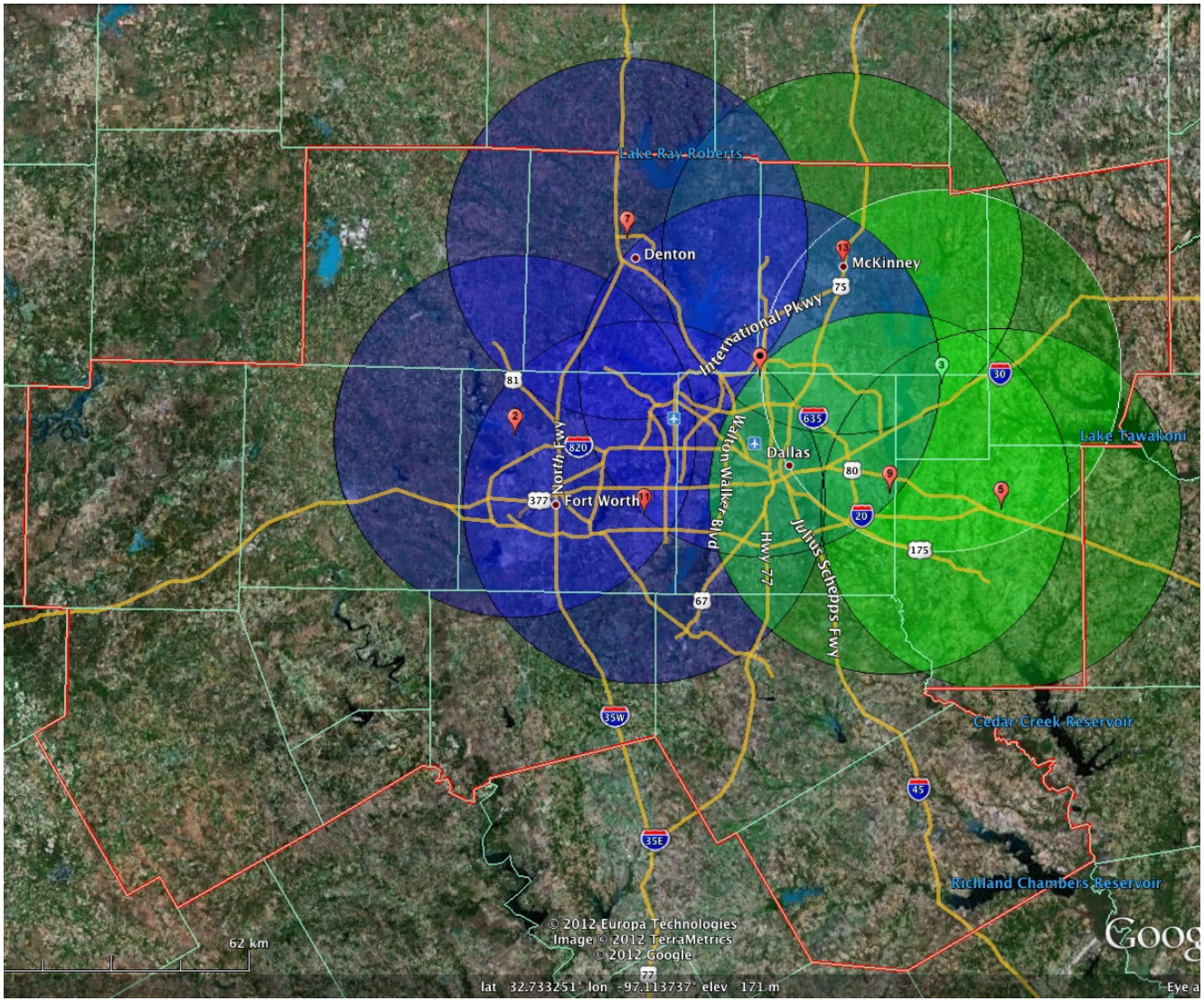
3. Develop replicable public/private/local model for regional sensor acquisition, deployment and ops

4. Sustain CASA's interdisciplinary, multi-institutional collaboration beyond year 10.

Partners

- CASA Institutions: UMass, CSU, OU
  - High resolution warning/forecast systems, flooding and severe weather
  - Research
  - Models for regional deployment of sensor networks
- North Central Texas Council of Governments (NCTCOG) _
  - Regional deployment, public safety, economic advantages
- NWS Office of Science and Technology
  - Network-of-networks
  - Shared cost models

DFW RADAR DEPLOYMENT



NETWORK ROLLOUT

First phase in blue
Second phase in green
NCTCOG region in red

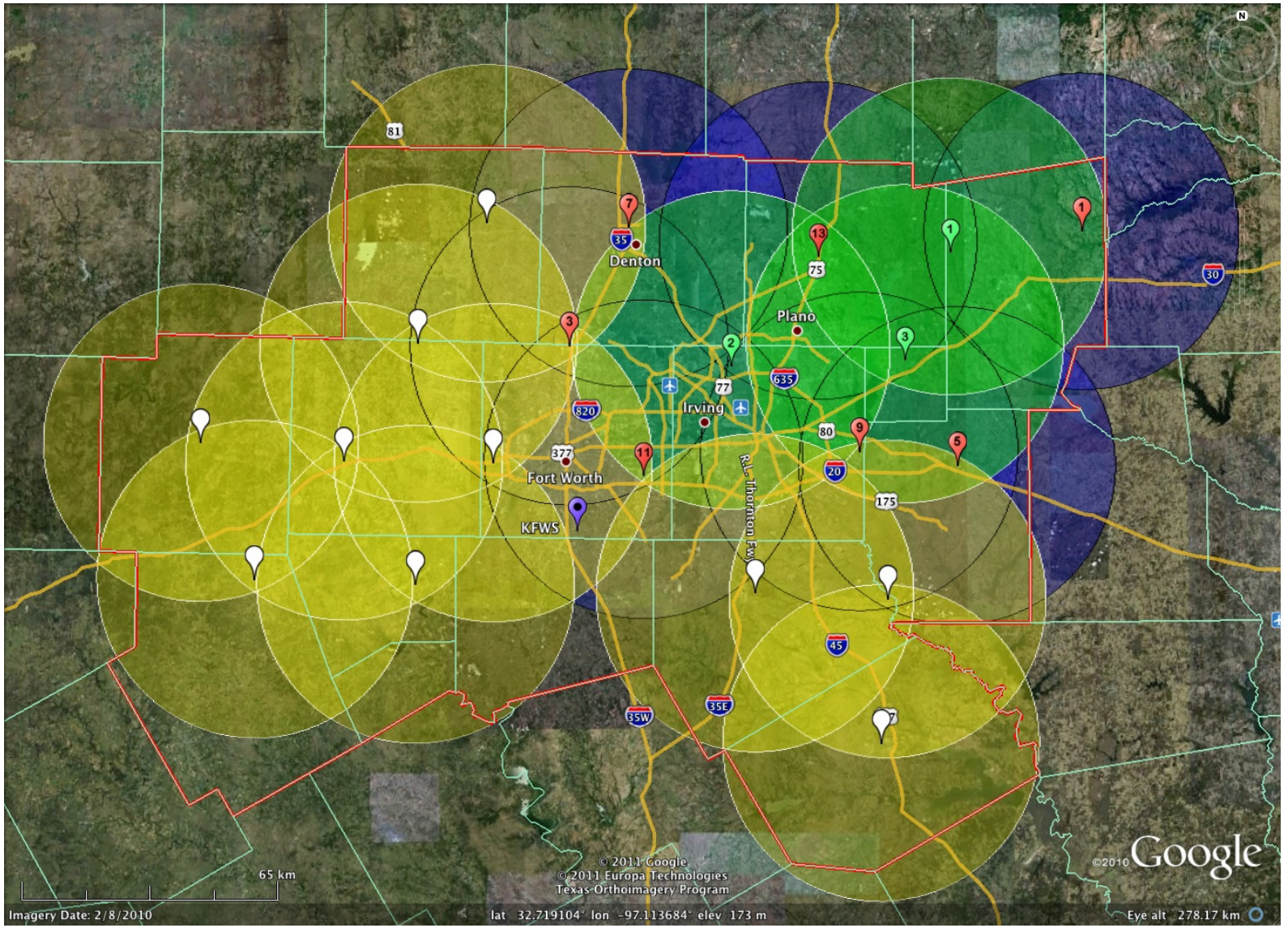
UNT, Denton
Discovery Park campus

UTA, Arlington
Carlisle Hall (Installed)

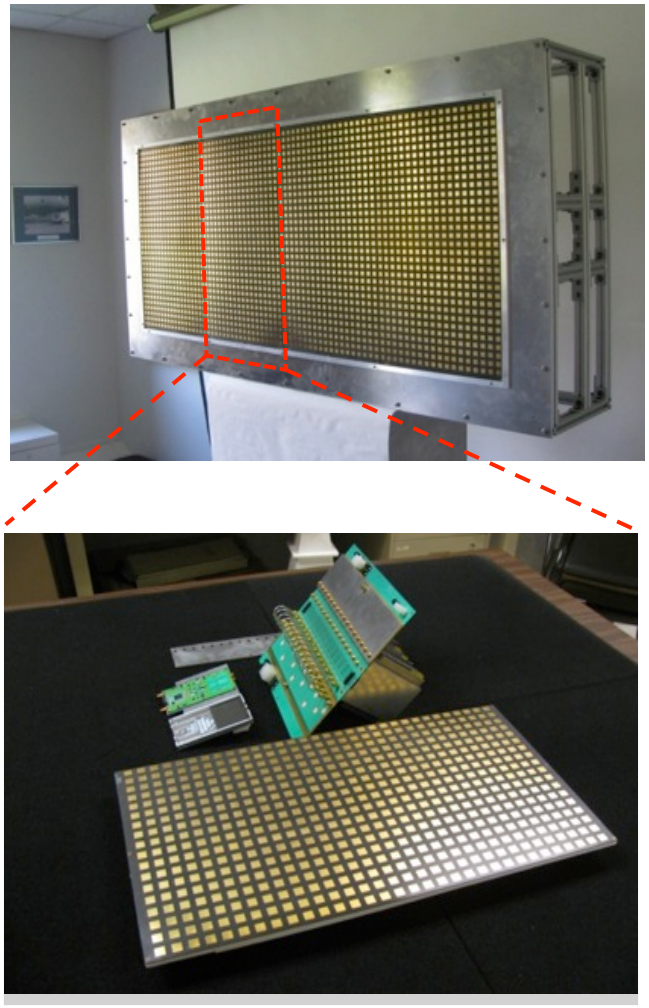
Town of Addison
General Services bldg.

City of Fort Worth,
Water tower

Region/market responsible for cost of radar build out to 16 -20 nodes to blanket region.



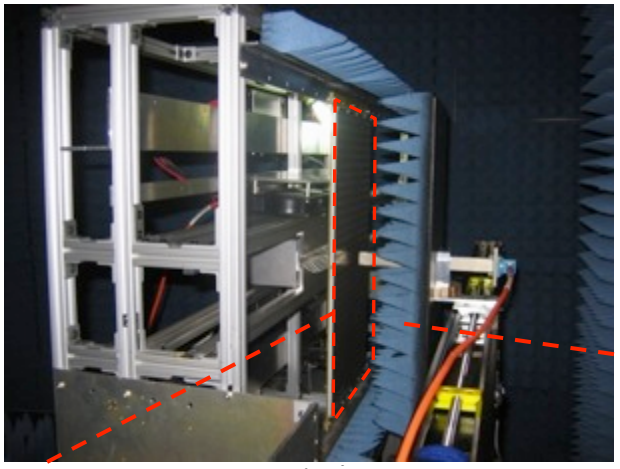
Phased-Array Antenna Panels



University of Massachusetts prototype demonstrating ~$10k (US) per LRU

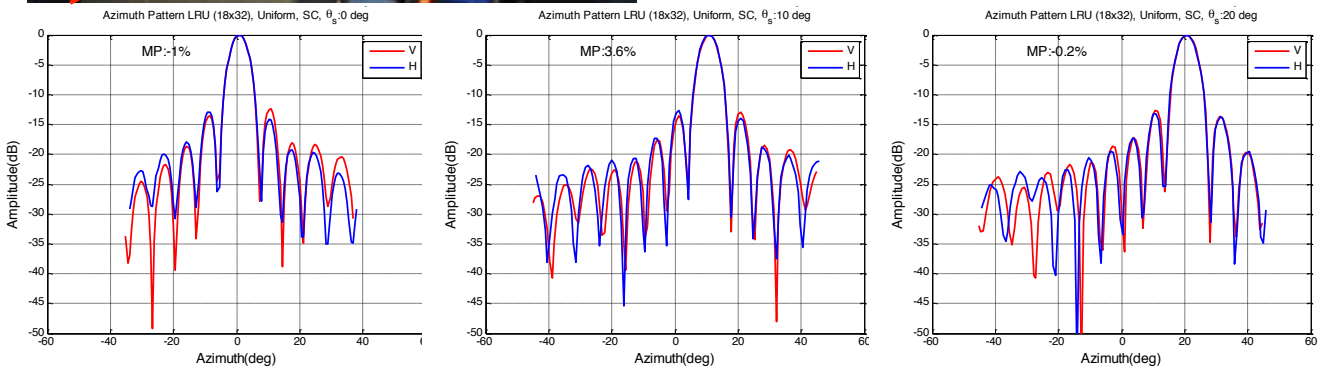
Table 5. Key specifications for phased-array panels for the dense network application.	
Peak transmit power per panel	10–100 W
Panel size	1 m × 1 m
Average beamwidth	2° × 2°
Polarization	Dual-linear T/R
Number of panels per site	3 or 4
Azimuth scan range	±45° for a three-panel installation ±60° for a four-panel installation
Elevation scan range	0°–20° for low-level coverage (<3 km) 0°–56° for coverage up to 21 km

Umass Amherst Phase-tilt Antenna Array Prototype Tests

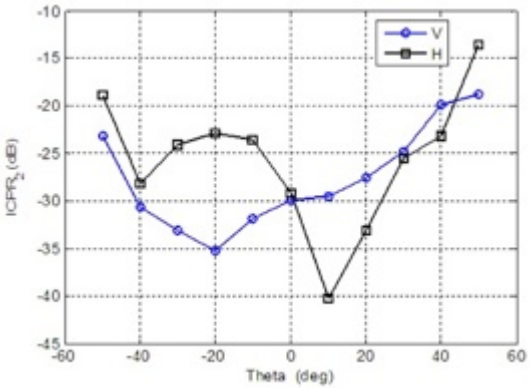


Dual Polarization Performance:

- Co-pol mis-match <5% to 45^0 (based on LRU NF measurements)
- -20 dB Xpol to 45^0 (calculated)



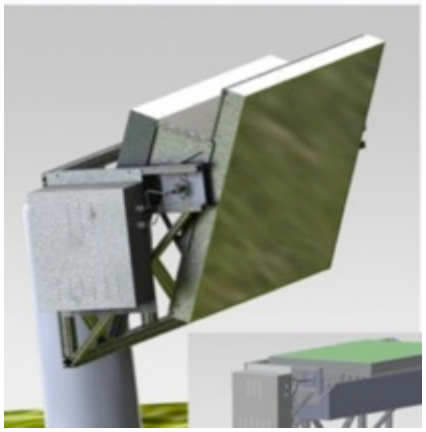
Co-pol
X-pol



J. L. Salazar et al, "Dual Polarization Performance of the Phase-Tilt Antenna Array in a CASA Dense Network Radar", Proc. IEEE Geoscience Remote Sensing Symposium, 2010.

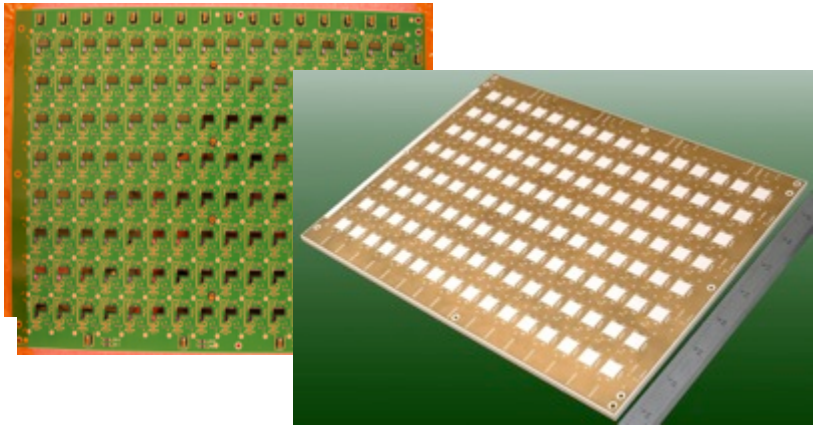
E-Scanned Antenna Technologies

First RF Corp



- Phase steer – azimuth
- Mech tilt – elevation
- 1.5 meter x 1 meter
- 70 W peak, 30% duty

Raytheon

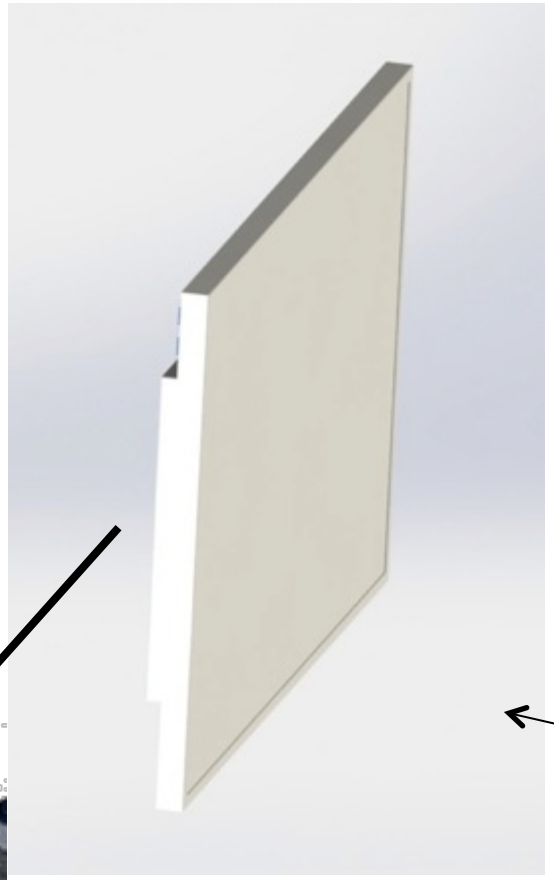


- 2D phase-phase array
- 1 meter x 1 meter
- ~ 100 W peak, 30% duty

Manufactured Product FRF – 166

FIRST RF Corporation

Towards a “Flat Screen TV” Phased Array



Rear face
Radiating face (front)

Notional dimensions:
1.2 m length
0.8 m height
0.1 m (10 cm!) depth

Summary

- Adaptive and collaborative observing strategy with low-cost radar network demonstrated
- Utility of CASA observing systems for providing high temporal and spatial resolution of high-impact weather events established
- Low-cost phased array X-band radars successfully developed and produced
- Transition from feasibility to reality of CASA radar system underway
- New applications, developments, and opportunities for CASA system?

Albrecht's view of clouds in MCC that initiated 29 June 2012 derecho