Engineering Research Center for
Collaborative Adaptive Sensing of the Atmosphere

Progress with the Collaborative Adaptive Sensing of the Atmosphere (CASA) Initiative

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(on behalf of D. McLaughlin and the CASA team)

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Norman, OK

University of Massachusetts Amherst
University of Oklahoma
Colorado State University
University of Puerto Rico Mayaguez

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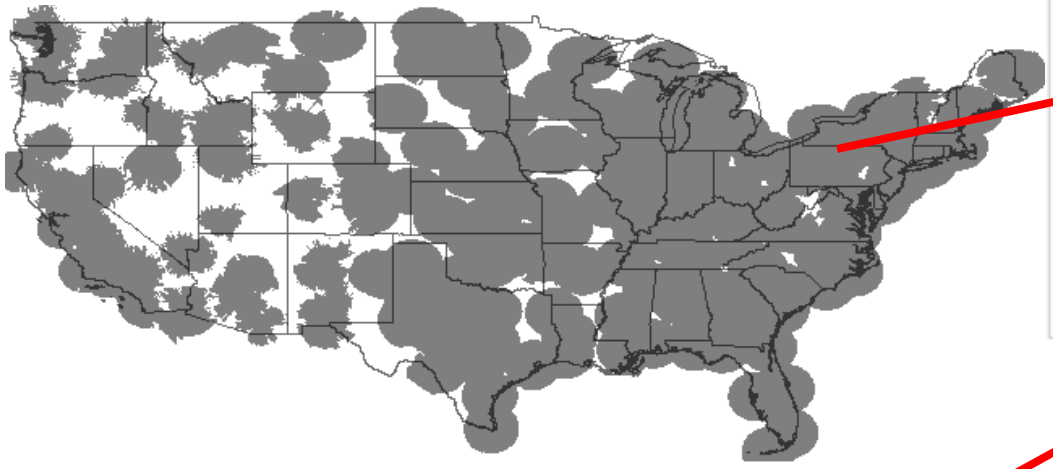
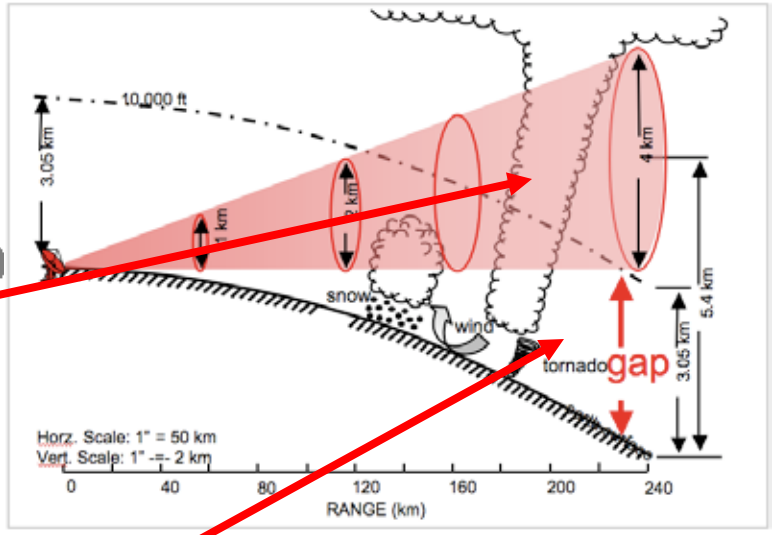
Motivation



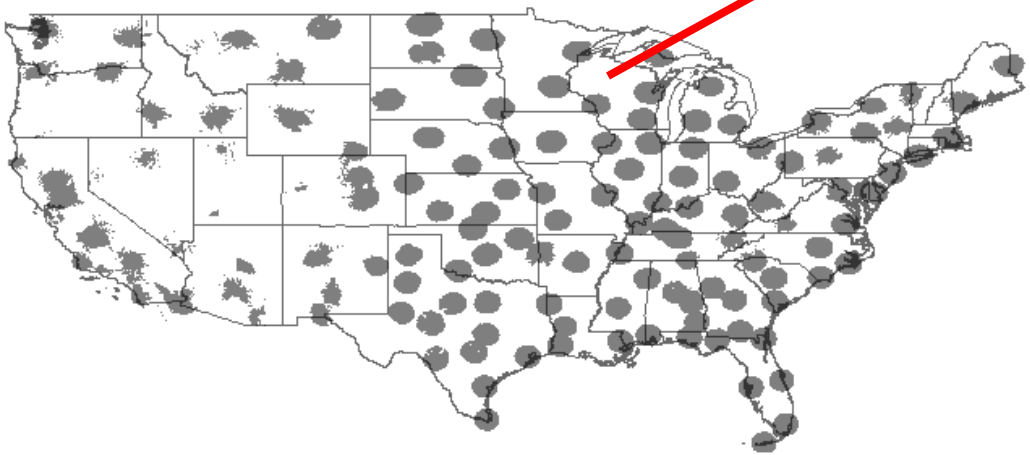


NEXRAD coverage at 3 km (~10k ft) AGL.

Today's systems provide:

- Inadequate coverage below 3km

- Insufficient spatial and temporal resolution - the space-time variability of phenomena such as tornadoes, downbursts, and urban flooding can exceed current capabilities



NEXRAD coverage at 1 km (~3200 ft) AGL.

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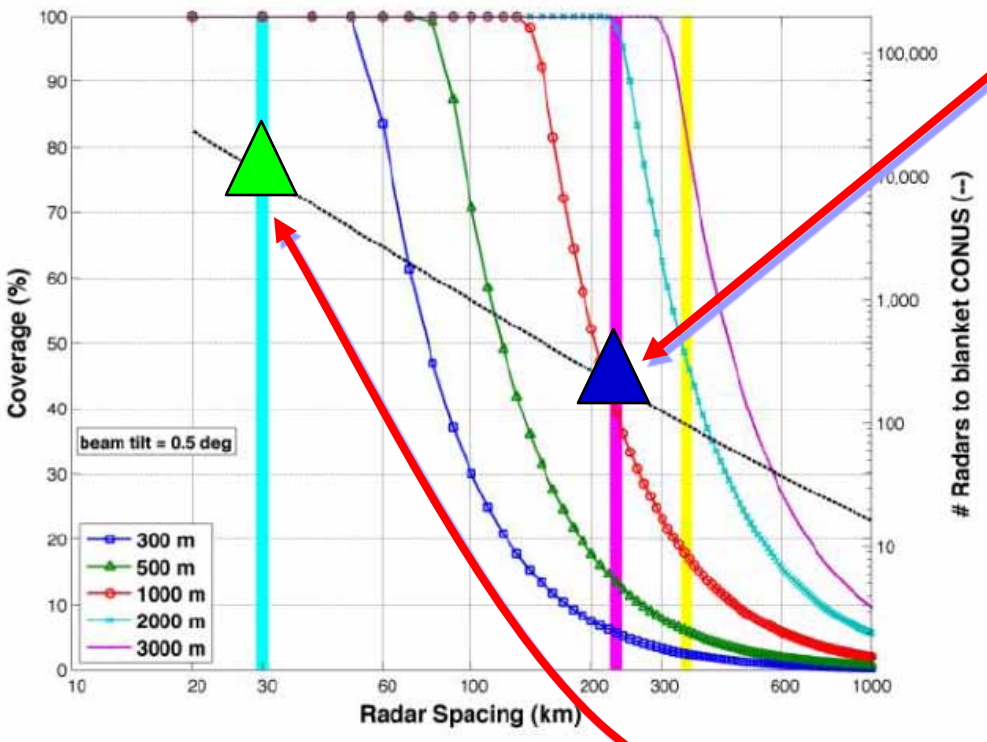
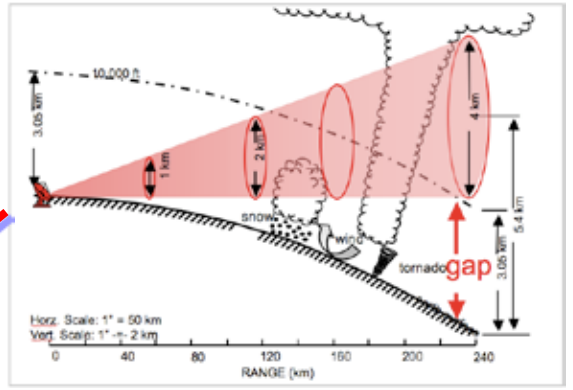
Charter

"Weather Radar Technology Beyond NEXRAD"
National Research Council, National Academies Press, 2002
Chair: Prof. Paul Smith

Recommendation – Far Term:
"The potential for a network of short-range radar systems to provide enhanced near-surface coverage and supplement (or perhaps replace) a NEXRAD-like network of primary radar installations should be evaluated thoroughly."

CASA Concept



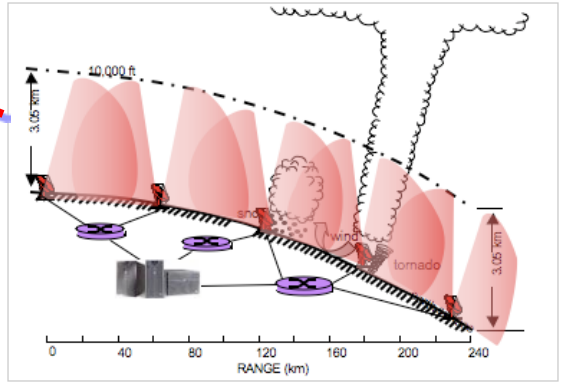


Present NEXRAD System:

- 150 radars
- 230 km apart
- 100% coverage > 3 km

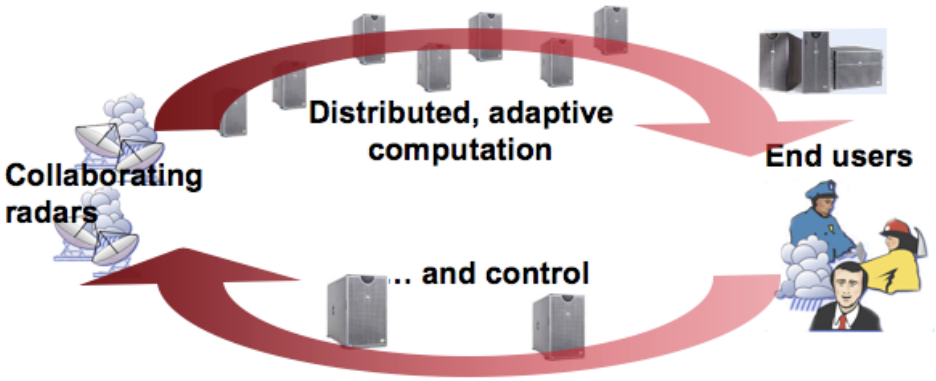
CASA concept

- 10,000 radars
- 30 km apart
- 100% coverage > 300m



For details, see "Short Wavelength Technology and the Potential for Distributed Networks of Small Radar Systems," by the CASA team, to appear Dec. 2009.

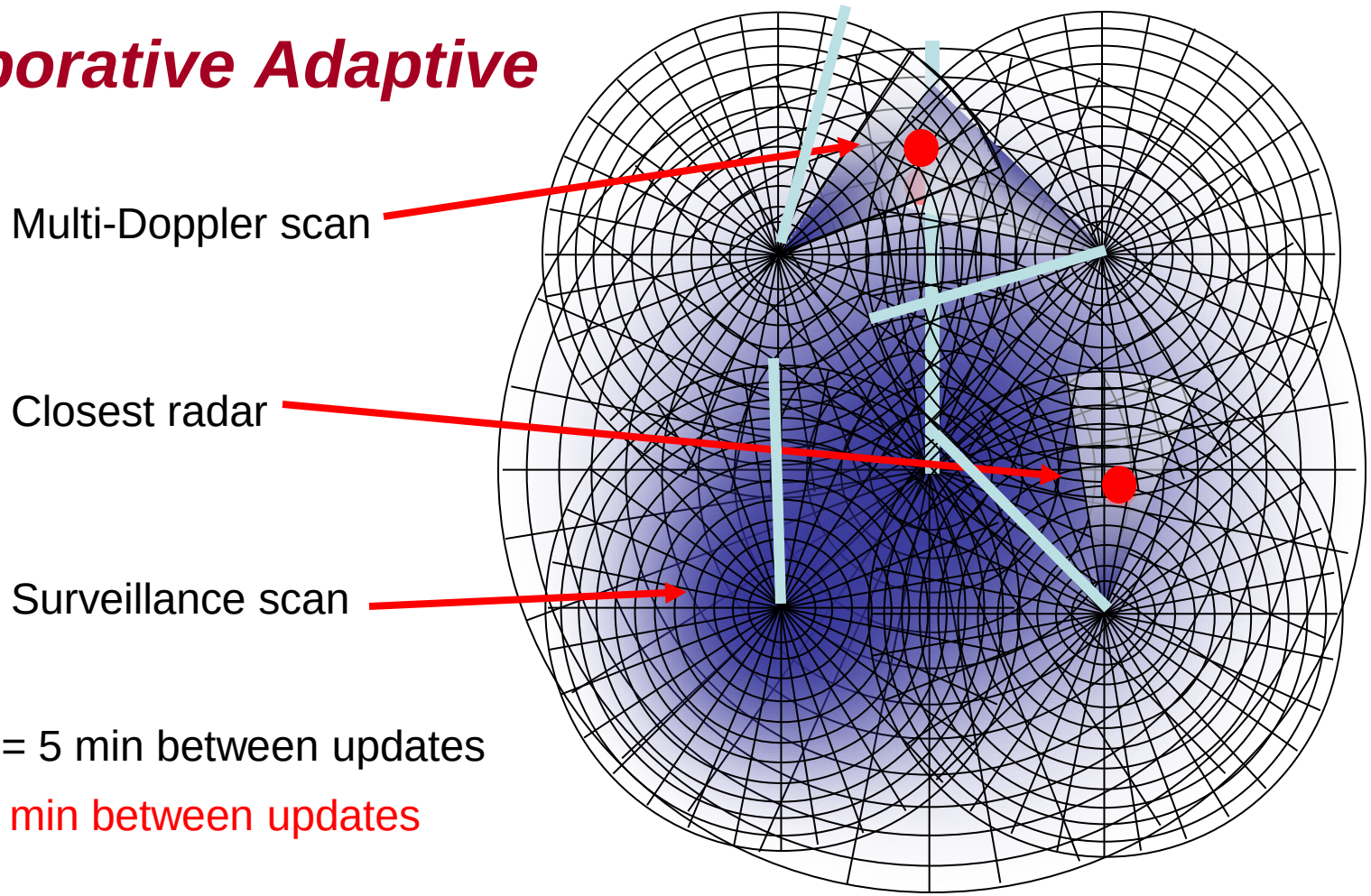
CASA Engineering



4 nodes, 30 km spacing, 40 km range, 7000 sq-km coverage area

- Small, low-power, short-wavelength, dual-pol radars
- Deployed with massive overlapping coverage
- Closed-loop architecture to sample the atmosphere “when and where end-user needs are greatest”

Collaborative Adaptive

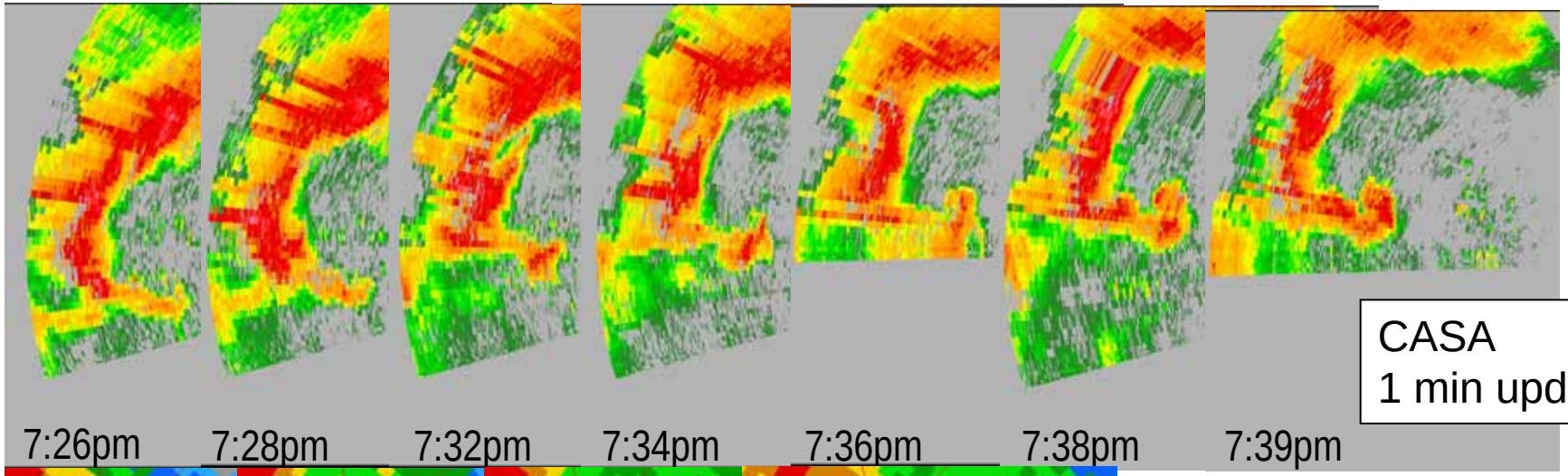


NEXRAD = 5 min between updates

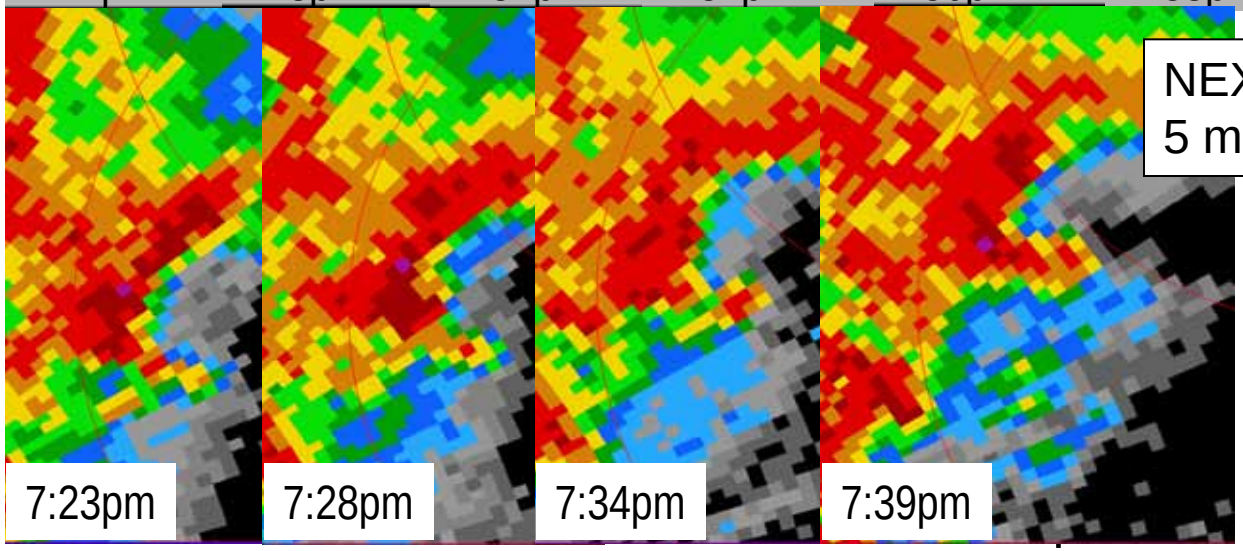
CASA = 1 min between updates

- **Allocate sensing collaboratively and adaptively in response to target dynamics (spatial+temporal), user data product need, and data quality**
- **Improved resolution, sensitivity, accuracy, and ability to support multiple users and multiple applications simultaneously.**

CASA IP1 Spatial-Temporal Resolution



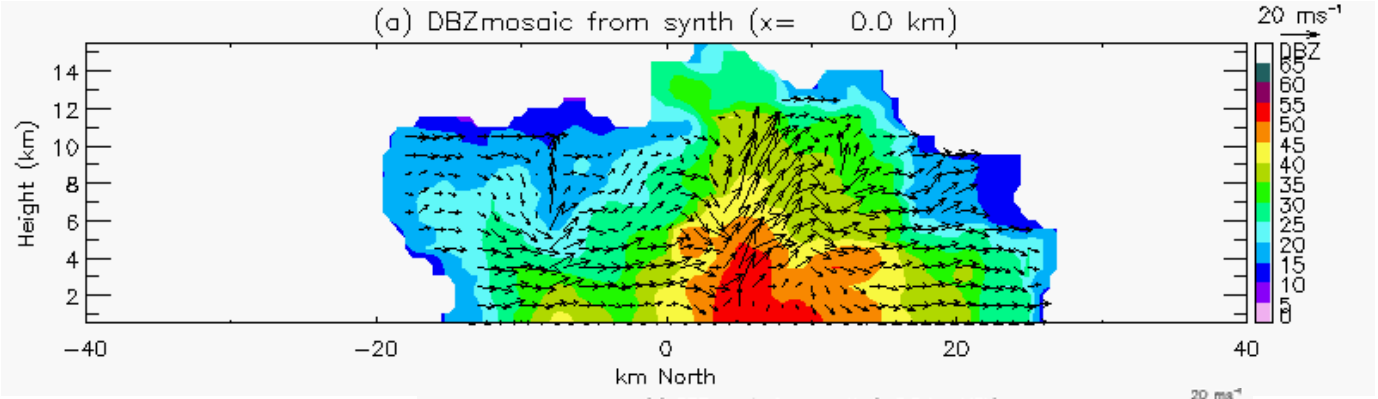
CASA
1 min updates

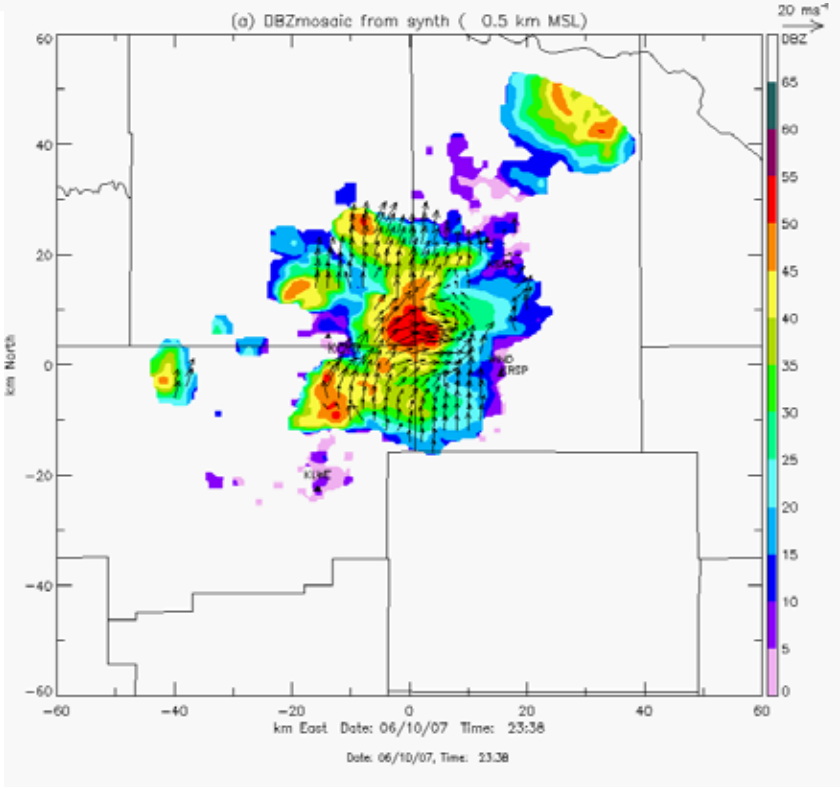


NEXRAD - KFDR
5 min updates

8 May 2007

CASA IP1 Multi-Doppler Winds

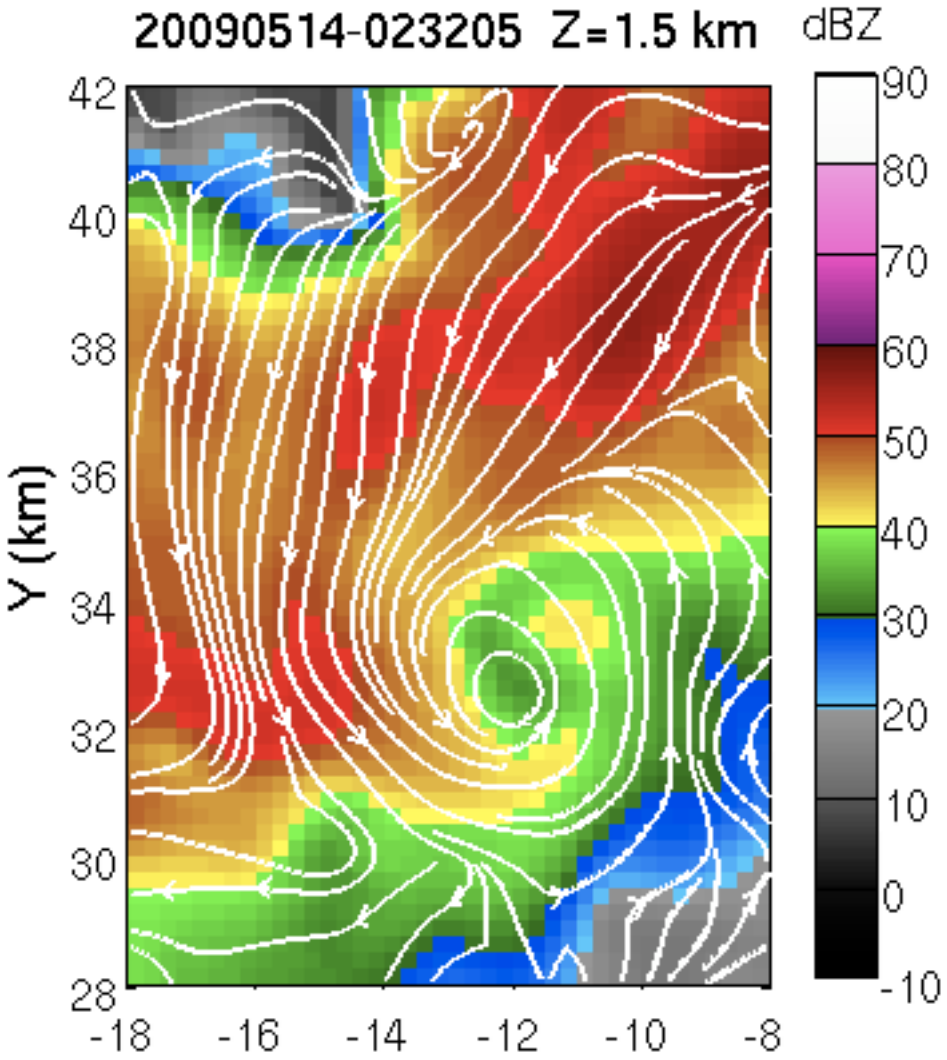




Dual Doppler Wind Retrievals from June 10, 2007.

Note the low-level coverage as well as storm top.

CASA IP1 Wind/Reflectivity Product

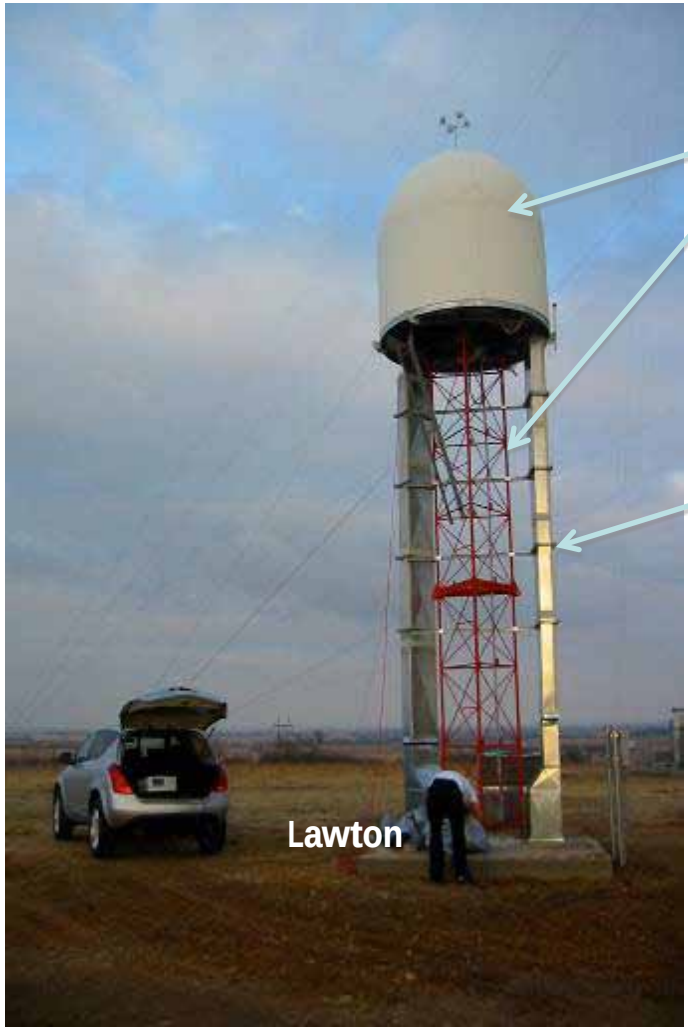


CASA IP1 - A Decision Support System

User needs enter every level of the design process - from sensing strategy to data product design & dissemination.

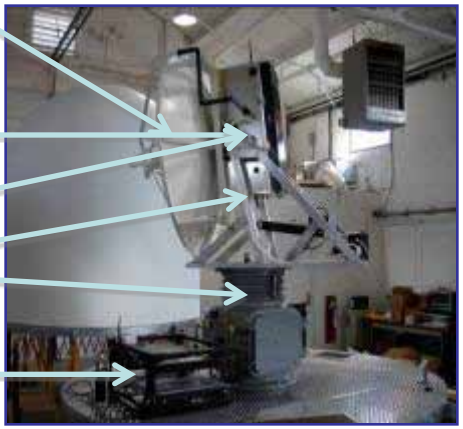
E. Bass and B. Philips, CASA

CASA Costing Experience



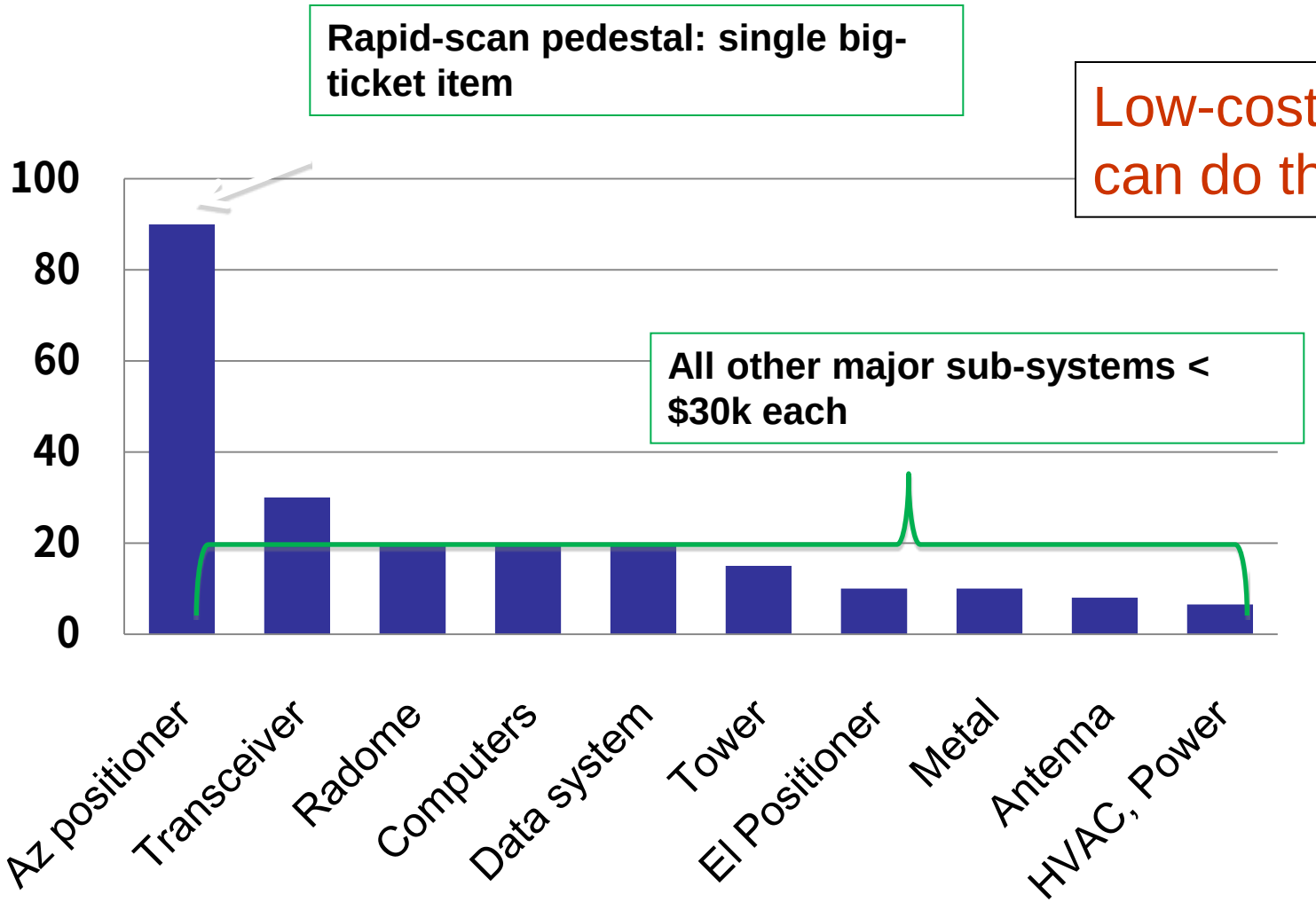
IP1 Node Component Costs	
Antenna	$8,000
Radome	$20,000
Tower (8m)	$15,000
Data Acq.	$20,000
Transceiver	$30,000
El Positioner	$10,000
Az Positioner	$90,000
Platform, frames	$10,000
Computers, storage	$20,000
HVAC	$6,000
Power line	$500
Total	**$229,500**
Note: 20 m towers cost $120,000	

IP1 Node Yearly O&M Costs	
Electric power	$2,000
Spare parts/repairs	$7,500
Networking	$16,500
Land Lease	$0
Total Annual	**$26,000**



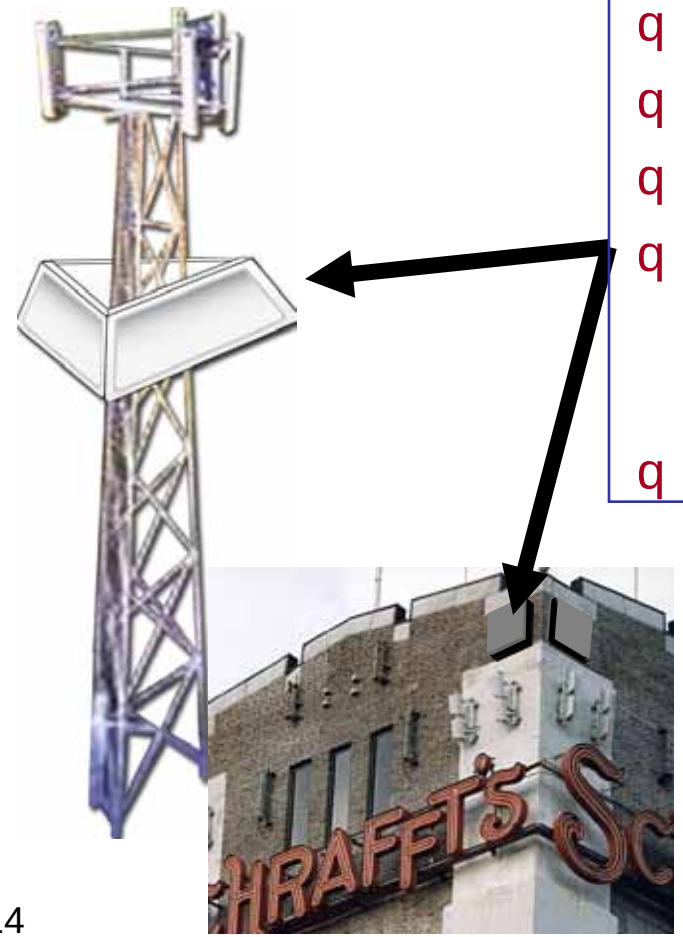
Note that these are parts costs only.

CASA Costing Experience



Low-Cost E-scan Panels

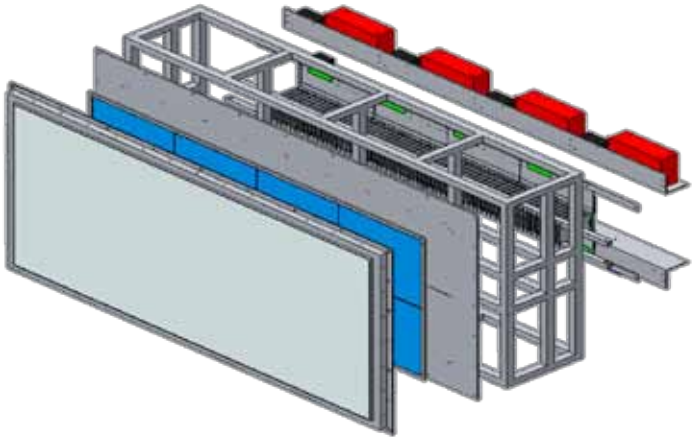
- 10W's to 100 W peak power per panel
- 2 pencil beam, 1m X-band array (9 GHz)
- Dual linear polarization
- # array panels per installation: 3 or 4
- Azimuth scan range: 45^0 to 60^0
- Elevation scan range:
  - $0\text{-}20^0$(low level coverage, < 3 km)
  - $0\text{-}56^0$ (full coverage, to 22 km)
- Cost: ~ $100k-200k per site



Actively being pursued by CASA enterprise partners

CASA "Phase-Tilt"

- E-scan in azimuth, M-scan in elevation
- Dual-polarized
- Elevation beam width ~3.6 deg
- Azimuth beam width ~2.0 deg (boresight)
- Max. peak Tx power ~60W
- Duty cycle ~30%
- Vaisala RVP900 processor



Antenna array lab testing

Radar panel field testing

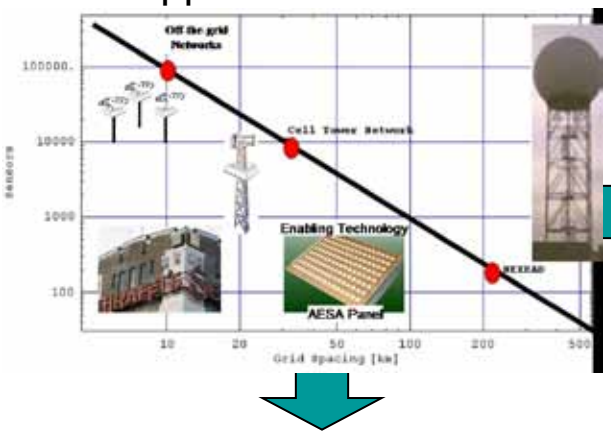
Radar panel field comparison

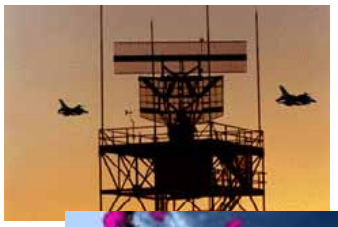
2 radar panels deployed

1/10 1/11 1/12

What's next…

CASA Approach





Potential New Applications

"… short-range, short-wavelength radars, which can be useful for estimating boundary layer winds, monitoring precipitation, and possibly tracking some C/B/N plumes."

[Source: National Research Council, Tracking and Predicting the Atmospheric Dispersion of Hazardous Material Releases: Implications for Homeland Security, 2003.]

Interest from Potential User's Growing

"… supplement (or perhaps replace) a NEXRAD-like network of primary radar installations should be evaluated thoroughly."
[Source: National Research Council, Weather Radar Technology Beyond NEXRAD, 2002]

"…augmenting the NEXRAD network with additional short-range radars to improve observation of low-level meteorological phenomena."
[Source: National Research Council, Flash Flood Forecasting over Complex Terrain, 2005.]

"Recommendation: Emerging technologies for distributed-collaborative sensing should be employed by observing networks, especially scanning remote sensors such as radars and lidars."

"The committee envisions a distributed adaptive "network of networks" (NoN) serving multiple environmental applications near the Earth's surface."

Need for multi-use architecture, for scaling the concept, & decision sciences – major CASA emphasis next 4 years

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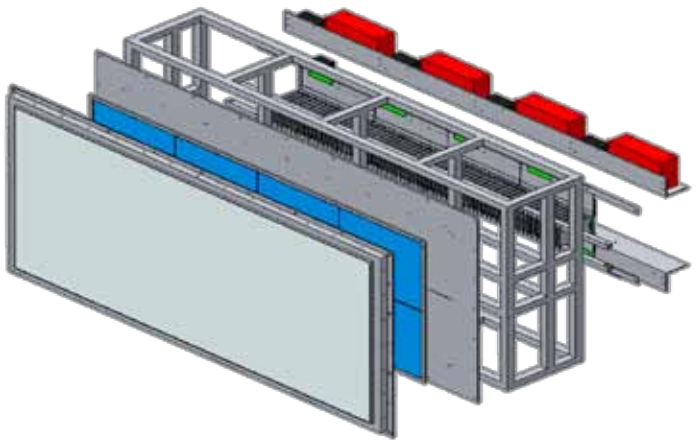
Summary

- **CASA: a compelling concept based on dense networks of small radars.**
  - It is the only current solution available to satisfy the gaps in low-level coverage and space-time sampling needs.
- **The research trials from the IP1 Oklahoma test-bed are proof-of-concept**
  - Boundary layer to the tops of storms.
- **CASA systems yield full 3D vector winds**
  - Critical to drive weather models, potential also to for aircraft surveillance
- ***Dense networks have the potential to supplement - or replace - the large civil infrastructure systems in use today.***

Backup - Escan Costing Experience



Component	Cost
Active Array	$55,000
Up/Down Converter*	$12,000
Elevation Controller	$10,000
Mounting Structure	$10,000
Data Acquisition	$40,000
Computer & Storage	$15,000
Total	$142,000
* Connectorized prototype	

- Active Array
- 64 T/R modules @ $500 ea = $32,000
- With electronics, frame, etc. ~55,000/array