MPAR Characteristics and Potential Service Improvements

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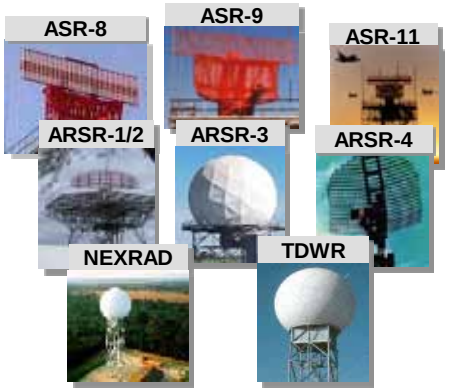
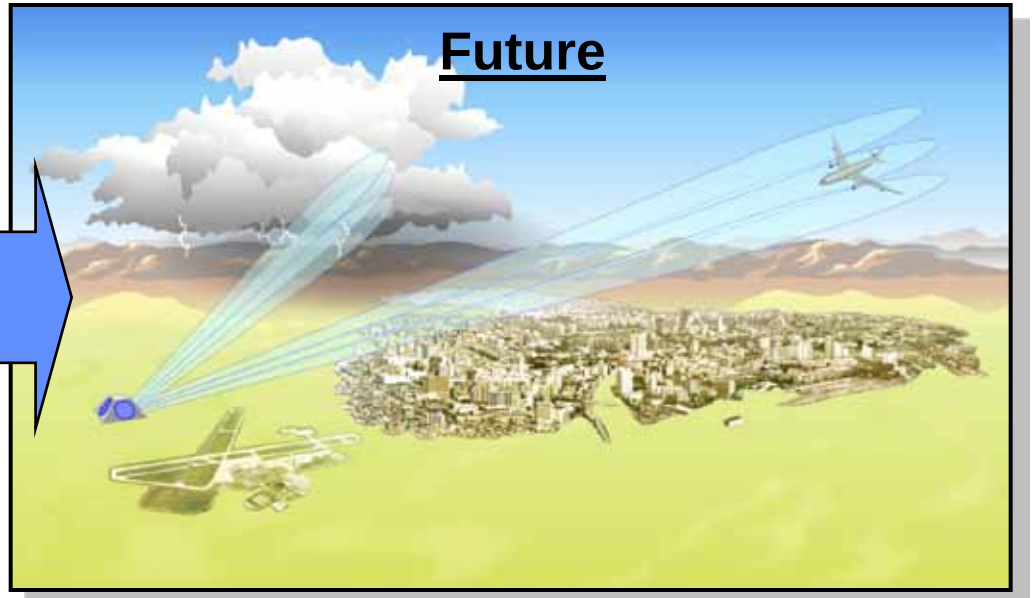
National Airspace Surveillance Infrastructure

Today



- Aging mechanically scanned radars
- 8 unique types for 4 different missions
- Over 500 total with redundant spatial coverage

Future



- State-of-the-art active phased array radars
- 1 type for all missions: Multifunction Phased Array Radar (MPAR)
- Efficient coverage and support infrastructure by eliminating redundancy
- Enhanced surveillance capabilities

CONUS Coverage

Current Air Surveillance Coverage

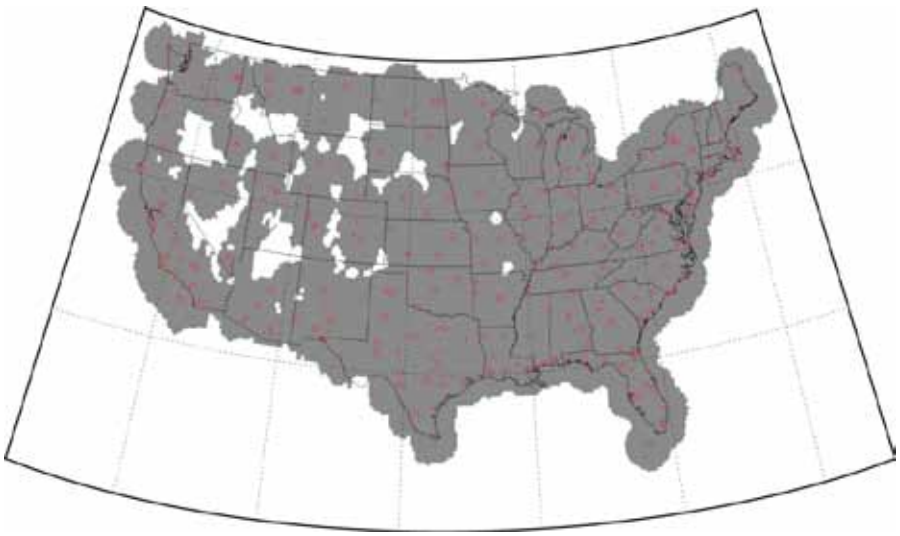
510 Total Radars, 8 types

Blue: weather radars only

Multifunction Radar Coverage

334 Total Radars, 1 type*

35% reduction



***Two tiered: Full-size MPARs and terminal-area MPARs**

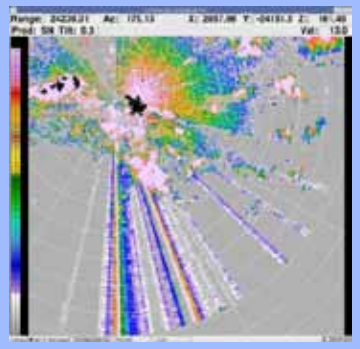
@ 5000 ft AGL

Outline

- MPAR concept
- Potential service improvements from MPAR characteristics
  - Streamlining to one radar type
  - Modularity, scalability, no moving parts
  - Rapid scanning
  - Adaptive scanning
  - Elevation angle space resolution and coverage
  - Multiple spaced receive beams
  - Polarimetry
  - High bandwidth, high PRF
- Summary

Streamlining to One Radar Type

- Standardized characteristics and operational parameters
  - Improved data mosaic/fusion
  - Better calibration coordination
- Standardized data format
  - More efficient development cycles for data products
  - Alignment with NextGen 4D weather data cube
- Unified management structure
  - Faster, coordinated response to user feedback
  - Uniform implementation of state-of-the-art upgrades
- Reduced footprint in radio frequency spectrum
  - Easier protection of operational band from interference



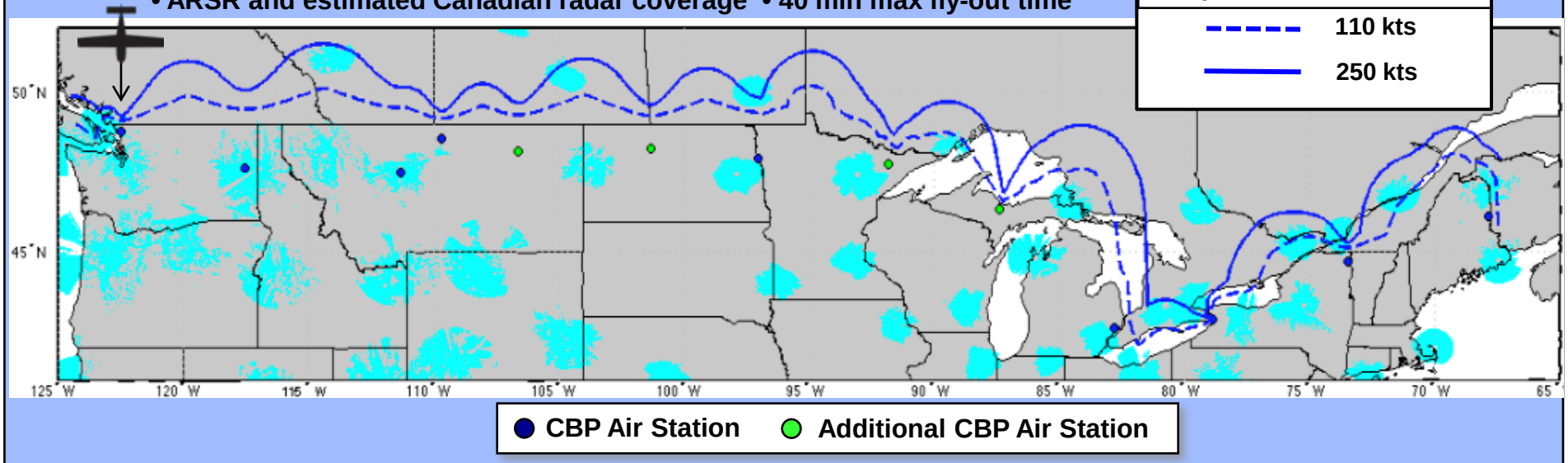
C-band radar interference from U-NII devices

Modularity, Scalability, No Moving Parts

- Sized to fit coverage and mission needs
- Increased robustness, maintainability
  - Amenable to remote siting

Homeland Border Air Surveillance Challenges

• 200 ft threat • Cessna 550 interceptor • 9 minute scramble • 0 dBsm threat
• ARSR and estimated Canadian radar coverage • 40 min max fly-out time



Many new radars needed to provide low-altitude coverage, especially in the mountainous Northwest region

Rapid Scanning

- **Better characterization of quickly evolving (hazardous!) weather**
  - **Tornadoes, microbursts, floods, convective growth & decay**
  - **Input to convective weather forecast models**

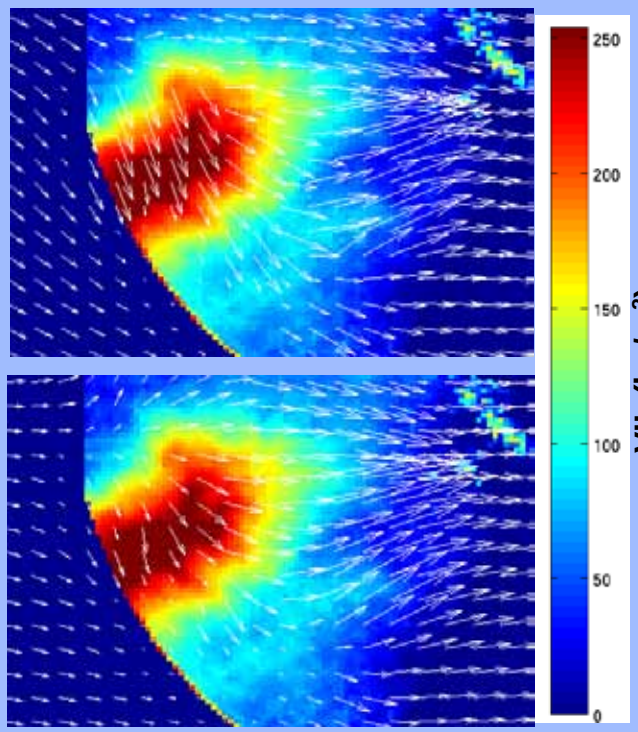
CIWS Convective Weather Forecast Model with NWRT Input Data

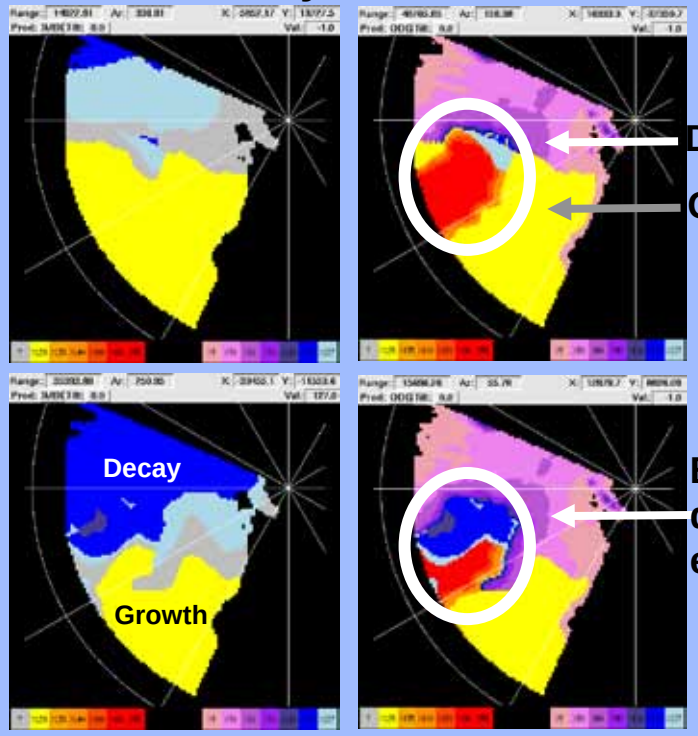
VIL & Track Vectors

Growth/Decay Trend-modified VIL

5-minute update (NEXRAD)

1-minute update (MPAR)





Decay not captured

Growth enhanced

Better captures decay on northern edge of cell

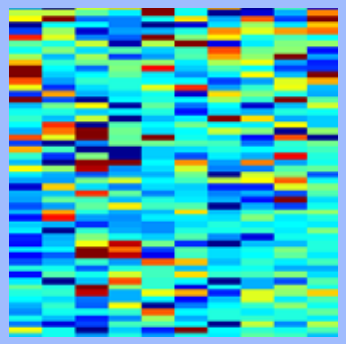
Benner, W. E., et al., Progress of MPAR program, *25th Conf. on IIPS for Meteorol., Oceanogr., and Hydro.*, AMS, 2009.

Adaptive Scanning

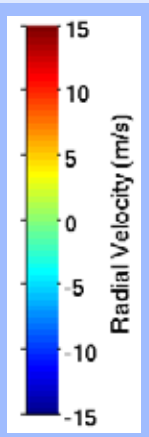
- Dedicated aircraft tracking modes
  - Reduced false track probability
- Targeted weather scans
  - Optimize data assimilation benefits for forecast models
  - Increase warning lead times on small-scale hazards such as tornadoes
  - Selective longer dwells to improve sensitivity in low-SNR conditions

NWRT Radial Velocity Variance Dependence on Dwell Time

Integration time = 0.057 s

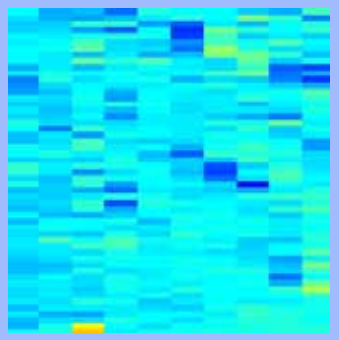


s_v = 8 m/s



SNR_{ave} = –4 dB

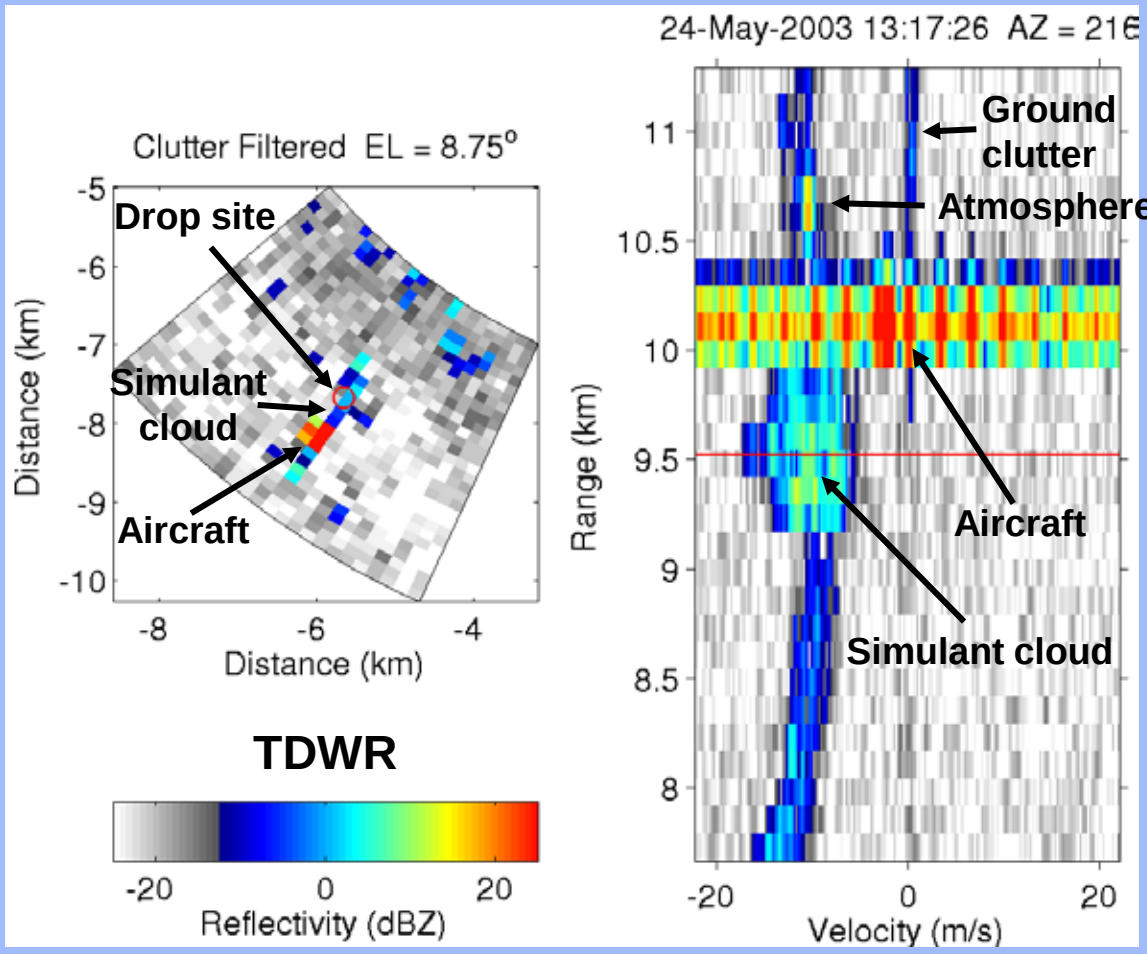
Integration time = 1.15 s



s_v = 1.8 m/s

Adaptive Scanning (Continued)

Observation of Chemical/Biological Agent Release from Aircraft



Limitation: Background atmospheric signal must be low enough for weak returns from small aerosols to be distinguishable

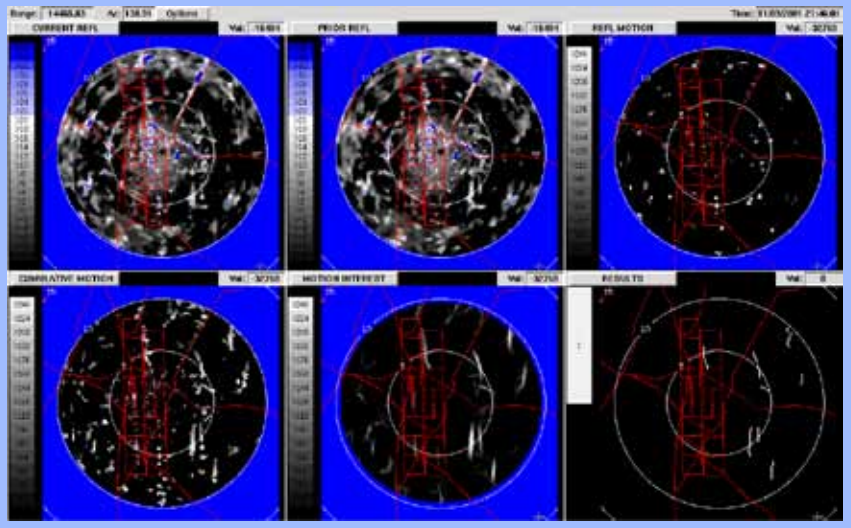
Only harmless simulants were used in these release experiments

Troxel, S. W., et al., *C-Band Aerosol Release Detector (CBARD) Algorithm Description*, Project Rep. WXCB-2, MIT Lincoln Laboratory, 2006.

Elevation Angle Space Resolution and Coverage

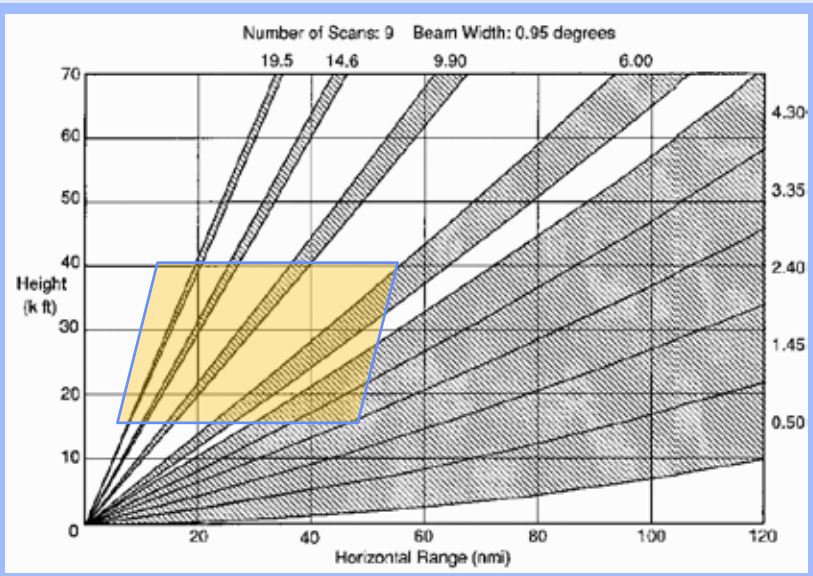
- **Height resolution (unavailable in current civilian ATC radars)**
  - **Noncooperative aircraft tracking, ADS-B backup**
  - **3D bird tracking**
- **Seamless elevation angle coverage (unavailable in current weather radars)**
  - **Improved weather characterization, especially echo tops**

MIT/LL Bird Tracking Algorithm



Troxel, S. W., Progress report on development of a terminal area bird detection and monitoring system using the ASR-9, *4th Joint Annual Meeting of Bird Strike Committee USA/Canada, 2002*.

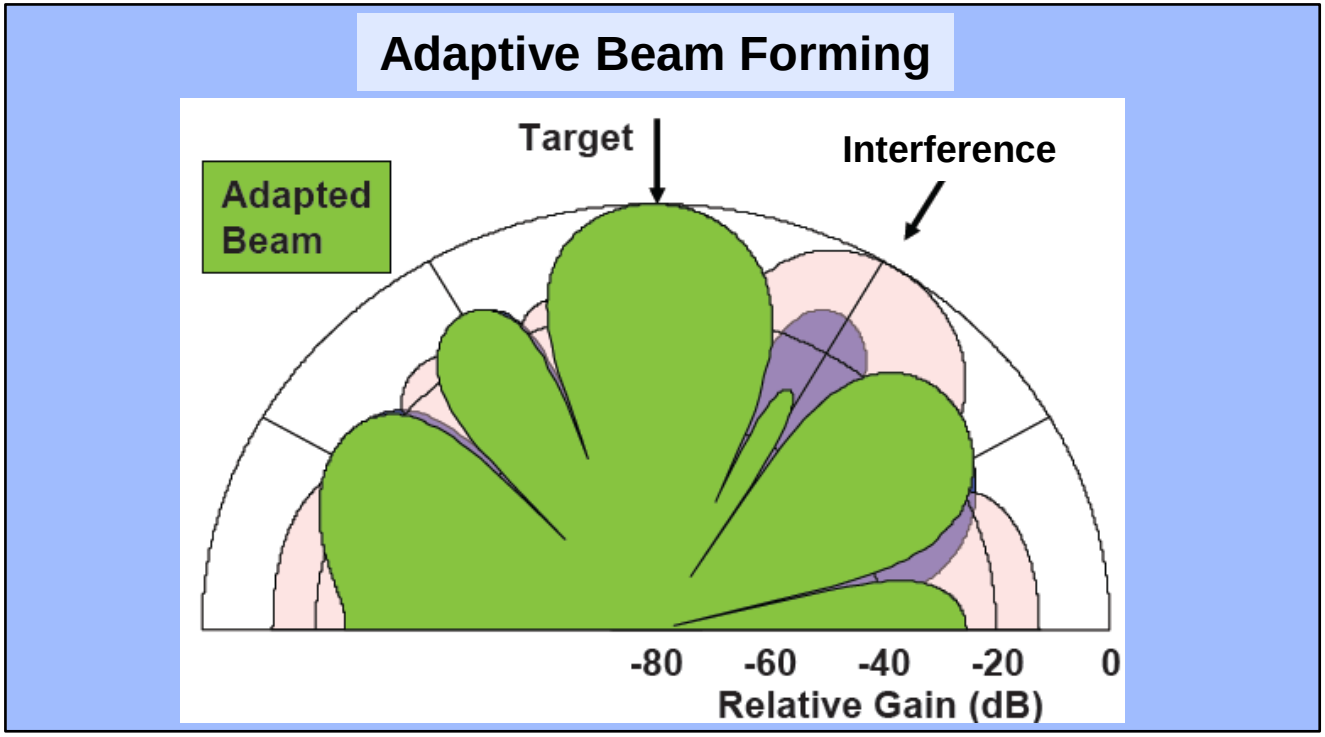
Fill in Gaps in Echo Tops Coverage



NEXRAD VCP 21

Multiple Spaced Receive Beams

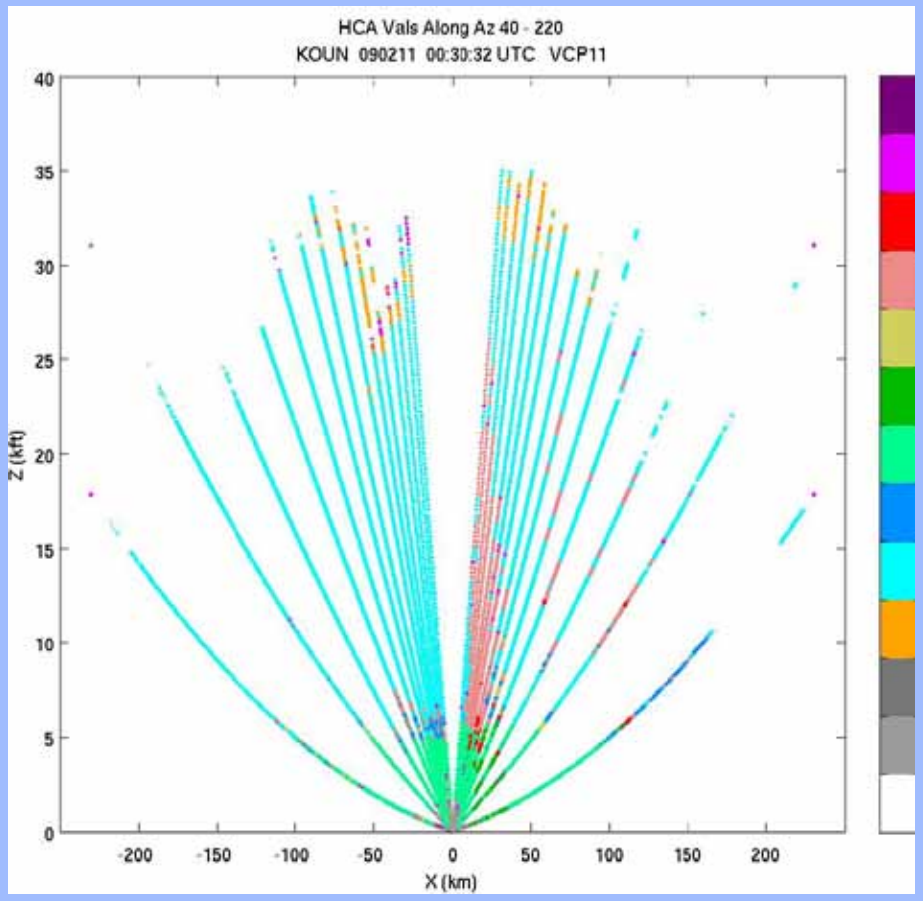
- Spaced antenna interferometry
  - Cross-beam wind estimation
- Digital beam forming, imaging
  - Enhanced angular target resolution
  - Selective/adaptive beam shaping and pattern nulling against clutter and interference



Polarimetry

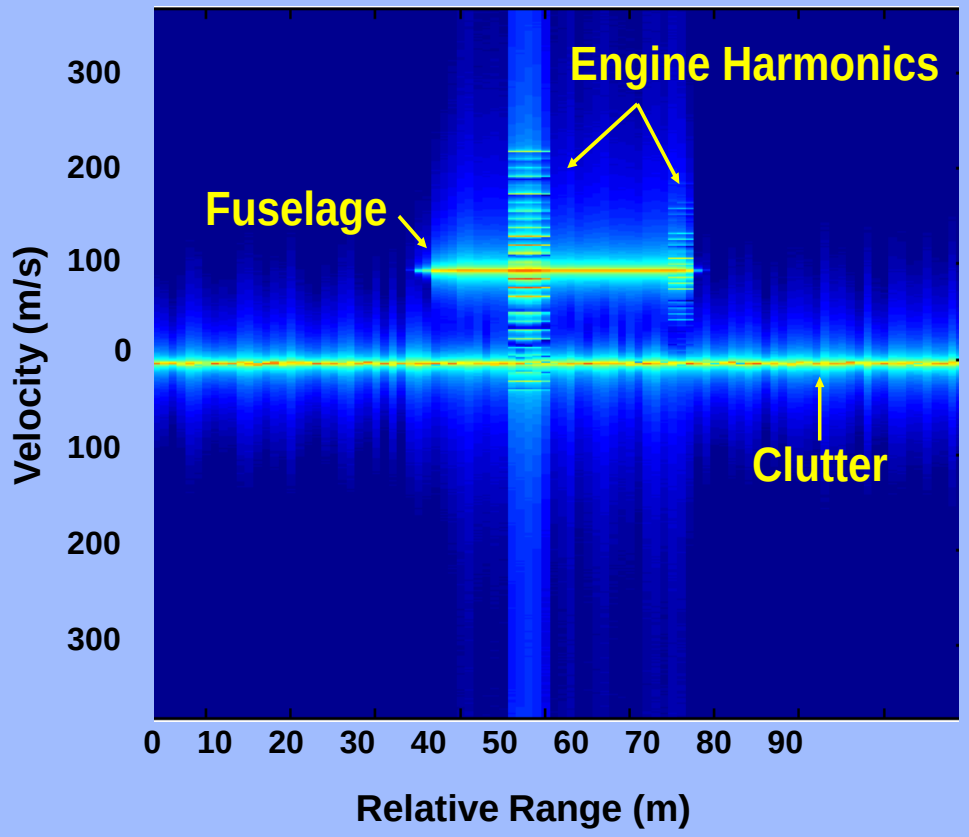
- **Target discrimination**
  - **Hydrometeors**
  - **Biological (birds, bats, bugs)**
  - **Ground clutter**
  - **Aircraft**
  - **Ash**
- **Improved quantitative precipitation estimates**
- ***Issues with phased array cross-polar coupling and calibration need to be worked out***

Hydrometeor Classifier



High Bandwidth, High PRF

- **Extreme range resolution and Doppler coverage**
  - **Noncooperative target ID**



- **Target ID mode has limited range swath and cannot operate concurrently with other modes**
- **Would be used in brief "point and ID" bursts based on external cues**

Notional plot—not actual data

Weber, M. E., et al., The next generation multi-mission U.S. surveillance radar network, *Bull. Amer. Meteor. Soc.*, 88, 1739-1751, 2007.

Summary

- There are many potential service improvements with MPAR due to
  - Advanced radar technical characteristics
  - Streamlining to single radar type
- But MPAR resource in energy/time/frequency domain is finite

Þ Which set of tasks and service improvements get implemented will ultimately depend on cost/benefit balance and alignment with NextGen observation requirements