

# Wind, Radar & FAA



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National Renewable Energy Laboratory

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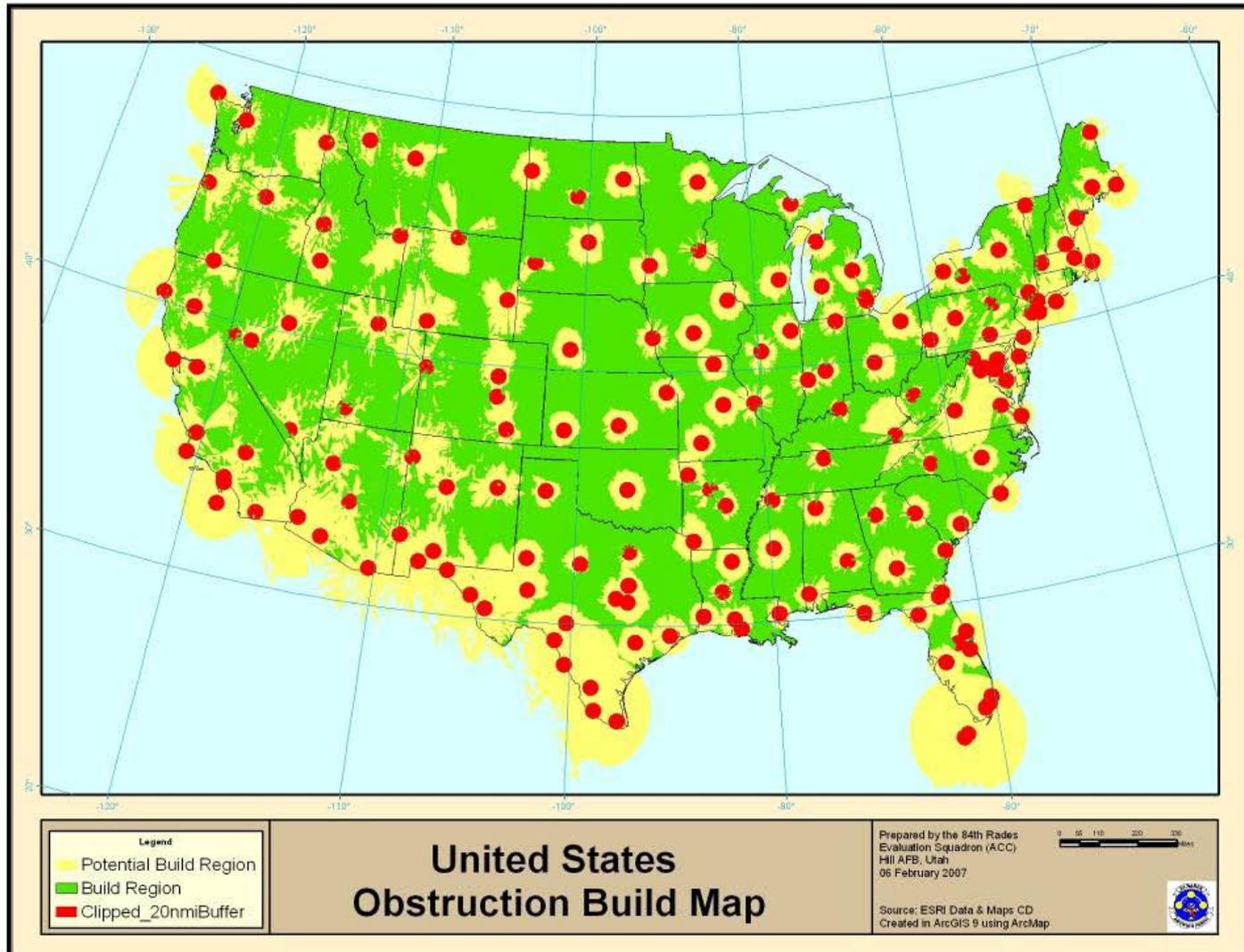
# Wind Radar Concerns

- Ongoing activities
  - >3000 MW under risk
    - ~300 MW approved since summer
  - All windy states impacted
- Mitigation under development
  - USAF and manufacturer actions under way
- FAA – 1<sup>st</sup> agency to contact
- DOD's large green energy goals
- Integrated process needed

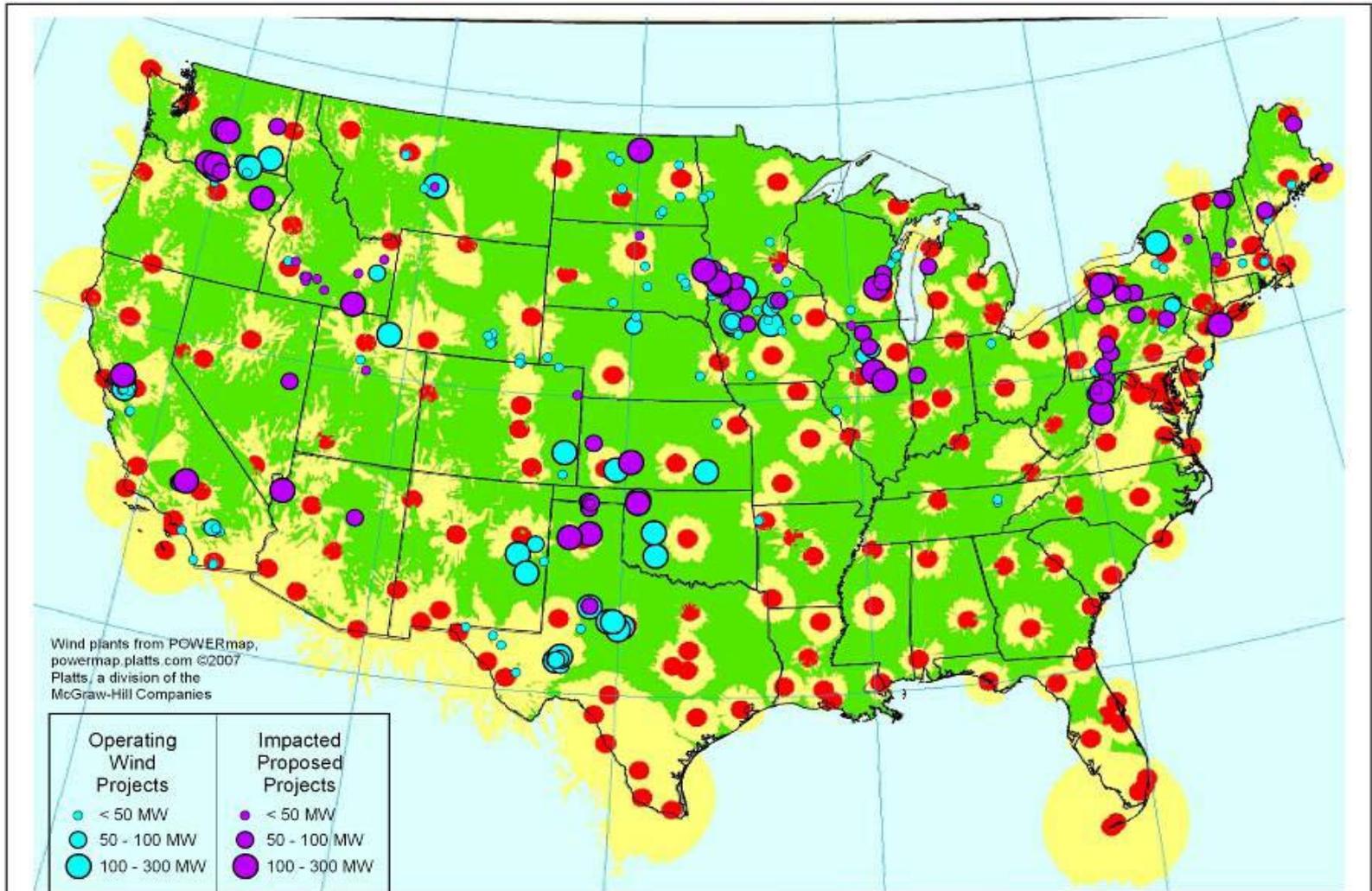


10/20/1998

# FAA Areas of Concern



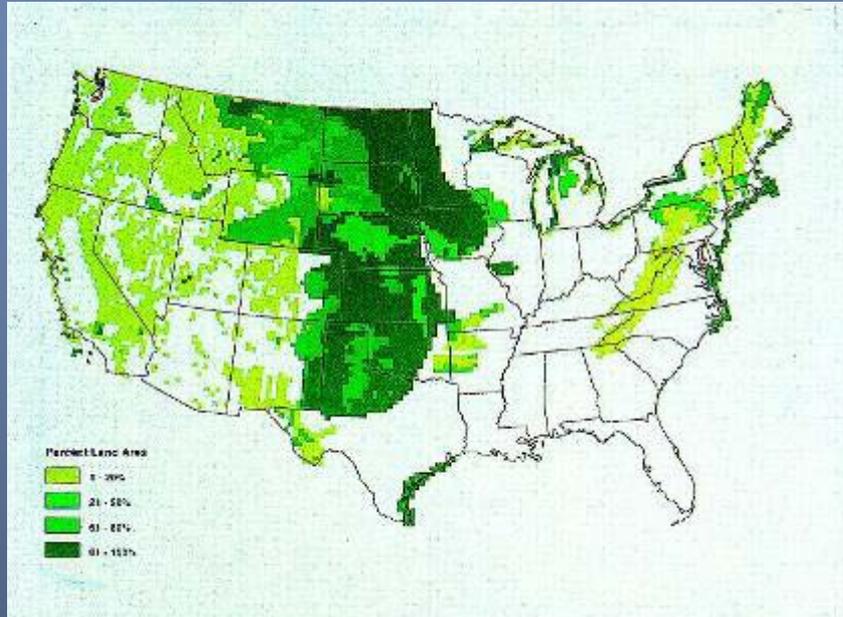
# FAA + Wind Projects



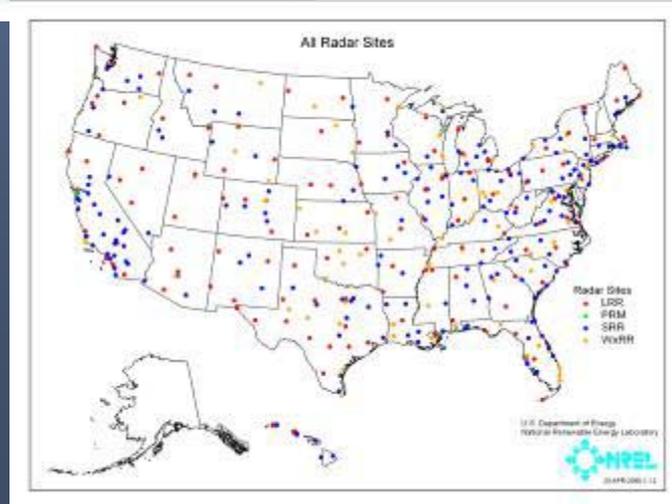
Base map is "United States Obstruction Build Map" obtained from Gary Seifert on Mar. 12, 2007.

100 0 100 200 300 400 Miles

Class 3  
or  
Higher  
Wind



Potential  
for  
Conflict



# FAA LRR Tool

## Instructions:

- Enter either a single point or a polygon and click submit to generate a long range radar analysis map.
- At least three points are required for a polygon, with an optional fourth point.
- The largest polygon allowed has a maximum perimeter of 100 miles.

Analysis Type:

Point	Latitude				Longitude			
	Deg	Min	Sec	Dir	Deg	Min	Sec	Dir
1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="N"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="W"/>

Datum:

## Map Legend:

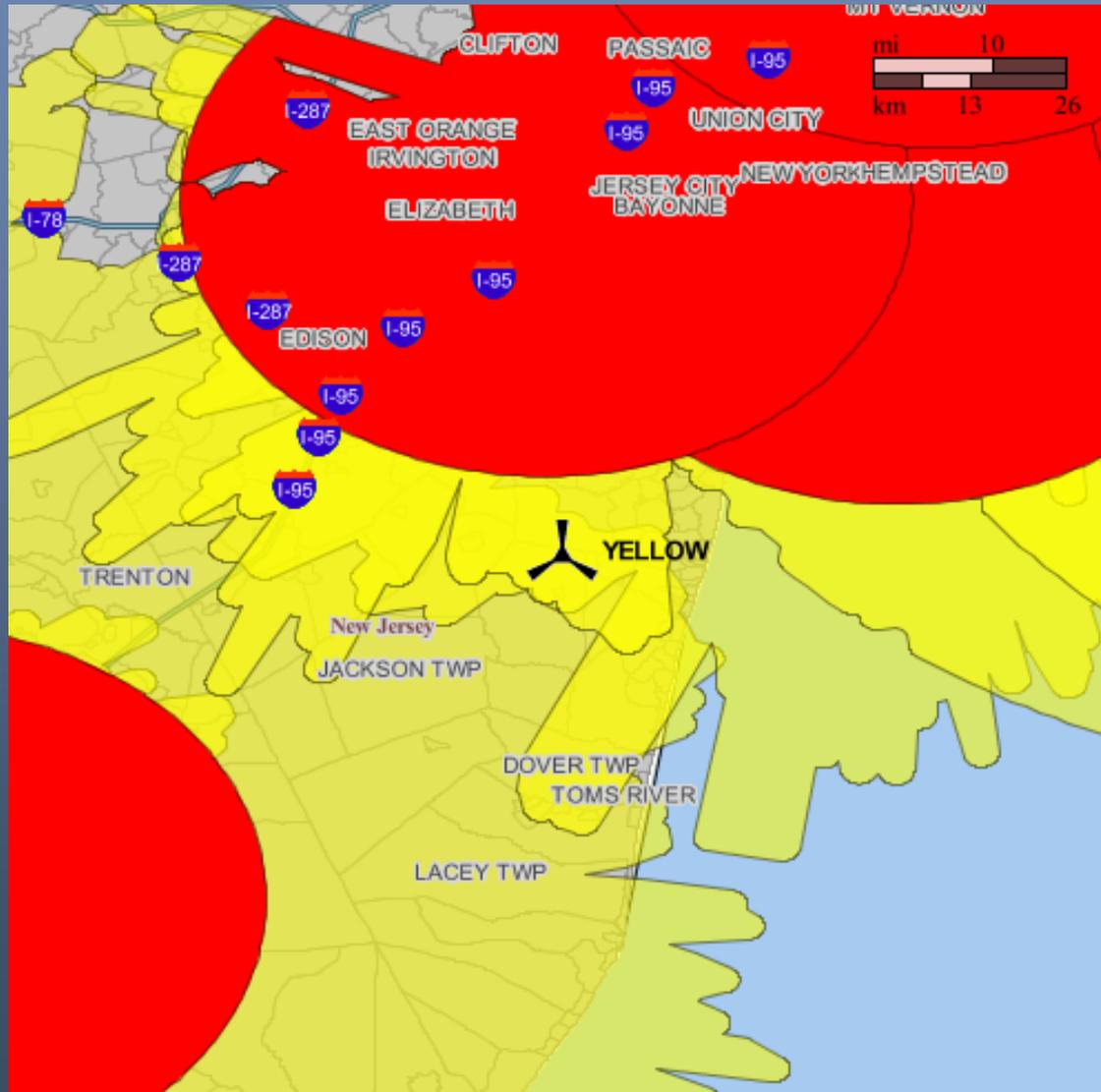
- **Green:** Development unlikely to impact long range radar operations. Standard aeronautical study required.
- **Yellow:** Potential for long range radar operational impact and mitigations options vary with development specifics. Standard aeronautical study required.
- **Red:** Long range radar operational impact highly likely, with diminished mitigation options. Extensive aeronautical study required.



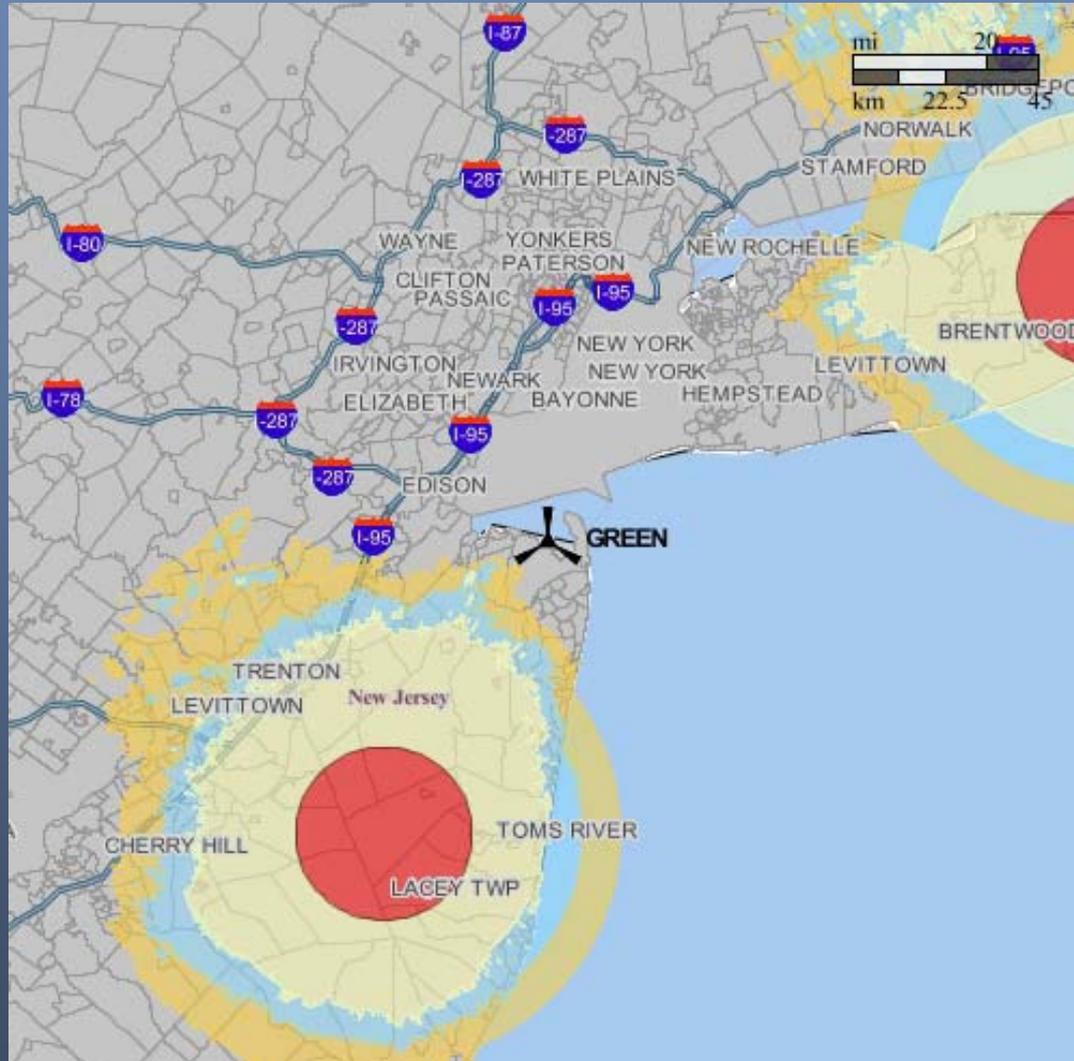
<http://oeaaa.faa.gov/oeaaa>

<https://www.oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action=showLongRangeRadarToolForm>

# FAA LRR Tool - FAA



# FAA LRR Tool - NEXRAD





# Why Worry about EMI/Radar Issues?

- Wind resources and radar missions can overlap
- There are many different missions - know your mission
- Be honest about the impact
- Significant impact can shut down the project
- Address up front and avoid long term problems
  - Energy security is a critical mission,
  - Air superiority is a critical mission
  - Drug Interdiction is a critical mission
  - Balance all missions

# Impact During Siting

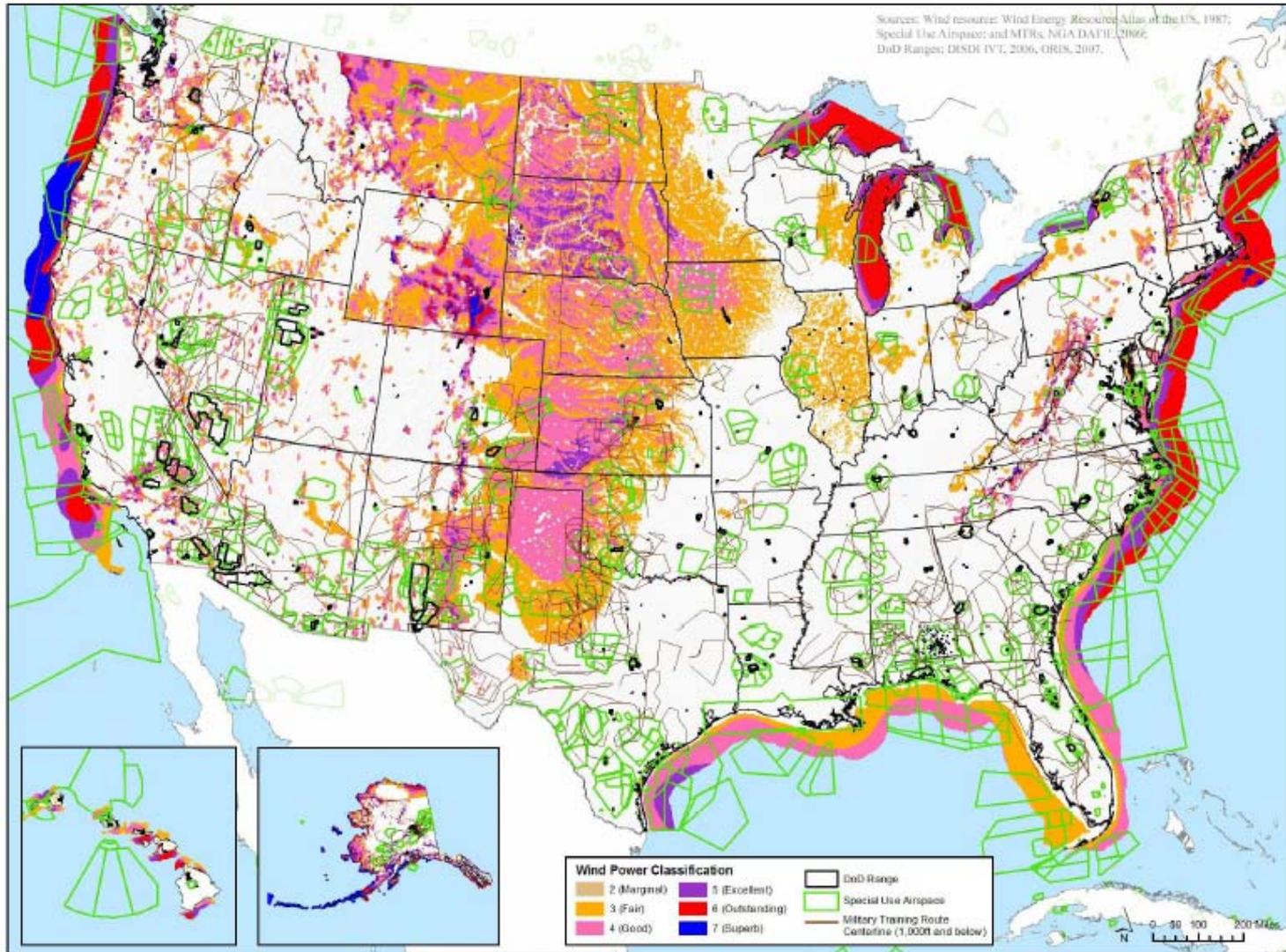
- Due Diligence Questions Must be Addressed
  - Radar
  - National Security Issues
  - Environmental
  - Cost
- Risk Management is Key
- Do Not Invest in Infrastructure Before Approved
- Location is Important
- Early Communication Critical
  - FAA
  - AF/DHS
  - Risk of Disclosure a Challenge
- Radar Line of Sight is First Filter
- Negotiate Final Turbine Locations – **new attitude at FAA**

# Interference

- If there is visibility, there is interference – interference is a relative term
  - Remember, turbines are big reflectors
    - Yet the Doppler only makes up 20% of the return signal!
  - Turbines are going to show up on the screen if visible to radar!
  - Interference is not the issue
  - Mission impact and co-existence are the issues
  - Does interference impact the mission?

# DoD and Wind

U.S. Wind Resource and DoD Ranges and Special Use Airspace



# BLM and DoD



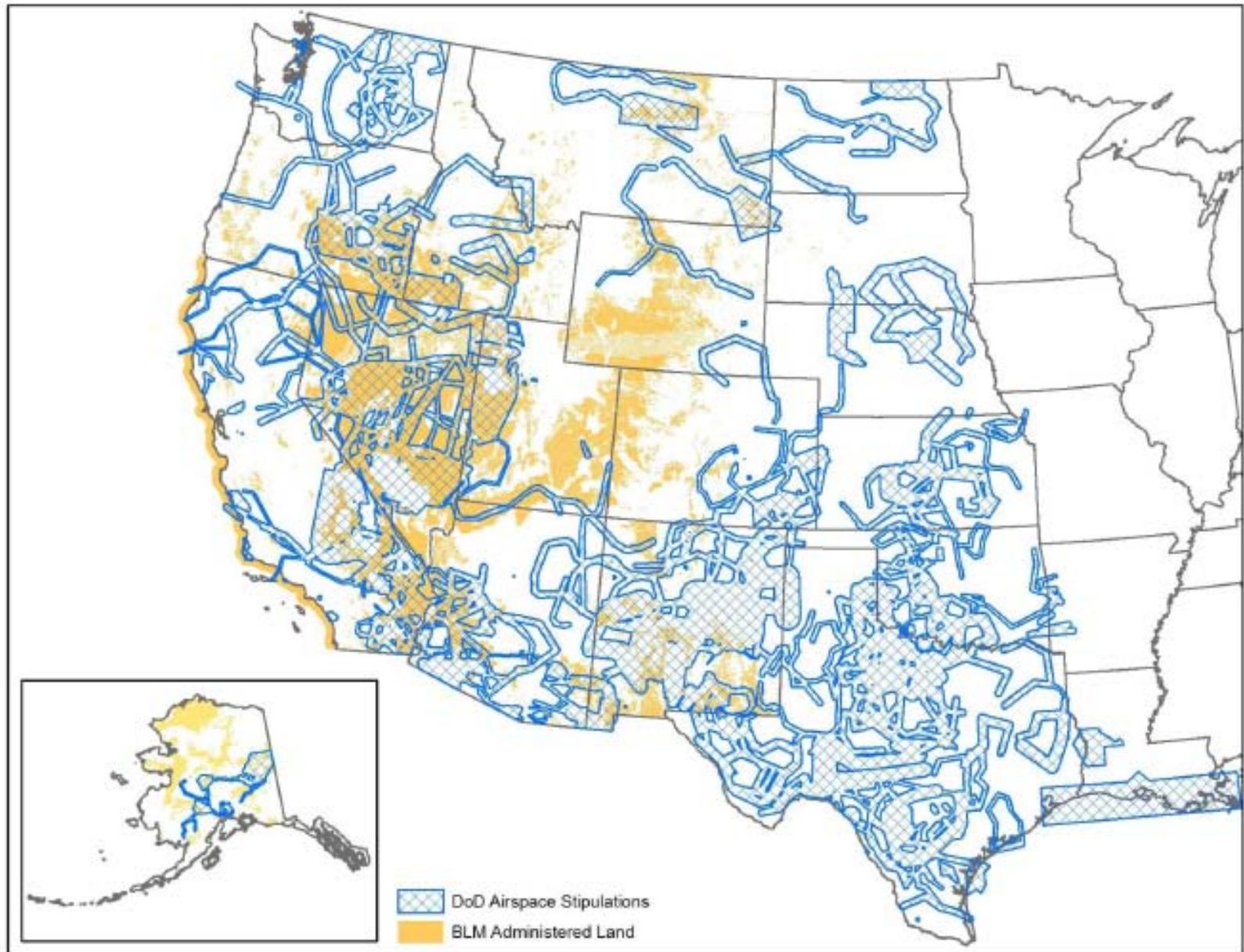
## Interagency Cooperation

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- **Outer Continental Shelf – DoD & DoI MoA 1983, update in progress**
- **West-wide Energy Corridors PEIS - 2006**
- **BLM & DoD Wind Energy Protocol – 2008**



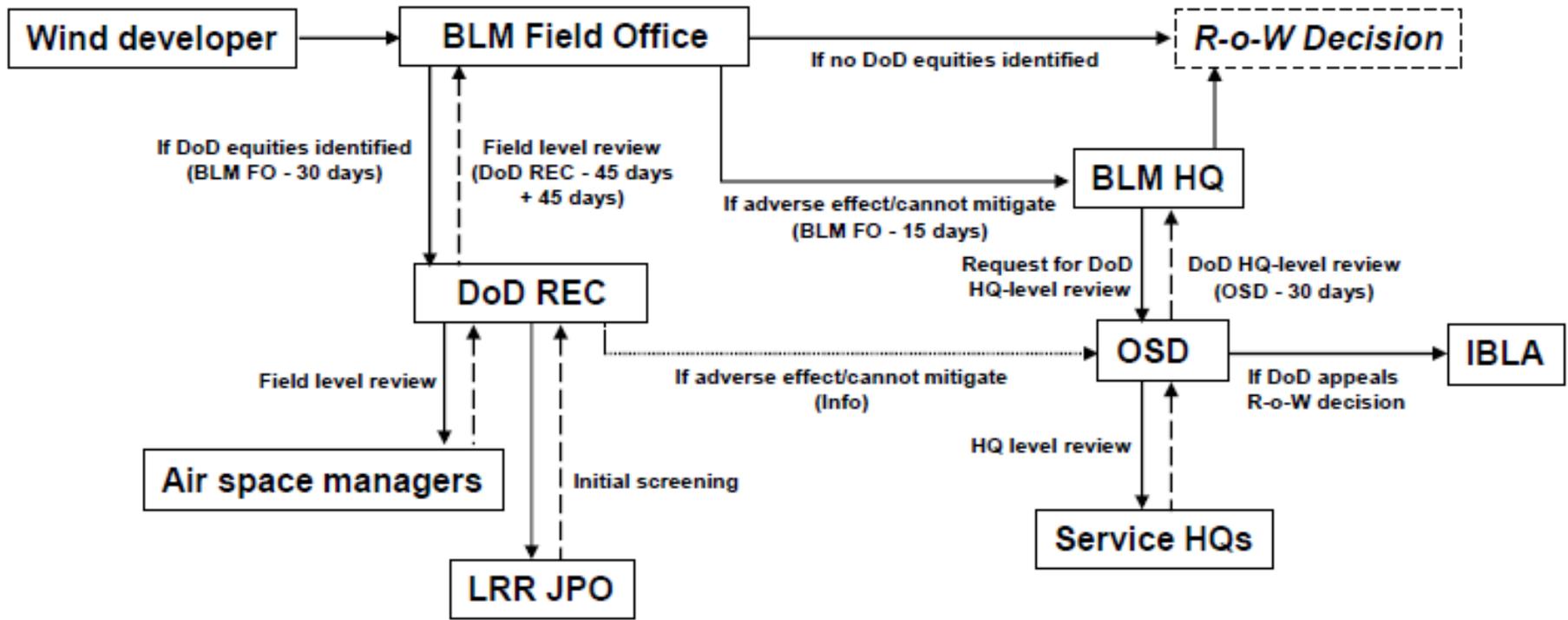
# DoD Airspace Stipulations in the Western U.S.



Not Suitable for Navigation

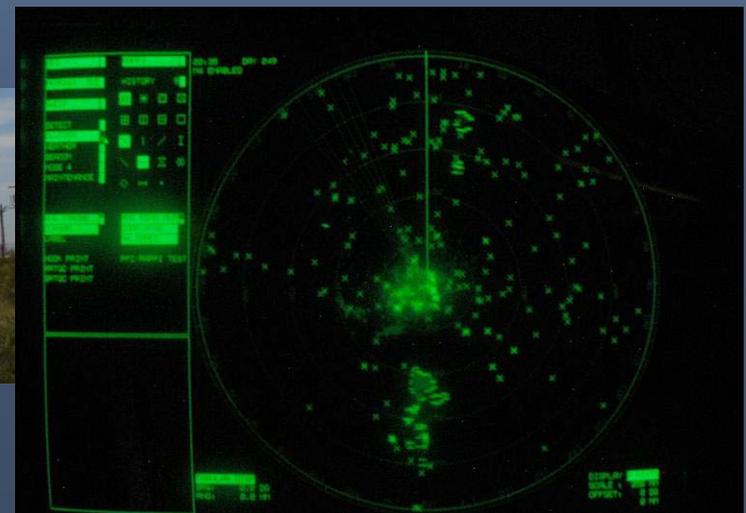


# DoD & BLM Wind Energy Protocol Process<sup>1</sup>



<sup>1</sup>This chart only includes the DoD and BLM protocol process, it does not represent the complete BLM right-of-way application process.

- FAA and DOD have different operational assessment criteria
- DOD has several internal agencies, all who have different criteria for operations and allowable impacts
- Software under control of radar manufacturers and wind issues are lower priority than FAA and DOD needs
- No single solution for process or mitigation technologies
- Impacts expected to increase as more turbines are installed



# Mitigation

- FAA and/or manufacturers mitigation is often available
- Only DOD, DHS, & FAA experts can determine if mitigation is acceptable
- Examples include, but are not all inclusive
  - Impact studies
  - Farm optimization
    - Refine turbine locations
    - Checkerboard
  - Adjust look angle, use multiple beams selectively
  - Reduce RCA (Radar Cross Section Area) – Stealth the Blades
  - Transponder integration
  - Software optimization
  - Added Hardware
    - Post processors and advanced software
    - Adding transmitters and receivers

# Mitigation

- Software improvements being investigated
  - Enhanced clutter mapping
  - Use of RAG Mapping
  - Concurrent processing
    - Separation of high and low beams
    - Tie to advanced clutter and geo based information
  - Improved signal processing
  - Improved filtering algorithms
  - Advanced tracking
  - Advanced adaptive Doppler filtering techniques

# Examples of Improvements

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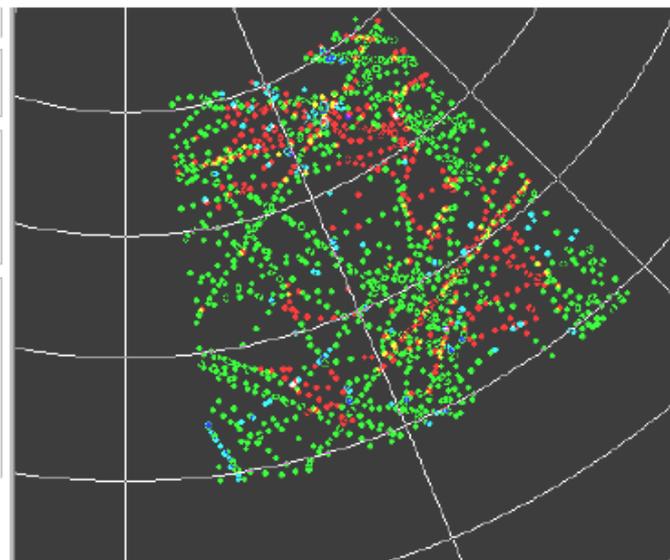
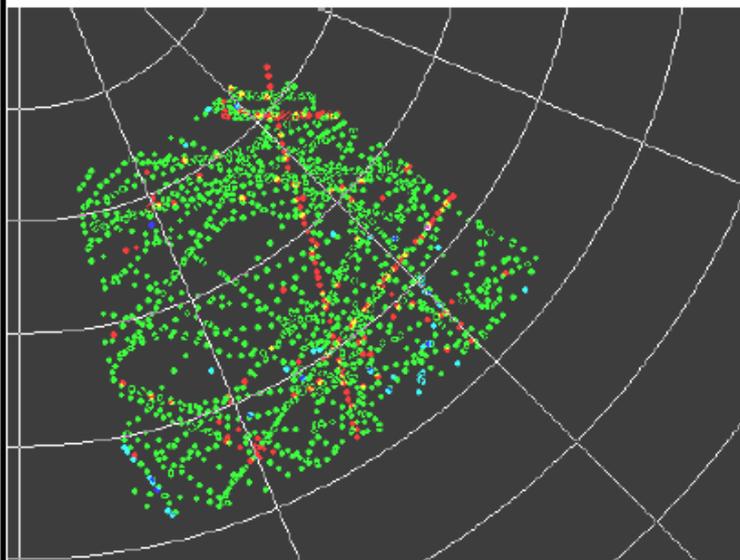
**Raytheon**

*Customer Success Is Our Mission*

## Track Eligibility - Optimized Comparison - WRA

ASR-11 (GPN-30)

Digitized GPN-20



Source: <http://www.nationalwind.org/assets/blog/Lok.pdf>

# Examples of Improvements

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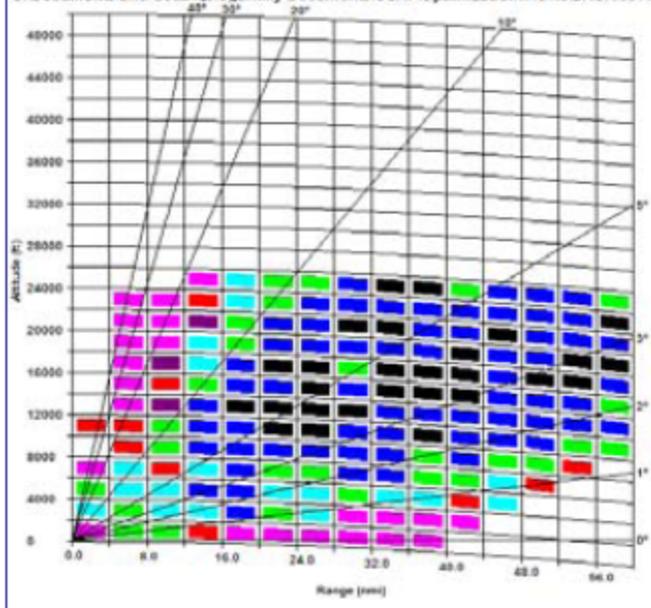
**Raytheon**

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## Track Eligibility – ASR-11 Optimization Final Results

PSR Probability of Detection, All Targets

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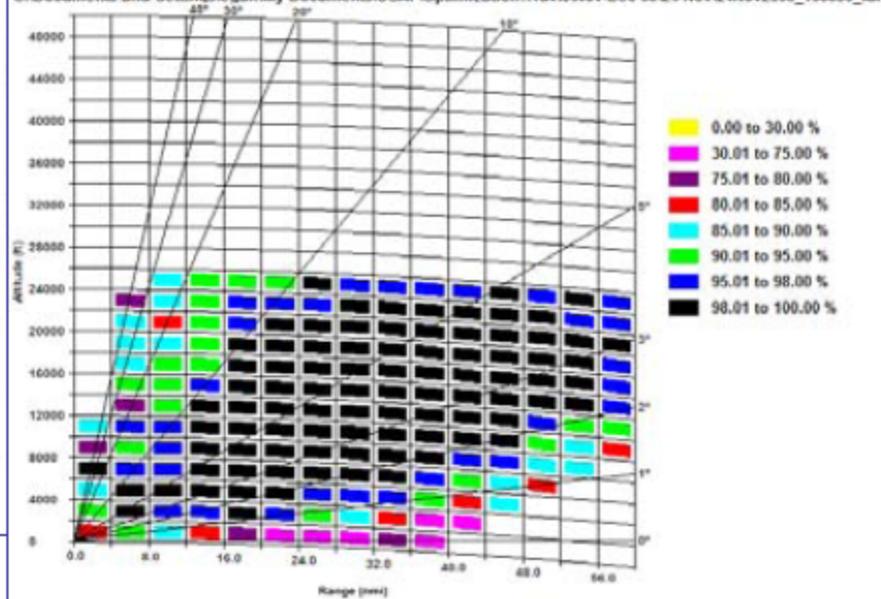


**Before**

Probability of Detection  
over WRA = 67.53%

PSR Probability of Detection, All Targets

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**After**

Probability of Detection  
over WRA = 92.72%

Source:

<http://www.nationalwind.org/assets/blog/Lok.pdf>

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# Improvements in Tracking Software

Before

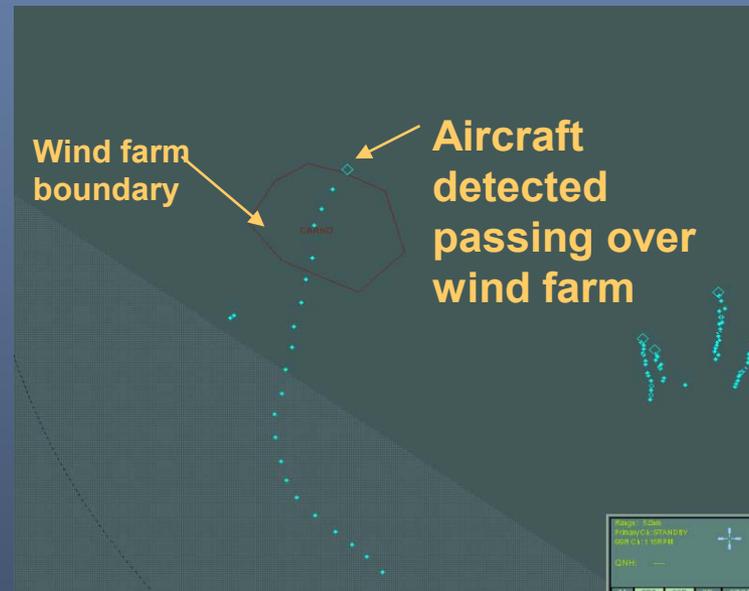
Primary lost, track lost

After

Track was maintained



Radar video as  
aircraft  
passes over wind  
farm



Resulting plot  
output  
from ADT

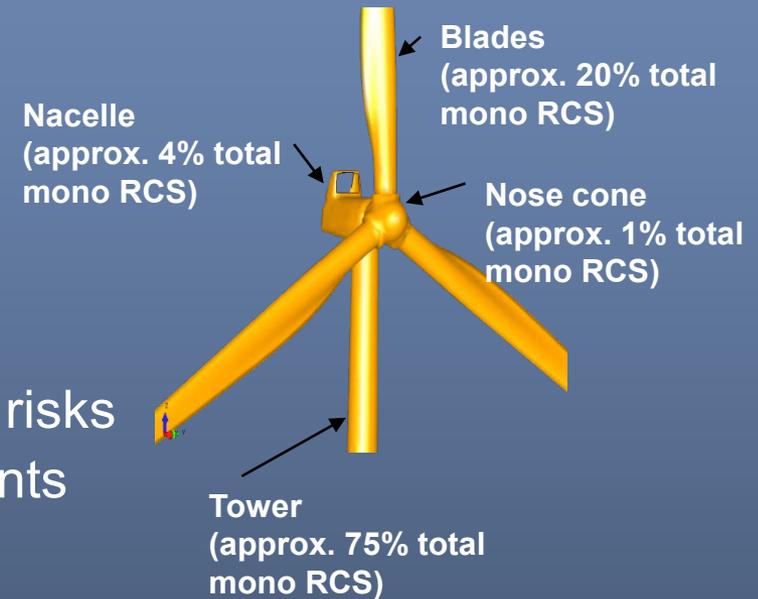
# Key issues being addressed:

- RFP for radar signatures at both LRR and ATC frequencies.
- ASR-4 (Airport Surveillance Radar) Assessment in Texas, fall 08
- Technical Expert Peer Meeting (November 07)
  - Key findings; US Stealth capabilities, innovative filtering, phase array systems, gap fillers, test signal generators, layout optimization, improved processing, transponders on turbines with performance data, sensor fusion, integrate optical with radar, integrate two pulse discrimination, etc
- Developing Assessment Guidelines for review
- RFP for Advanced tracking demonstration on existing LRR systems
- Develop Assessment Process



# Key issues being addressed:

- Develop Wind-Radar Checklist
- Operations Impact Guidelines
- Expand Mitigation Toolbox
- Provide Outreach
  - Integrate screening tools
  - Educate developers on processes and risks
- Plan FY-08 Case Studies and R&D Elements
- Coordinate with Manufacturers of Stealth Turbines
- Support Field Tests (Mitigation and Stealth Technologies)
- Develop assessment appeals process



# Prioritized Technical Meeting Findings

- FAA and/or manufacturers mitigation is often available
- Only radar and operations experts can determine if mitigation is acceptable
- Mitigation examples include, but are not all inclusive
  - Impact studies
  - Farm optimization
    - Refine turbine locations
    - Checkerboard
  - Adjust look angle, use multiple beams selectively
  - Reduce RCA – Stealth the Blades
  - Transponder integration
  - Software optimization
  - Added Hardware
    - Post processors and advanced software
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# Prioritized Mitigations being Investigated

- Software improvements
  - Enhanced clutter mapping
  - Use of RAG (Range Aperture Gate) Mapping
  - Concurrent processing
    - Separation of high and low beams
    - Tie to advanced clutter and geo based information
  - Improved CFAR processing
  - Improved filtering algorithms
  - Advanced tracking
  - Advanced adaptive Doppler filtering techniques



# How problems are being addressed:



- Multi-pronged approach; multi-stakeholder involvement
- Collaborative research, case studies, radar evaluations, metrics refinements, tools, mitigation development and information sharing
- Commission independent wind radar baseline tests
- Foster technical solutions
- Reduce encroachment mentality
- Make results public and shared
- Foster mitigation discussions,
  - Toolkit meeting October 2007
  - Technical meeting December 2007
  - Jason report meeting January 2008
  - Next technical meeting being planned

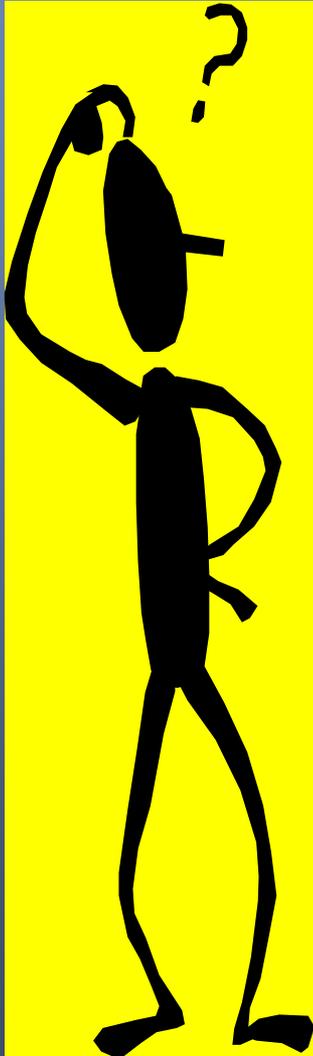
- DOE Wind-Radar
  - Technical Assistance to Agencies & Industry
    - Weakened by recent JPO change in prescreening support
  - Mitigation Case Studies
  - Demonstrations – make results public
  - R&D (Blades, Sensors)
  - Multi-pronged approach; multi-stakeholder involvement
  - Collaborative research, case studies, radar evaluations, metrics refinements, tools, mitigation development and information sharing
  - Commission independent wind radar baseline tests
  - Foster technical solutions
  - Reduce encroachment mentality
  - Make results public and shared
  - Shadowing study underway
  - Scheduling three demonstrations
    - Advanced software on ASR-11
    - Gap filling radar on ASR-11
    - Concurrent Processing

# Summary

- Raise awareness for action
- Involve all concerned parties
- There is interference from wind turbines
- Do due diligence early
- Case by Case assessment needed
- Approach all issues openly and fairly
- No and Yes are both acceptable answers
- Understand what brought on “NO”
- Address mitigation
- Communicate well and often
- Strive for Win-Win Solutions
- Research and mitigations needed
- Processes needed



# Questions?



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# Carpe Ventem



[www.windpoweringamerica.gov](http://www.windpoweringamerica.gov)