SAND2013-10431P

Wind Turbine Impact on Radar

Overview of the Interagency Field Test and Evaluation Program

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

This work is sponsored by DOE under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, recommendations and conclusions are those of the authors and are not necessarily endorsed by the United States Government.

Outline

- **Background**
- **Flight Test**
- **Way Ahead**

Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

Wind Turbine Impacts

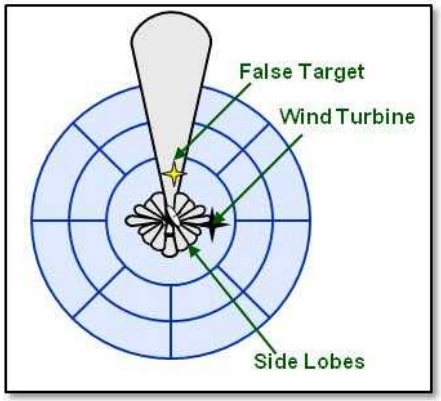
Turbines are growing in size and number

- Tip speeds over 225 mph
- Blades more than 50 m long
- 30 – 40 dBsm
- Wind farms with 100s of turbines

- Decreased Sensitivity (P_D)
- False Targets (P_{FA})
- Corrupted Track Quality

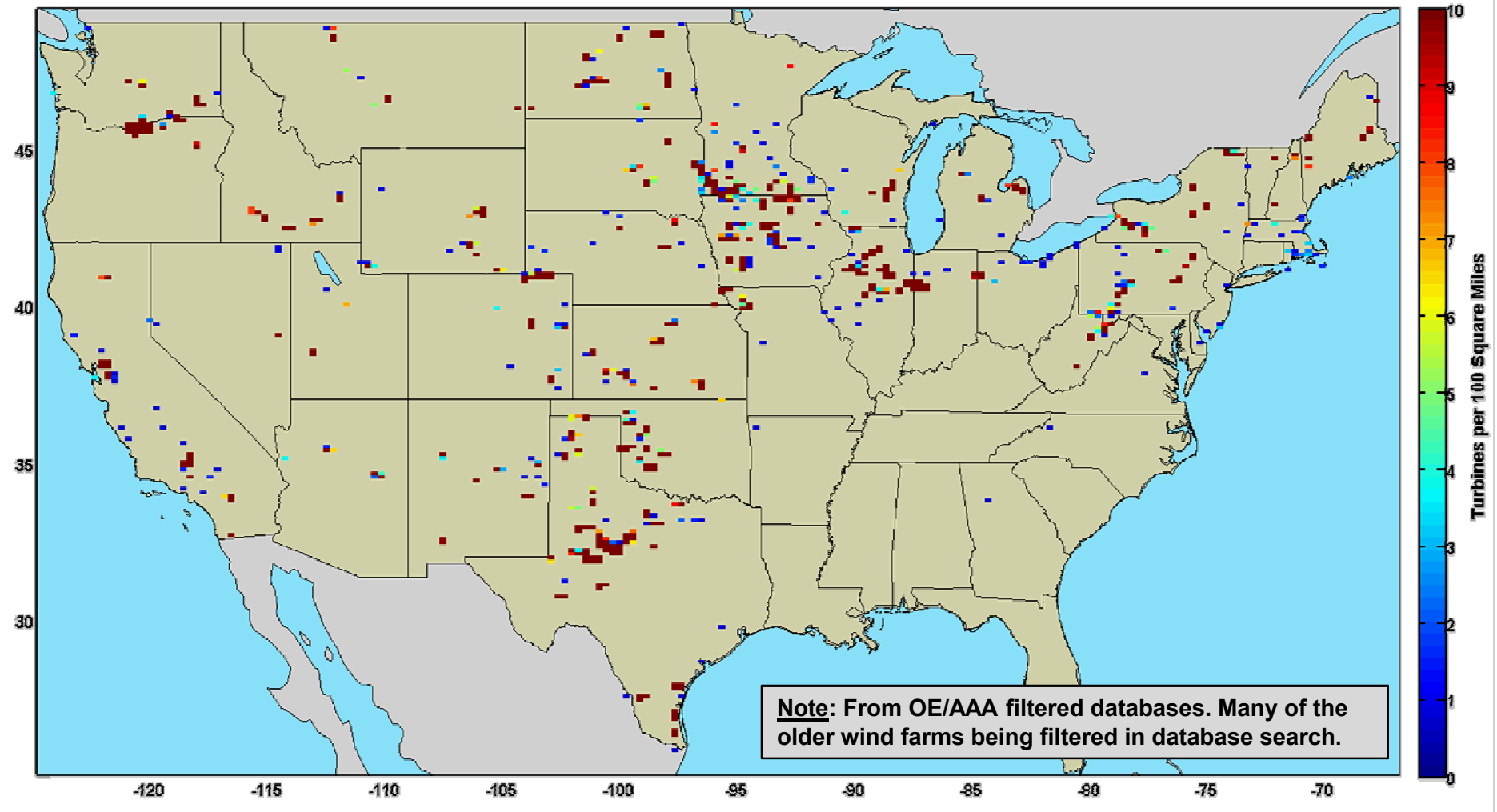
Concern for:

- Flight Safety
- Homeland Air Security



Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

Wind Turbine Are Impacting More Radars

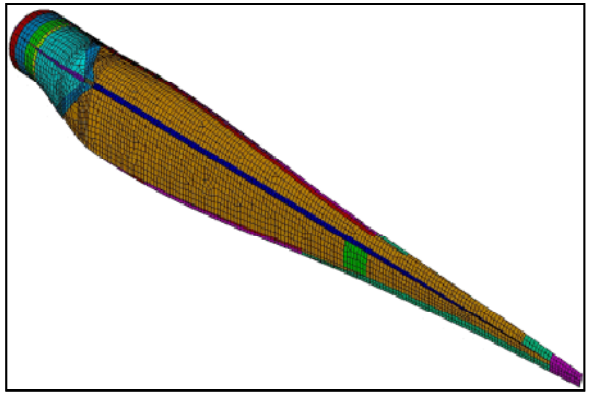


Visible to Radar LOS

Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

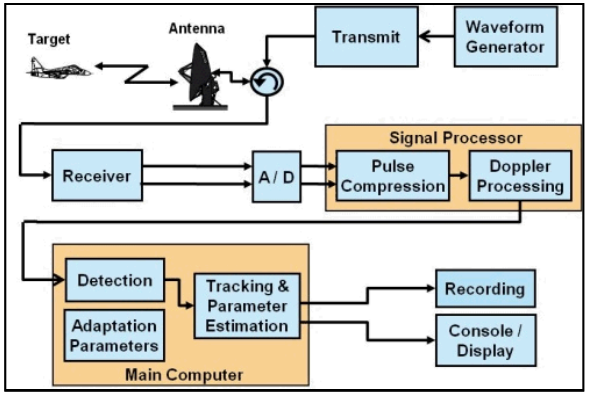
Industry Proposed Mitigation Options

Reduced Signal Turbines



Replacement Radar

Radar Upgrades



Wind Farm Siting

Augmentation Radar

C2/Automation Upgrades

Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

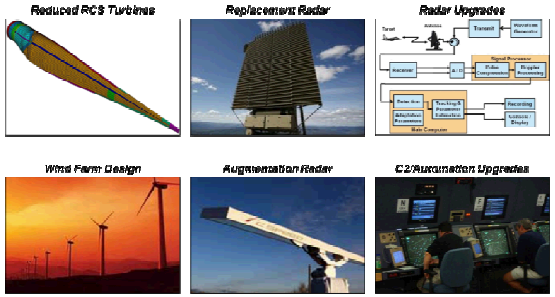
Interagency Field Test & Evaluation

Evaluate wind turbine impact and industry mitigations

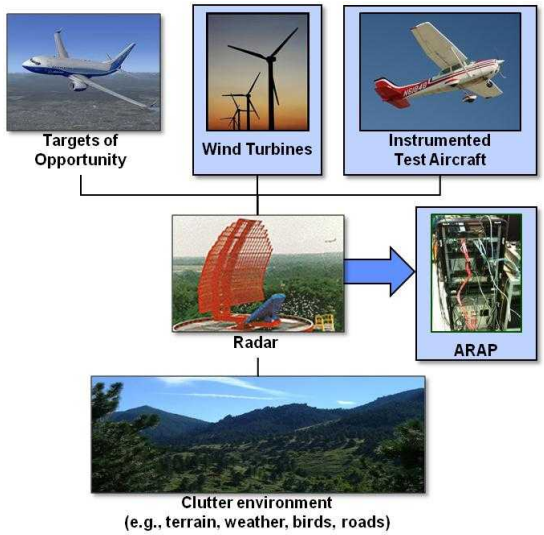
Steering Committee

DOE, DoD, DHS, FAA

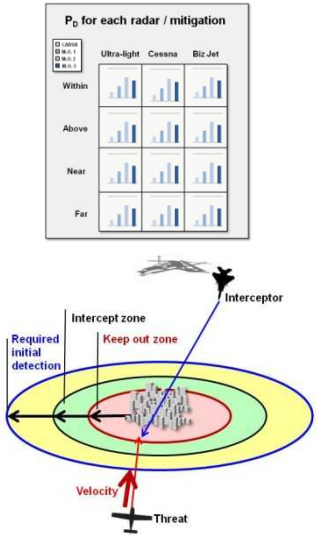
Industry Mitigations



Flight Tests & Analysis

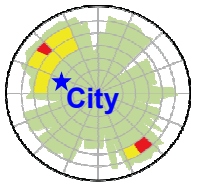


System Analysis

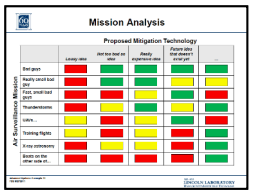


- 2-year, jointly funded program
- 3 flight campaigns
  - CARSR (Tyler, MN)
  - ASR-11 (Abilene, TX)
  - ARSR-4 (King Mountain, TX)
- Invite selected mitigations
  - Selected 11 concepts to assess
- System analysis of mission impact

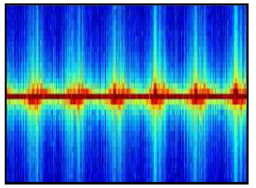
Interagency Field Test & Evaluation Products



Characterize Current Impact



Assess Proposed Mitigations



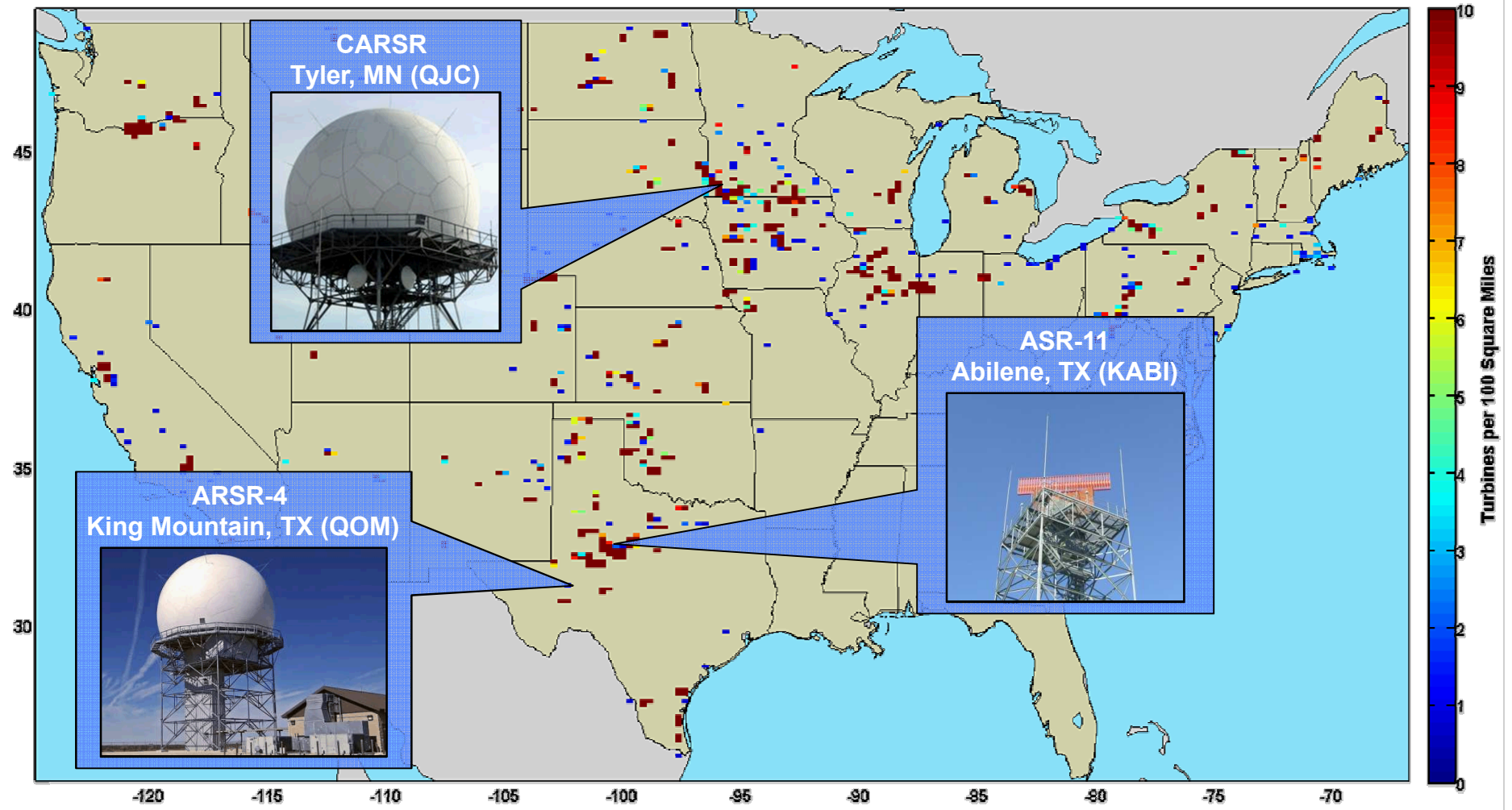
Data for Future R&D

Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

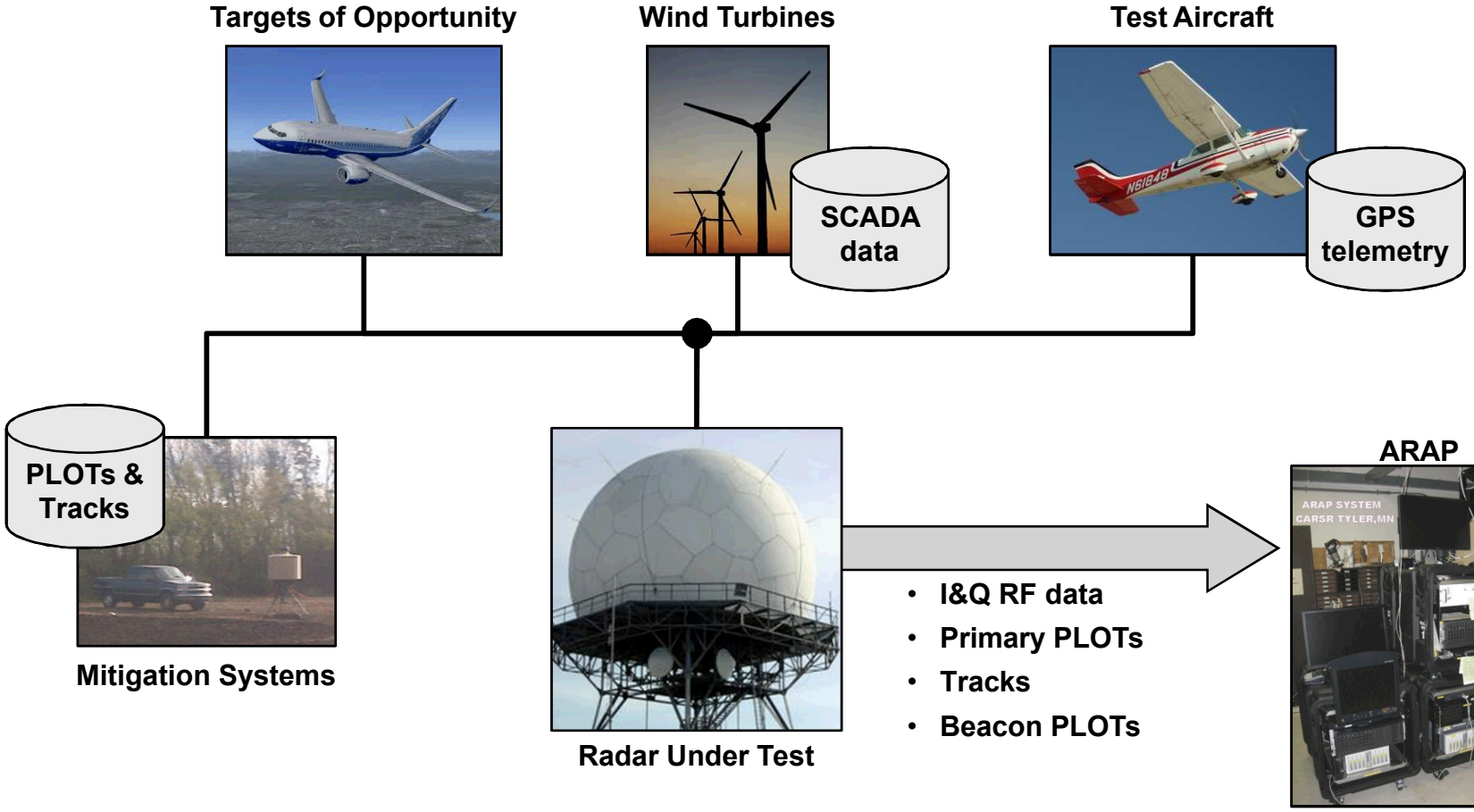
Outline

- Background
- Flight Test
  - Overview
- Way Ahead

IFT&E Flight Campaigns



Field Test Overview



Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

Wind Turbine Data Requested From Wind Farm Owners/Operators

- **Facilitating collection of wind farm data**
  - **Wind turbine information (static)**
    - Turbine location (latitude, longitude), Elevation (of base)
    - Manufacturer, model/type
    - Tower height (AGL), Blade length
    - Materials, Etc.
  - **Operating data from wind turbines during test**
    - Timestamp
    - Yaw angle, Blade pitch angle, Blade speed (RPM)
    - Etc.
  - **Meteorological tower data during test**
    - Wind speed at hub height
    - Wind direction

Turbine ID	Timestamp	Wind speed (m/s)	Rotor speed (rpm)	Nacelle position (°)	Blade 1, actual value (°)	Blade 2, actual value (°)	Blade 3, actual value (°)

How The Data Is Used

- Used to analyze the effects that operating wind turbines have on radar systems
  - Characteristics of the radar return from a wind turbine
    - Strength of the return (RCS)
    - Doppler shift characteristic
  - will vary relative to:
    - Turbine orientation
      - Nacelle direction
      - Blade pitch angle
    - Rotation rate
- We analyze how the radar performs across these variations to assess the impacts

Outline

- Background
- Flight Test
  - Overview
- Way Ahead

Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

Findings

- **Wind farms significantly degrade performance**
  - **Significant degradation of detection over wind farms**
  - **Significant increase in false alarms over wind farms**
  - **Significant degradation of tracking over wind farms**
  - **Did not observe impact on transponders (“Secondary”)**
- **Tested Solutions are promising, but need additional work**
  - **High false alarm rates**
  - **Integration questions**
  - **Tracker performance**

Approved for Public Release
MSJA#: MS-64100A
SAND #2012-9809

TSPEAR – Siting Framework

- Integrated analysis of various databases
  - Maximize Renewable Energy deployment
  - Minimize impact on mission operations
- Modular framework architecture design / portal
  - Works in *concert* with existing tools (MCAT/ROEMS etc.)
  - Ability to create tools where gaps are identified
- Available to industry and government stakeholders
  - Individual tools, models, and data remain secure
  - Aid industry in siting farms to *streamline evaluation processes*