

U.S. DEPARTMENT OF
ENERGY

Office of
**ENERGY EFFICIENCY &
RENEWABLE ENERGY**

Wind Turbine – Radar Interference Mitigation Project ID #M10

Benjamin Karlson



Sandia National Laboratories



Sandia
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FY17-FY18 Wind Office Project Organization

“Enabling Wind Energy Options Nationwide”

Technology Development

Atmosphere to Electrons

Offshore Wind

Distributed Wind

Testing Infrastructure

Standards Support and International
Engagement

Advanced Components, Reliability, and
Manufacturing

Market Acceleration & Deployment

Stakeholder Engagement, Workforce
Development, and Human Use Considerations

Environmental Research

Grid Integration

Regulatory and Siting

Analysis and Modeling (cross-cutting)

Project Overview

M10: Wind Turbine – Radar Interference Mitigation

Project Summary

This effort is aimed at solving deployment barriers for wind energy systems by developing mitigation methods which reduce or eliminate the adverse effect of wind turbines on radar systems. Sandia continues to support and lead Wind Turbine Radar Interference Mitigation (WTRIM) activities including strategic planning, field-testing, as well as mitigation technology development, demonstration and deployment. The work plan for FY17 and FY18 is aligned with the Federal Interagency Wind Turbine Radar Interference Strategy published by the DOE.

Project Objective & Impact

The overall objective of this project is to enable the timely and cost-effective deployment of wind energy systems across the United States without adversely impacting national radar systems and federal agency missions. This project will be successful when there are sufficient assessment tools, mitigation solutions, and review and approval processes in place to overcome any significant barriers to wind energy deployment, primarily measured by delays in development timeline or prohibitive mitigation cost leading to project abandonment and de facto exclusion.

Project Attributes

Project Principal Investigator(s)

Benjamin Karlson

DOE Lead

Patrick Gilman

Project Partners/Subs

Sub:

BEM Int'l – Bryan Miller

Partners:

Department of Defense

Department of Homeland Security

Federal Aviation Administration

National Oceanic and Atmospheric Administration

Bureau of Ocean Energy Management

MIT Lincoln Laboratory

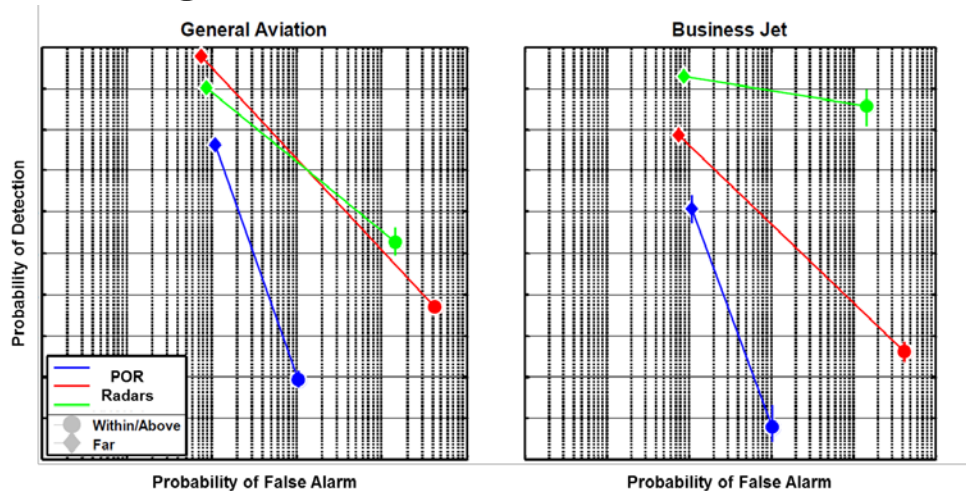
Air Force Research Laboratory

Project Duration

October 2016 – September 2018

Technical Merit and Relevance

When located within the line-of-sight of a radar system, wind turbine blade rotation can cause interference.¹ This radar interference can often be mitigated to an extent by existing technologies & procedures.



Wind energy development continues to expand, and technological advances have led to larger, more efficient systems capable of producing energy in previously undevelopable areas which will increase the probability for conflicts with radar missions related to air traffic control, weather, homeland security, and national defense.

The Department of Defense (DOD) Siting Clearinghouse has evaluated thousands of wind energy projects since 2011 to determine potential impacts on military operations.



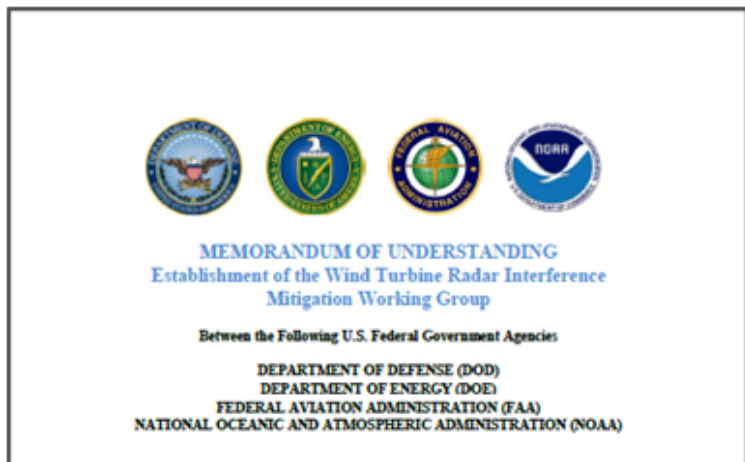
Photo credit: Abigail Vander Hamm, AWEA

If a project is deemed to have unacceptable risk and all options have been exhausted without mitigating concerns, the DOD may recommend that the FAA issue a determination of hazard.²

1. Sandia National Laboratory. Interagency Field Test & Evaluation Industry Report: Wind Turbine-Radar Interference Test Summary. September 2014.

2. United States Government Accountability Office. [Defense Infrastructure: DOD Efforts to Prevent and Mitigate Encroachment at Its Installations](#). November 2016.

Approach and Methodology



- Establishes the Wind Turbine Radar Interference Mitigation (WTRIM) Working Group, a general framework of cooperation and coordination between DOD, DOE, FAA, and NOAA, with DHS and BOEM as observers

- *WTRIM Working Group Goals:*

- Develop near (5 years), mid (10 years), long-term (20 years) mitigation solution recommendations.
- Determine funding requirements to implement workable solutions.

- **Federal WTRIM Strategic Themes:**

1. Improving the capacity of government and industry to evaluate the impacts of existing and planned wind energy installations on sensitive radar systems
2. Developing and facilitating the deployment of hardware and software mitigation measures to increase the resilience of existing radar systems to wind turbines
3. Encouraging the development of next-generation radar systems that are resistant to wind turbine radar interference.

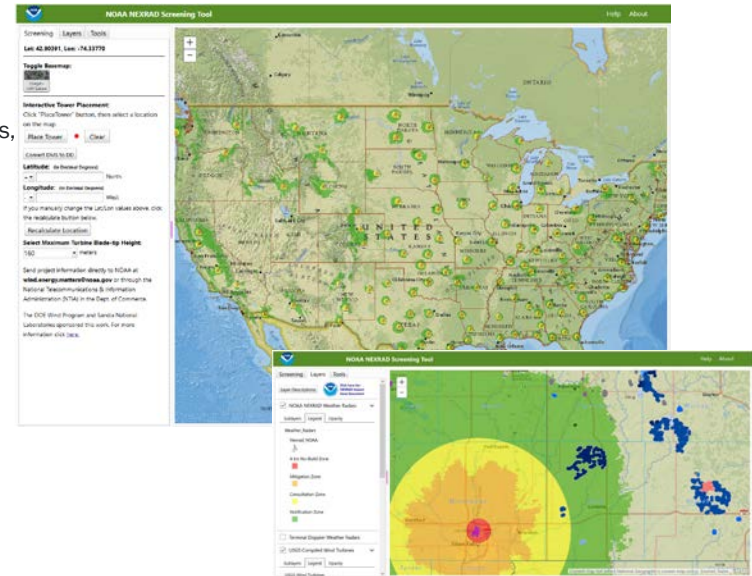


Approach and Methodology

Our work plan aligns directly with the Federal Interagency Wind Turbine Radar Interference Mitigation Strategy. The work plan also includes the overarching task of facilitating and supporting the WTRIM Working Group.

Improving the capacity to evaluate the impacts of existing and planned wind energy installations

- **Task 1 – WTRIM Working Group Facilitation and Support**
 - Lead bi-weekly working group calls, coordinate and facilitate quarterly meetings, support prioritization of project tasks and direction, respond to issues
 - Support from Bryan Miller
- **Task 2 – WTRIM Tools Catalog**
 - Identify and catalog existing tools used to analyze potential impact of wind turbines
- **Task 3 – NEXRAD Public Screening Tool**
 - Create a publicly available online tool for NEXRAD impact screening

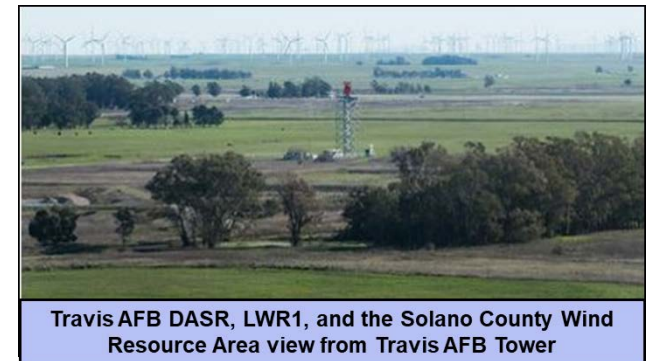


Facilitating deployment of mitigation measures to increase the resilience of existing radar systems to wind turbines

- **Task 4 – Pilot Mitigation Project (PMP) Support**
 - Facilitate on-going PMPs including test planning documents, pre-test site assessments, collection of field data, data analysis, and reporting
 - Support from Bryan Miller
- **Task 5 – Lightning Protection and Associated Radar Impacts Mitigation**
 - Investigate new techniques to reduced the radar cross section of a wind turbine blade through modeling and simulation

Encouraging the development of next-generation radar systems that are resistant to wind turbine radar interference

- **Spectrum Efficient National Surveillance Radar (SENSR) Input**

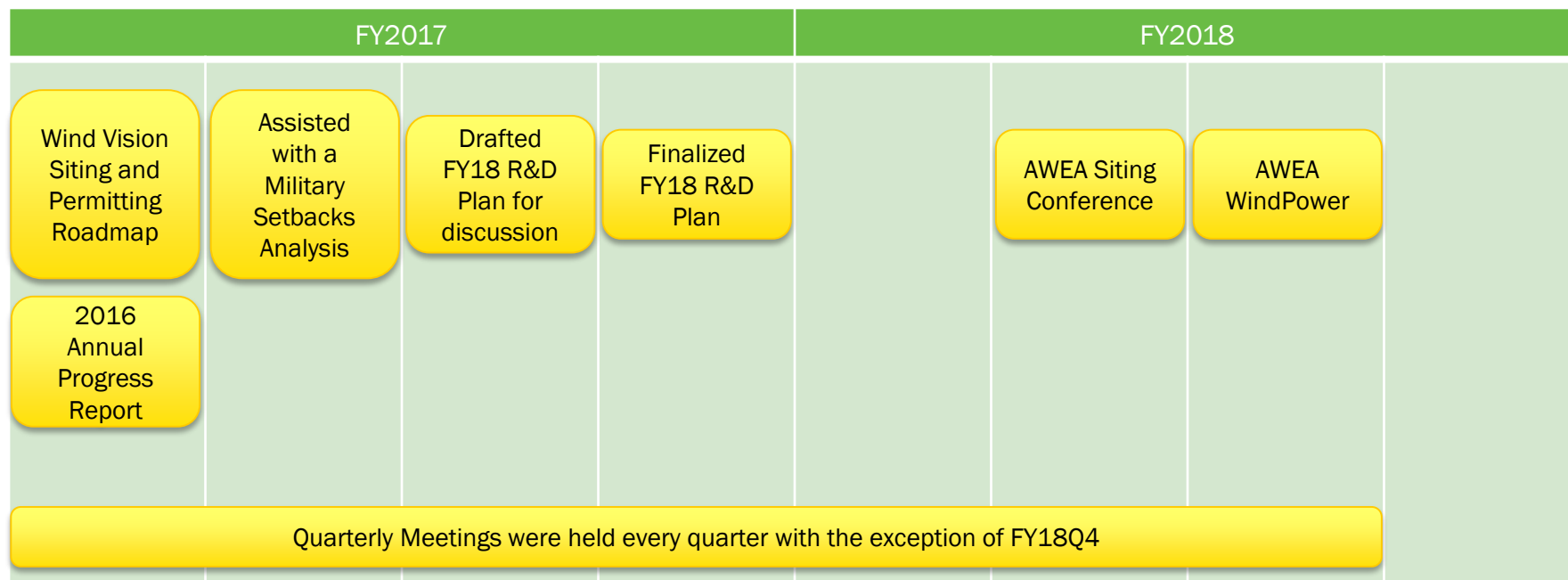


Travis AFB DASR, LWR1, and the Solano County Wind Resource Area view from Travis AFB Tower

Accomplishments and Progress

- **WTRIM Working Group Facilitation & Support**

- SNL acts as the WTRIM Working Group Facilitator
 - Organized bi-weekly Working Group teleconferences
 - Maintains WG task list and action items and distribution list
 - 150+ teleconferences
 - Planned and executed quarterly in-person meetings
 - Solicit input and draft annual WTRIM R&D plans and progress reports

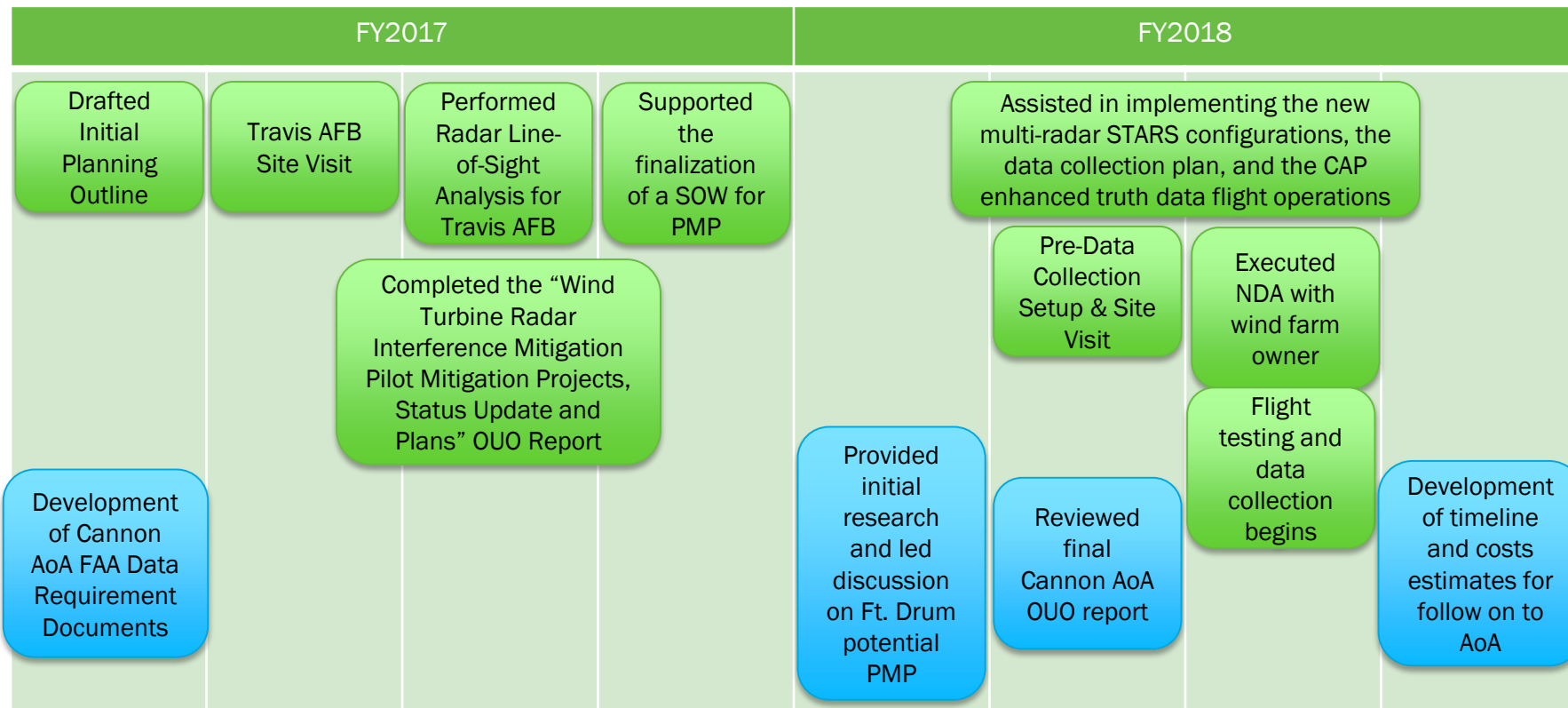


Accomplishments and Progress

- **Pilot Mitigation Projects**

- **Travis Air Force Base (AFB), CA**

- Facilitated the SOW for PMP
 - Facilitate weekly teleconference calls during test
 - Arranged for the delivery of wind turbine SCADA data



- **Cannon AFB, NM Analysis of Alternatives (AoA)**

- Participated in teleconference calls
 - Reviewed and provided SME input on core AoA products

Accomplishments and Progress

- **Pilot Mitigation Projects**

To maintain the quality of the air picture that exists today, reduce the time required to implement mitigation solutions, minimize the cost of delivering effective air surveillance services to government users, and meet renewable energy goals, all while managing the risk to stakeholders

- **Travis Air Force Base, CA**

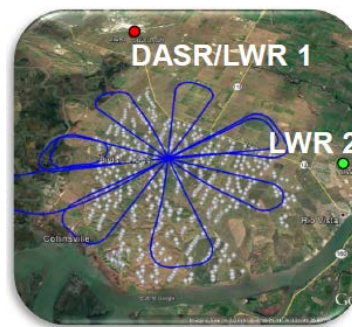
- The integration of an infill radar system into the NAS via the FAA's STARS Air Traffic Control system
- The Air Force Research Laboratory (AFRL) has managed and executed the data collection study
- SNL has been integral in facilitating meetings and supporting the development of test plans and contracts.
- SNL has partnered with wind farm owners in the area for the wind turbine telemetry during the test.

Project Deliverable:

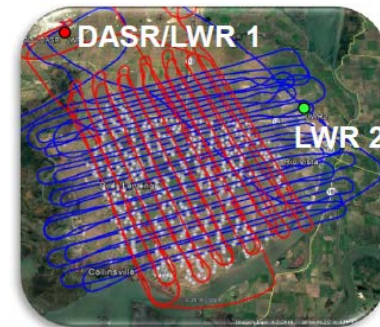
- Interface Control Document for Infill Primary Radar into Standard Terminal Automation Replacement System (STARS)

As of March 2019

No. of CAP flight campaigns	8
No. of CAP flight analyses	8
No. of turbines with SCADA data received	183
No. of sorties flown	30



Sector Search



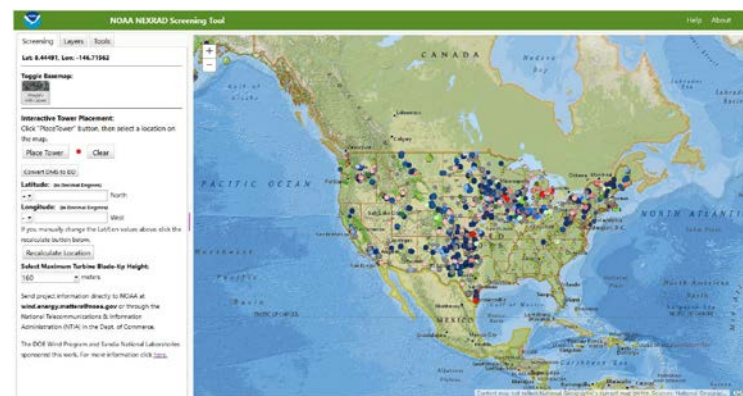
Spring

Accomplishments and Progress

• NOAA NEXRAD Public Screening Tool

– Sandia worked closely with NOAA to create a public tool that:

- Allows users to insert proposed wind turbines and obtain a preliminary review of potential impacts to weather radars;
- Provides users basic NEXRAD wind turbine constraint zones tailored to specific, selectable wind turbine heights.



<http://energy.sandia.gov/energy/renewable-energy/wind-power/wind-turbine-siting-and-barrier-mitigation/>

• WTRIM Modeling & Simulation Tools Catalog

– A catalog of the modeling and simulation capabilities and databases for wind turbine radar interference and related issues

- 19 tools: models, simulations, and databases

• Lightning Protection and Radar Impacts Mitigation

- Completed initial modeling and analysis for new wind turbine lightning protection cable configurations to reduce radar-cross-section
- OOU report produced and delivered



Communication, Coordination, and Commercialization

- Publications:

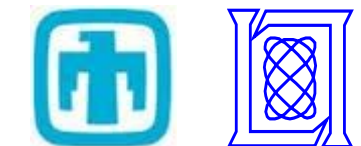
- Provided inputs to the updated Wind Vision Roadmap for Siting and Permitting Chapter
- “Wind Turbine Radar Interference Mitigation Pilot Mitigation Projects, *Status Update and Plans*” OOU SAND Report
- 2018 WTRIM Factsheet
- WTRIM Modeling & Simulation Tools Catalog, SAND Report
- Wind Turbine Lightning Mitigation System Radar Cross Section Reduction, SAND Report

- Presentations:

- AWEA Siting and Environmental Compliance Conference Poster Presentation
- AWEA WindPower
 - WTRIM Listening Session
 - AWEA Radar and Airspace Subcommittee Meeting

- Other:

- Travis Air Force Base PMP Wind Developer Open House, June 2018
- 2018 Sustaining Military Readiness Conference Panel Member, *Mitigation Strategies in Energy Siting*, Aug. 2018



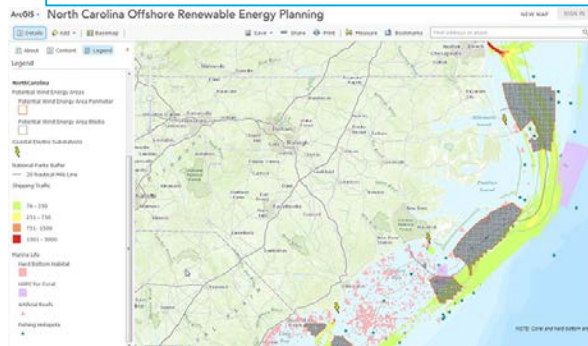
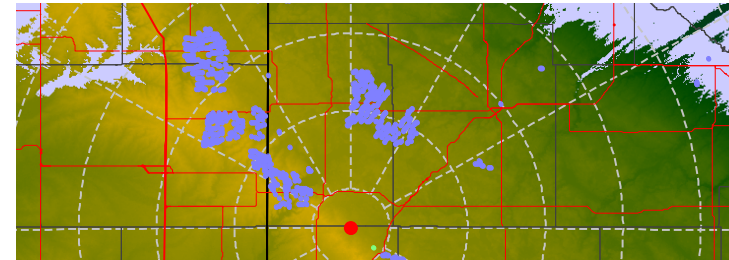
Upcoming Project Activities

FY19/Current Research:

- Updated MOU
- WTRIM Working Group Facilitation
 - Completion of Annual Progress reports for calendar year 2018 & 2019
- Travis AFB Pilot Mitigation Project – Completion
- WTRIM Modeling & Simulation Tools Catalog update
- NEXRAD Public Screening Tool merge and update

Proposed Future Research:

- Continued WTRIM Working Group facilitation
- Support Pilot Mitigation Projects
- Updating the Federal Strategy for WTRIM
- Offshore mitigation



Photos Courtesy of BEM Int'l, LLC