SANDIA REPORT
SAND2018-4370
Unlimited Release
April 2018

Wind Turbine Radar Interference Mitigation (WTRIM) Modeling & Simulation Tools Catalog

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EXECUTIVE SUMMARY

Wind energy development in the United States has been steadily growing over the past decade. This trend has resulted in the expansion of wind energy into areas that have a good wind resource but may have other deployment barriers being looked at more closely. One such barrier is that of the potential impact that wind turbines pose to radar systems. Wind turbines located within the line-of-sight of radar systems can cause clutter and interference and can result in performance degradation.

Mitigation of any interference that wind turbines have on radar systems begins with the understanding of the potential those impacts to radar systems through modeling and simulation.

The intent of this document is to catalog and provide the reader with a list of the modeling and simulation capabilities along with enabling databases for wind turbine – radar interference and related issues that are currently in use in various government agencies as well as those tools that are available to the public for free or fee. A brief description of the tool is given along with other pertinent characteristics of the tool including the owner, developers, user, classification, status, and the point-of-contact. This document does not provide an exhaustive description of the tools' capabilities nor does it include tools that were developed privately.

The information compiled in this document was obtained from both publicly available sources as well as from direct data requests from government agencies.

Table 1. High Level Overview of Models & Databases Related to WTRIM

Tool	Owner	GIS	Public	In Use	Radars Modeled	Turbines Modeled	Line-of-Sight	Viewshed	P_D/P_{FA} Otuput
AWEA U.S. Wind Industry Map†	AWEA	●	●	●					
DOD Preliminary Screening Tool†	DOD		●	●	○			●	
Marine Cadastre†	BOEM NOAA	●	●	●					
Mission Compatibility Awareness Tool (MCAT)‡	DOD	●		●	○		○	○	
NEXRAD Public Screening Tool‡	DOE	●	●	●	○	○		○	
NOAA NEXRAD Internal Tool‡	NOAA	●		●	○	●	○	○	
Obstruction Evaluation / Airport Airspace Analysis (OE/AAA)†	FAA		●	●	○			○	
Radar Obstruction Evaluation Model/Simulator (ROEMS)‡	NORAD	●		●	●	●	●	●	●
Renewable Energy and Defense Geospatial Database†	NRDC	●	●	●			○		
Risk of Adverse Impact on Military Operations and Readiness Areas (RAIMORA)†	DOD		●	●					
RL Space Time Adaptive Processing Algorithm Development Tool (RLSTAP/ADT)	DOD			●	●	○			○
ROTHR WTRI Prediction Tool	DOD				●	●			
SilverSphere™ Energy Toolkit‡	Private	●	●	●	○	●	●	●	○
Tools for Siting, Planning, and Encroachment Analysis for Renewables (TSPEAR)‡	DOE	●	○		○	●	●	●	○

Tool	Owner	GIS	Public	In Use	Radars Modeled	Turbines Modeled	Line-of-Sight	Viewshed	P_D/P_{FA} Otuput
U.S. Wind Turbine database‡	DOE	●	●	●					
Windfarm Impact Tool (AF RADAR Toolbox) ‡	DOD	●		●					
Other Non WTRIM Tools									
Energy Zones Mapping Tool‡	DOE	●	●	●					
High-voltage EMI Modeling Suite (HEMI)‡	DOD	●							
Solar Glare Hazard Analysis Tool (SGHAT)‡	DOE	●	○	●					

Table Terms & Symbols Defined:

●	True
○	Partly True
†	Information gathered from public website
‡	Information gathered from direct contact with POC
Radars Modeled:	Broad term; defined in range from simple line-of-sight viewsheds or minimum range impact overlays to very detailed radar models that take into account radar and target specific parameters producing Pd, Pfa, Track data, , etc. for at least one radar type.

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TABLES

NOMENCLATURE

AFRL	Air Force Research Laboratory
AGL	Above Ground Level
AIS	Automatic Identification System
ARSR	Air Route Surveillance Radar
ASR	Airport Surveillance Radar
BOEM	Bureau of Ocean Energy Management
CAC	Common Access Card
CARSR	Common Air Route Surveillance Radar
CODAR	Coastal Ocean Dynamics Applications Radar
DHS	Department of Homeland Security
DOD	Department of Defense
DOD SC	DoD Military Aviation and Installation Assurance Siting Clearinghouse
DOE	Department of Energy
DRDC	Defence Research and Development Canada
FAA	Federal Aviation Administration
GIS	Graphical Information System
GW	Gigawatt
IFT&E	Interagency Field Test & Evaluation
LBNL	Lawrence Berkley National Laboratory
MCAT	Mission Capability Awareness Tool
MIT LL	Massachusetts Institute of Technology Lincoln Laboratory
MW	Megawatts
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
P_D	Probability of Detection
P_{FA}	Probability of False Alarm
OE/AAA	Obstruction Evaluation / Airport Airspace Analysis
OEG	Obstruction Evaluation Group
OCS	Outer Continental Shelf
OSD	Office of the Secretary of Defense
RCS	Radar Cross-Section
RL-STAP	Research Laboratory – Space Time Adaptive Processing
ROEMS	Radar Obstruction Evaluation Model / Simulator
ROTHR	Relocatable Over-The-Horizon Radar
SNL	Sandia National Laboratories
TSPEAR	Tools for Siting, Planning, and Encroachment Analysis for Renewables
USGS	United States Geological Survey
USWTD	United States Wind Turbine Database
WERA	Wave Radar
WTRI	Wind Turbine-Radar Interference
WTRIM	Wind Turbine-Radar Interference Mitigation

1. INTRODUCTION

Now reaching to heights over 495 feet and operating with speeds at the blade exceeding 200 knots to achieve average power capacities of 1.9 MW, and with over 82 GW of installed wind power at the end of 2016, the U.S. is on target to supply 20% of the nation's electricity by 2030. The siting process for a wind farm project can be a lengthy, costly, and complicated process. While it is critical to site wind farms based on wind resource, transmission availability, and environmental impacts, the compatibility with military missions including radar systems must also be considered. When installed in the line-of-sight of radar systems, wind turbines can cause significant clutter and interference, creating concerns about flight safety, homeland security, national defense, and severe weather warning missions. In some cases, these concerns have led to denials of wind farm permits.

With their mission to enable U.S. deployment of clean, affordable, reliable, and domestic wind energy, the Department of Energy (DOE) joined with other key agencies – the Department of Defense (DoD), the Federal Aviation Administration (FAA), the National Oceanic and Atmospheric Administration (NOAA), and the Bureau of Ocean Energy Management (BOEM) – to establish the Wind Turbine Radar Interference Mitigation (WTRIM) working group.

In 2016, the Department of Energy published a *Federal Interagency Wind Turbine Radar Interference Mitigation* Strategy that outlined the WTRIM working group's objectives and coordinated activities within three strategic themes to achieve those objectives. In line with theme 1 of DOE's strategy, which aims to improve government and industry capacity to evaluate the impacts of wind turbines on sensitive radar systems, this document aims to lay out the various modeling and simulation tools in use to understand the wind turbine radar interference (WTRI) issue. As stated by DOE, "mitigation of wind turbine radar interference starts with ensuring that wind developers and responsible agencies have an understanding of the potential impacts to radars…" This understanding begins with accurate and informed modeling and simulation.

1.1. Scope of Document

The intent of this document is to catalog modeling and simulation capabilities as well as key enabling databases for wind turbine radar interference and renewable energy system deployment related issues that are currently in use in various government agencies as well as those tools and databases that are available for developers of renewable energy projects either for free or fee. A brief description of the tool is given along with other pertinent characteristics of the tool including the owner, developer, users, classification, status, and the point-of-contact. This document does not provide an exhaustive description of the tools' capabilities.

The information compiled in this document was obtained from both publicly available sources as well as from direct data requests from the owners of the various tools.

1.2. Agency Missions

Each agency involved in the WTRI issue has a different mission to either protect assets and/or move forward with wind energy deployment. While many of these missions are unique to each agency there are those that overlap. In order to be good stewards of tax-payer dollars and limit redundancies amongst agencies it is important to understand those agencies' missions and their corresponding tools to ensure those missions are met. Below is a brief description of the missions of the various agencies that are involved with the WTRI issue, in no order.

1.2.1. Department of Defense – Military Aviation and Installation Assurance Siting Clearinghouse

The Department of Defense has a wide array of missions and assets under its purview that could be affected by wind turbine (and other renewable energy) development. These range from long-range radar systems to military training routes and special use airspace to operational test and training missions that require the protection of pristine environments free of electromagnetic effects. The DoD Military Aviation and Installation Assurance Siting Clearinghouse (DoD SC) manages the review of potential impacts that wind turbines may have on the DoD missions and assets. The DoD SC website specifically notes that they "Protect the DoD's mission capabilities from incompatible energy development by collaborating with the DoD Components and external stakeholders to prevent, minimize, or mitigate adverse impacts on military readiness and operations, including test and evaluation activities."

Because of the size of the DoD and its many components and missions over the years, multiple tools were built to evaluate the impacts of wind turbines on those agency's respective missions. DoD provides funding to the FAA who operates the bulk of the National Airspace System (NAS) radars as well as funds and maintains a wide-array of surveillance, test, research and development, and Long-range HF radar systems. All of which are susceptible to wind turbine generated radar interference.

1.2.2. Department of Energy

The Department of Energy's Wind Energy Technologies Office invests in research and development activities as part of its mission to advance U.S. wind systems, reduce the cost of electricity, accelerate the deployment of wind power, and boost economic growth. As part of its mission to address market and deployment barriers, including siting impacts, that will enable further deployment of wind farms in the U.S., the DOE is engaged in activities that address potential impacts to other federal agency's missions. The DOE has been actively engaged in the WTRI issue since 2007 beginning with the creation of the Interagency Field Test & Evaluation flight campaigns to quantify the impact that wind turbines can have on radar systems.

The DOE remains engaged in the WTRI issue through the development of tools, maps, and databases.

1.2.3. Federal Aviation Administration

The Federal Aviation Administration (FAA) operates over 400 surveillance radar systems, including Airport Surveillance Radars (ASRs), Air Route Surveillance Radars (ARSRs), and Terminal Doppler Weather Radars (TDWRs). "In administering Title 14 of the Code of Federal Regulations (14 CFR) Part 77, the prime objectives of the FAA are to promote air safety and the efficient use of the navigable airspace." As part of that objective the FAA, in coordination with the DOD SC, the National Oceanic and Atmospheric Administration, and Department of Homeland Security, operates the Obstruction Evaluation / Airport Airspace Analysis (OE/AAA) website that allows for a filing process for any construction which may affect the navigable airspace. Bottom line, each of the agencies listed above employ capabilities (e.g. radar, navigational, and communication systems) that, if interfered with, can impact navigable airspace.

1.2.4. National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration's (NOAA) operates a network of 160 Doppler weather radars known as the Next Generation Weather Radar (NEXRAD) system. The NEXRAD system is one of the main tools to generate forecasts and severe weather warnings to protect life, property, and safe aircraft operations.

NOAA core missions include:
"To understand and predict changes in climate, weather, oceans and coasts;
To share that knowledge and information with others; and
To conserve and manage coastal and marine ecosystems and resources."

Next Generation Weather Radar (NEXRAD) System

NOAA's National Severe Storms Laboratory and its partnering agencies developed the Weather Surveillance Radar-88, Doppler (WSR-88D) system during the 1980s with the first operational deployment occurring in 1992, four years after the NOAA Radar Operations Center (ROC) was established in Norman, Oklahoma in 1988. NOAA ROC personnel have reported when wind turbines are built within the line-of-sight of NEXRAD systems their NEXRAD operators have seen wind turbines visible on their radar screens and within the data-streams that feed multiple users. This can impact radar data quality and performance.

Integrated Ocean Observing System (IOOS)

The Integrated Ocean Observing System (IOOS®) Program operates 140 SeaSonde radars (CODAR HF systems) as the national U.S. contribution to the 165 current systems deployed as a part of the IOOS Program around North America. A key advantage of these HF radars is an ability to utilize the highly conductive properties of sea water to propagate well beyond the horizon due to a "waveguide-type" effect. The waveform characteristics allow the processing of signals from multiple targets at the same time (currents, waves, tsunamis, vessels, etc.) making this system a critical part of search and rescue, hazardous material spills response, marine navigation, etc.

In 2016, as offshore wind in the U.S. started becoming a reality, concerns regarding the potential impact of wind turbine generated radar interference prompted NOAA and BOEM to partner in a two-year study to assess, characterize, and determine potential mitigation capabilities for offshore HF systems.

1.2.5. Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) has recently come into the fold of the WTRIM working group as wind farm development begins to expand into the offshore area. BOEM has been charged with the management of the Outer Continental Shelf (OCS) "for environmental sustainability, economic development, and national security." With the wind industry expanding into the offshore area, BOEM is responsible for wind development in Federal waters.

Although BOEM does not operate large-scale radar capabilities, their mission can be heavily impacted by delays in deployment of offshore wind energy systems, disruption of commercial fishing operations / shipping lanes, or degradation of surveillance systems dedicated to national defense or marine safety. This concern brought BOEM and NOAA together as partners in the earlier mentioned study to assess, characterize, and determine potential mitigation capabilities for offshore HF systems.

1.2.6. Department of Homeland Security

The Department of Homeland Security (DHS) missions include "preventing terrorism and enhancing security; managing our borders; administering immigration laws; securing cyberspace; and ensuring disaster resilience." As part of the DHS mission to manage and protect the nation's borders DHS utilizes the Air and Marine Operations Surveillance System (AMOSS), which is a sophisticated radar and data processing and command, control, and communications systems.

As with the Department of Defense, DHS is a partnering agency with the FAA providing funding for National Airspace (NAS) surveillance radars. Since national radar capabilities are critical to DHS missions, DHS is also highly interested in assessing, characterizing, and determining impacts of wind turbines on their surveillance systems as well as identifying effective mitigation capabilities.

2. TOOLS LIST

Table 2. Modeling & Simulation and Database List

Tool	Owner	Classification	Status	Users	Brief Description	Point of Contact
AWEA U.S. Wind Industry Map	AWEA	Public	In Service	Wind Industry	A GIS mapping tool showing all online utility-scale wind projects and wind-related manufacturing facilities across the U.S.	stats@awea.org
DOD Preliminary Screening Tool	Siting Clearinghouse	Public	In Service	Wind Industry	A website available to developers to obtain a preliminary review of potential impacts to Long-Range and Weather Radar(s), Military Training Route(s) and Special Airspace(s) prior to official OE/AAA filing.	Steve Sample steven.j.sample4.civ@mail.mil
Marine Cadastre	BOEM & NOAA	Public	In Service	Offshore Industry	An integrated marine GIS map that provides data, tools, and technical support for ocean and Great Lakes planning.	info@marinecadastre.gov
Mission Compatibility Awareness Tool (MCAT)	Navy	OUO	In Service	DOD	A project tracking, analysis, and GIS mapping tool to visualize potential specific mission impacts and promote land use compatibility with military missions.	Steve Chung steve.u.chung@navy.mil
NEXRAD Public Screening Tool	Sandia National Laboratories	Public	In Service	Wind Industry	A GIS mapping tool that enables developers to obtain a preliminary review of potential impacts to NEXRAD and WSR-88 weather radars.	Ben Karlson bkarlso@sandia.gov

Tool	Owner	Classification	Status	Users	Brief Description	Point of Contact
NOAA NEXRAD Analysis Tool	NOAA	OUO	In Service	NOAA	Based on the TSPEAR structure, this is a controlled-access web-based portal for NOAA analysts to enter project information and view it in a GIS format. The tool also provides NEXRAD viewshed and line-of-sight analysis.	Jessica Schultz jessica.a.schultz@noaa.gov
Obstruction Evaluation / Airport Airspace Analysis (OE/AAA)	FAA	Public	In Service	FAA / DOD / Wind Industry	An FAA administered web-enabled software that enables developers to submit proposed projects and the FAA and DOD to review and coordinate decisions primarily related to new construction proposed in airspace.	Mike Helvey micheal.helvey@faa.gov
Radar Obstruction Evaluation Model / Simulator (ROEMS)	NORAD / DRDC	OUO	In Service	NORAD / DRDC	A simulator that calculates the Probability of Detection (P_D) impact, Probability of False Alarm (P_{FA}) impact, signal/noise ratio, and other technical parameters of wind turbines on modeled radar systems.	Frederick "Stitch" Shepherd frederick.l.shepherd.civ@mail.mil
Renewable Energy and Defense Geospatial Database	NRDC	Public	In Service	Wind Industry	A GIS mapping tool containing layers for Military Ranges and Installations, Military Training Routes & Special Use Airspace, Radar Sites, and conservation areas.	Matthew McKinzie nrdcinfo@nrdc.org

Tool	Owner	Classification	Status	Users	Brief Description	Point of Contact
Risk of Adverse Impact on Military Operations and Readiness Maps (RAIMORAs)	Siting Clearinghouse	Public	In Service	Wind Industry	Downloadable maps that designate geospatial areas where the introduction of structures associated with projects filed with the FAA pursuant to 49 U.S.C. 44718 could have adverse impact on military operations and readiness.	Steve Sample steven.j.sample4.civ@mail.mil
Research Laboratory Space-Time Adaptive Processing (RL-STAP)	Air Force Research Laboratory	OUO	Operational	DOD	A tool that provides the ability to develop and evaluate adaptive signal processing algorithms to produce indicative clutter return estimates.	Michael Callahan Michael.callahan.10@us.af.mil
ROTHR WTRI Prediction Tool	Navy	OUO	Non Operational	DOD	Information unavailable at time of publication.	Jack Buckingham Jack.buckingham@navy.mil
SilverSphere™ Energy Toolkit	Peak Spatial Incorporated	Public (License required)	In Service	Wind Industry	Developed in part as the TSPEAR framework, the toolkit is a portal architecture to enter project information and view it in a GIS format. The tool also contains models of radar systems and wind turbines to assess the impact from turbines.	Royal Koepsell Royal.koepsell@peakspatial.com
Tools for Siting, Planning, and Encroachment Analysis for Renewables (TSPEAR)	Sandia National Laboratories	Public	Non Operational	Wind Industry	Sandia specific SilverSphere™ Energy Toolkit portal.	Ben Karlson bkarlso@sandia.gov

Tool	Owner	Classification	Status	Users	Brief Description	Point of Contact
U.S. Wind Turbine Database	Lawrence Berkley National Laboratory	Public	Available by Q2 FY18	Wind Industry / DOD	A set of databases that provide the locations of land-based and offshore wind turbines in the United States, corresponding wind project information, and turbine technical specifications.	Ben Hoen bhoen@lbl.gov
Windfarm Impact Tool (Radar Toolbox)	DOD	OUO	In Service	DOD / FAA	Previously known as the Air Force Radar Tool Box, this is a Windows-based analysis program to assist in radar system installation, performance analysis, and optimization.	Robert Heaton Robert.heaton@navy.mil
Other Non WTRIM Tools						
Energy Zones Mapping Tool (EZMT)	Argonne National Laboratory	Public	In Service	Energy Developers	An online mapping tool to identify potential energy resource areas and energy corridors in the United States.	James Kuiper jkuiper@anl.gov
High-voltage EMI Modeling Suite (HEMI)	Idaho National Laboratory	OUO	Non Operational	DOD	A model to predict electromagnetic interference (EMI) generated by high voltage transmission lines. Can be used to evaluate siting of energy projects near military activities.	Carl Kutsche carl.kutsche@inl.gov
Solar Glare Hazard Analysis Tool (SGHAT)	Sandia National Laboratories	OUO	In Service	DOD	A modeling tool that determines when and where solar glare can occur throughout the year from a user-specified PV array as viewed from user-prescribed observation points.	Cliff Ho ckho@sandia.gov

3. MODEL DETAILS

AWEA U.S. Wind Industry Map

Owner	**American Wind Energy Association**
Point-of-Contact	stats@awea.org
Developer	Unknown
Users	Wind Industry
Classification	Public
Status	In service
Website	http://gis.awea.org/arcgisportal/apps/webappviewer/index.html?id=eed11ec3b624742f8b18280e6aa73e8ec
Description	The AWEA U.S. Wind Industry Map allows users to view all online utility-scale wind projects and wind-related manufacturing facilities across the U.S. There are two map layers that users can view: - U.S. Online Wind Projects - U.S. Wind Manufacturing Facilities Users can view annual wind capacity additions over time by clicking the Time Slider widget on the map. All data is current though the second quarter of 2017. AWEA members may also access Market Database Pro, a comprehensive, interactive database of all online, under construction, and advanced development wind projects, and all active wind-related manufacturing facilities. Over 50 data points available at both the project and turbine level. Advanced interactive mapping services available with filtered search capabilities, summary maps, political boundaries, and electricity region boundaries. Source: AWEA; gis.awea.org/argisportal/apps/webappviewer/index.html?id=eed1ec3b624742f8b18280e6aa7338ecc

DOD Preliminary Screening Tool

Owner	**Department of Defense Siting Clearinghouse**
Point-of-Contact	Steve Sample Steven.j.sample4.civ@mail.mil (703) 571-0076
Developer	CGH Technologies, Inc.
Users	Wind Industry
Classification	Public
Status	In service
Website	https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action==showLongRangeRadarToolForm
Description	The Preliminary Screening Tool enables developers to obtain a preliminary review of potential impacts to Long-Range and Weather Radar(s), Military Training Route(s) and Special Airspace(s) prior to official OE/AAA filing. This tool will produce a map relating the structure to any of the DoD/DHS and NOAA resources listed above. The tool allows users to enter either a single point or a polygon into the map to generate a visual analysis. Currently the tool supports pre-screening on: • Air Defense and Homeland Security radars (Long Range Radar) • Weather Surveillance Radar (NEXRAD) • Military Operations Additionally, the site contains a Wind Turbine Build Out tool that displays an overview of determined and proposed wind turbine or MET tower projects within the continental United States.

Marine Cadastre

Owner	**Bureau of Ocean Management & National Oceanic and Atmospheric Administration**
Point-of-Contact	info@marinecadastre.gov
Developer	Unknown
Users	Offshore Wind Industry
Classification	Public
Status	In service
Website	https://marinecadastre.gov/
Description	MarineCadastre.gov, a joint BOEM and NOAA initiative providing authoritative data to meet the needs of the offshore renewable energy siting and marine planning communities, is an integrated marine information system that provides data, tools, and technical support for ocean and Great Lakes planning. It includes over 280 data layers and offers four web-based tools and two desktop tools. Web-based Tools: 1. The National Viewer that provides interactive mapping of ocean-related data and information from authoritative sources to support ocean-planning efforts. 2. The Ocean Law tool allows users to search a database of environmental laws and other documents for the Outer Continental Shelf. 3. The Environmental Studies Program Information System allows users to search by text of map to find BOEM-funded studies and other related documents. 4. The Ocean Reporting Tool provides summary statistics and interpretive analysis for general information, energy and minerals, natural resources and conservation, transportation and infrastructure, and economics and commerce. Desktop Tools: 1. The Automatic Identification System (AIS) Data Handler is an AIS data conversion tool and ArcGIS add-in that streamlines the acquisition, loading, filtering, display, and analysis of AIS vessel-tracking data. 2. An AIS Track Builder allows users to convert a collection of point features into a track line. Examples of use of the Marine Cadastre are: • Map and identify areas for potential offshore energy leasing • Reveal potential use conflicts • Enable a network of national and local information sharing Source: https://marinecadastre.gov

Mission Compatibility Awareness Tool (MCAT)

Owner	**Department of Defense**
Point-of-Contact	Steve Chung steve.u.chung@navy.mil (619) 532-4268
Developer	Epsilon Systems
Users	DOD only - Navy
Classification	OUO – CAC enabled – unclassified
Status	In service
Website	NA
Description	The Mission Compatibility Awareness Tool (MCAT) helps DOD visualize mission impacts and promote land use compatibility with military missions. It was adopted to help manage information and promote timely review of project proposals. MCAT provides an intuitive energy and land use encroachment management, project tracking, analysis, and visualization tool over a secure web medium. MCAT is the amalgamation of a comprehensive project tracking relational database with a GIS that provides a complete Common Operating Picture (COP) of mission compatibility and delivers an effective tool that enables decision-makers to research and conduct pro-active, transparent, defensible, and authoritative assessments and investigations of projects that may encroach upon mission objectives. MCAT provides the Navy a tool to evaluate wind turbines for mission conflicts as they are filed with the FAA. Using the GIS module, the Navy can visualize where turbines are located in relation to military sites. MCAT does not model the effect the turbines may have on radar systems.

NOAA Public NEXRAD Screening Tool

Owner	**Sandia National Laboratories**
Point-of-Contact	Ben Karlson bkarlso@sandia.gov (505) 377-3774
Developer	Peak Spatial Enterprises
Users	Wind Industry
Classification	Public
Status	In service
Website	http://energy.sandia.gov/energy/renewable-energy/wind-power/wind-turbine-siting-and-barrier-mitigation/

Description	The NOAA Public NEXRAD Screening Tool enables developers to obtain a preliminary review of potential impacts to weather radars prior to an official filing with the OE/AAA. The tool is an online GIS-enabled site that Includes USGS installed wind turbine database.
	
	The Tool contains three WTRI related map layers that the users can view:
	- NOAA NEXRAD Weather Radars, including the
	  o 4 km No-Build Zone
	  o Mitigation Zone
	  o Consultation Zone
	  o Notification Zone
	- Terminal Doppler Weather Radars
	- USGS Compiled Installed Wind Turbine Database
	
	The Tool allows users to insert proposed wind turbines by:
	- Selecting the Maximum Turbine Blade-Tip Height from the dropdown list.
	- Zooming to the area on the map of interest.
	- Then selecting a location on the map to place a turbine. Users can also enter the Latitude and Longitude directly in the textboxes or fine tune the location.

NOAA NEXRAD Analysis Tool

Owner	**National Oceanic and Atmospheric Administration**
Point-of-Contact	Jessica Schultz jessica.a.schultz@noaa.gov
Developer	Peak Spatial Enterprises
Users	NOAA
Classification	OUO
Status	In service
Website	NA
Description	The NOAA Internal Tools System provides the NOAA Radar Operations Center (ROC) the ability to enter, visualize, analyze and share siting details for proposed wind energy project and specifically run NEXRAD viewshed and line of sight assessments on those projects. The toolkit architecture allows NOAA to add and edit project, site, and individual turbine details and to use assessment tools to analyze those project details against NEXRAD constraints that the project may encounter. The toolkit includes secured project database, GIS mapping, and NOAA's NEXRAD tools that an approved user may access at any time using web browsers. NOAA can control access to their project and create, modify, and delete users as needed through a project's development lifecycle. A user can provide a view only access to project information or provide select team members with the ability to modify project details. The configuration of this toolkit was demonstrated during Sandia's TSPEAR project which led to the creation of the NOAA NEXRAD Analysis Tool.

Obstruction Evaluation / Airport Airspace Analysis (OE/AAA)

Owner	**Federal Aviation Administration**
Point-of-Contact	Mike Helvey Mike.Helvey@faa.gov (202) 267-9354
Developer	FAA
Users	FAA / DOD / Wind Industry
Classification	Public
Status	In service
Website	https://oeaaa.faa.gov/oeaaa/external/portal.jsp
Description	In administering Title 14 of the Code of Federal Regulations Part 77, the prime objectives of the FAA are to promote air safety and the efficient use of the navigable airspace. To accomplish this mission, aeronautical studies are conducted based on information provided by proponents on an FAA Form 7460-1, Notice of Proposed Construction or Alteration. The FAA administers a national web-enabled software that enables government users to review and coordinate decisions primarily related to new construction proposed in airspace. The OE/AAA provides users with information related to the construction of towers as well as a number of tools including the Notice Criteria Tool. the DOD Preliminary Screening Tool, the Wind Turbine Build Out, and the Distance Calculation Tool. The Wind Turbine Build Out display provides an overview of determined and proposed wind turbine/met tower projects within the continental United States. Wind turbine developers are required to file with the FAA at least 45 days prior to any construction if the new structure exceeds 200 feet AGL or if it will be in proximity to an airport and will exceed the slope ratio listed in FAR Part 77.9(b). After submission by a developer of a proposed wind farm an aeronautical study will be conducted by the FAA Air Traffic Organization, Obstruction Evaluation Group (OEG) for off-airport studies. The submitted information is made available to other FAA offices and military representatives that need to review the proposal. Those offices will provide comments to the OEG and after all comments have been received, the OEG technician or specialist will issue the appropriate letter of determination. Source: https://oeaaa.faa.gov

Radar Obstruction Evaluation Model/Simulator (ROEMS)

Owner	**North American Aerospace Defense Command & Defense Research and Development Canada**
Point-of-Contact	Frederick "Stitch" Shepherd frederick.l.shepherd.civ@mail.mil (719) 556-3260
Developer	Analytical Graphics, Inc.
Users	NORAD & DRDC
Classification	OUO
Status	In service
Website	NA
Description	The Radar Obstruction Evaluation Model/Simulator (ROEMS) is an automated information system designed as a user application with ability to emulate a wide variety of air traffic control and air defense radar systems in use in the United States and Canada. ROEMS can emulate a wide variety of wind turbines parameters and characteristics which affect radar performance. The primary function of ROEMS is to assess radar probability-of-detection (Pd) of air tracks (or other measurable parameter that indicates radar performance such as probability of maintaining air track, etc) within a radar search volume in user-defined clutter environments; clutter environments will include, as a minimum, those conditions created by wind turbine interference, building obstructions, terrain, and expected radio frequency (RF) interference. A secondary function of ROEMS is to identify wind turbine re-location/re-orientation options which have the capability to improve radar performance with regards to Pd. ROEMS consists of an information system with high fidelity radar emulation models, high fidelity obstruction emulation models (i.e., wind turbines, etc), user interface features, and automated data input and conversion capabilities to allow ease of data manipulation from a wide range of obstruction project sponsors. ROEMS runs on System Tool Kit (STK), which is proprietary software owned by AGI. NORAD owns the rights to ROEMS and can provide users with the ROEMS software for free; however, users must purchase an STK license from AGI for ROEMS to work.

Renewable Energy And Defense Geospatial Database (READ)

Owner	**National Resource Defense Council**
Point-of-Contact	Matthew Mckenzie nrdcinfo@nrdc.org
Developer	NRDC
Users	Renewable Energy Developers
Classification	Public
Status	In service
Website	https://www.nrdc.org/resources/proactive-planning-tool-renewable-energy-development
Description	Working with U.S. Department of Defense (DoD), NRDC developed a first-of-its-kind mapping and analytic tool called the Renewable Energy And Defense Geospatial Database, or READ-Database. This tool provides Geographic Information Systems (GIS) data and is available online to help renewable energy developers identify appropriate sites for renewable projects such as utility-scale wind, solar, and geothermal energy facilities, that are unlikely to interfere with military activities and training, and have the fewest environmental conflicts. There are three data layers within the READ-Database that can help renewable energy developers determine the compatibility of a proposed renewable energy project with the DoD mission: Military Ranges and Installations, Military Training Routes and Special Use Airspace, and Radar Sites. Radar sites within the READ-Database consist of NEXRAD and Terminal Doppler weather radar stations, Airport Surveillance Radar installations, and Air Route Surveillance Radar installations that have been identified in open publications by DoD, the FAA, NOAA or DoD contractors. In addition, Line-of-Sight (LOS) calculations are included in the READ-Database for these radars, assuming either a 100-meter or 250-meter wind turbine blade tip height. The defense-related information used by NRDC to develop this on-line tool was compiled from open sources and from unclassified geospatial data provided by the Department of Defense. This information may not be current and does not necessarily reflect the official policy of the Department of Defense or the U.S. Government, and should be used for preliminary planning purposes only. Source: https://www.nrd.org/resources/proactive-planning-tool-renewable-energy-development

Risk of Adverse Impact on Military Operations and Readiness Area Maps (RAIMORAs)

Owner	**Department of Defense Siting Clearinghouse**
Point-of-Contact	Steve Sample Steve.j.sample4.civ@mail.mil (703) 571-0076
Developer	DOD
Users	Wind Industry
Classification	Public
Status	In service
Website	http://www.acq.osd.mil/dodsc/about/maps.html
Description	Risk of Adverse Impact on Military Operations and Readiness Areas (RAIMORAs) are maps that designate geospatial areas where the introduction of structures associated with projects filed with the FAA pursuant to 49 U.S.C. 44718 could have adverse impact on military operations and readiness. Energy developers are encouraged to consult the maps accessible on this page early in their siting decision processes, and if there is a potential impact, consult the Clearinghouse for an informal review of their project. The maps designate geospatial areas where the introduction of structures associated with projects filed with the FAA pursuant to 49 U.S.C 44718 could have adverse impact on military operations and readiness. Pursuant to Part 211 of title 32, Code of Federal Regulations, adverse impacts could impair or degrade the ability of the armed forces to perform warfighting missions, conduct military operations, and assure readiness to include flight operations, research, development, testing, and evaluation and training. Note that additional RAIMORAs are in development and this is not a complete depiction of all possible RAIMORAs within a given area. Source: http://www.acq.osd.mil/dodsc/about/maps.html

Research Laboratory Space-Time Adaptive Processing Tool (RL-STAP)

Owner	**Air Force Research Laboratory**
Point-of-Contact	Michael Callahan Michael.callahan.10@us.af.mil
Developer	CAE Soft Corporation (no longer in business)
Users	DOD
Classification	Unclassified – Export Controlled/ITAR Restricted
Status	Non-operational
Website	NA
Description	The Research Lab – Space Time Adaptive Processing (RLSTAP) software is a high fidelity, pulse-to-pulse, time domain simulation that allows radar engineers to easily predict environmental and hardware limitation effects on radar system performance. Using the object-oriented graphical user interface, the user can navigate through pull-down menus to simulate multi-channel airborne radar data in realistic clutter and jamming environments, develop and evaluate STAP algorithms, and assess system performance of signal processing technologies. A summary of the included effects and capabilities follows: 1. Pulse modulation and pulse compression (range sidelobes and coherent interference of target scatterers) 2. Discrete target and clutter models (interpolation to exact viewing angle) 3. Target and aircraft motion within a Coherent Processing Interval (CPI) (range and Doppler walk; range bins laying across the target differently) 4. Doppler processing with sidelobes 5. Coherent and non-coherent integration with angle estimation 6. Motion compensation 7. Multi-channel systems for Space-Time Adaptive Processing (STAP) 8. Digital beamforming and STAP 9. Detection (Constant False Alarm Rates (CFARs)) 10. Synthetic Aperture Radar (SAR) and Inverse SAR (ISAR) 11. Detailed antenna modeling: beamformers, phase shifters, Time Delay Units (TDUs), etc. 12. Installed antenna patterns 13. Hardware-effects that limit performance: stable local oscillator (STALO), mixers, Analog-to-Digital Converters (A/Ds), filters, etc. RLSTAP contains models for the ground-based radars, space-based radars, airborne surveillance, radar-guided missiles, airborne weapon delivery systems, airborne unmanned vehicles, and ship-based radars. RLSTAP contains a generic 3-blade wind turbine model. RLSTAP operates in the Windows environment.

ROTHR Wind Turbine Radar Interference Prediction Tool

Owner	**Department of Defense**
Point-of-Contact	Jack Buckingham Jack.buckingham@navy.mil
Developer	MIT Lincoln Laboratory
Users	Navy
Classification	OUO
Status	Non-operational
Website	NA
Description	Information unavailable at time of publication.

SilverSphere™ Energy Toolkit

Owner	**Peak Spatial Enterprises**
Point-of-Contact	Royal Koepsell Royal.koepsell@peakspatial.com (855) 732-5772
Developer	Peak Spatial Enterprises
Users	Wind Industry
Classification	Public – License required
Status	In service
Website	http://peakspatial.com/solutions/
Description	The SilverSphere™ Energy Toolkit is a wind energy constraint assessment and analysis toolkit that can be tailored to meet the needs of specific users. The toolkit provides wind developers and government agencies to conduct assessments as well as to track to configuration of wind developments as they undergo any required design changes. The toolkit provides users the ability to enter, visualize, analyze and share siting details and constraints for their wind energy projects. The toolkit allows users to add and edit project, site, and individual turbine details and to use assessment tools to analyze those project details against constraints that the project may encounter. The toolkit includes secured project database, geographic mapping, and constraint assessment tools that a user may access at any time, from virtually any location, using web browsers to access this functionality. The toolkit includes a Radar Assessment tool that computes key parameters that ultimately determine a proposed wind plant development's Radar Score, scoring each turbine visible to radars in a development. These include radar-turbine line-of-sight, radar view sheds, and probability of detection, probability of false alarm. This allows wind developers to conduct exploratory project assessments before submitting specific plans to government agencies for approval.

Tools for Siting, Planning, and Encroachment Analysis for Renewables (TSPEAR)

Owner	**Sandia National Laboratories**
Point-of-Contact	Ben Karlson bkarlso@sandia.gov (505) 377-3774
Developer	Peak Spatial Enterprises
Users	Wind Industry
Classification	Public – License required
Status	Non-operational
Website	N/A
Description	TSPEAR is essentially SilverSphere™ Energy Toolkit modified for Sandia National Laboratories to include a number of radar systems. The TSPEAR toolkit uses existing databases and models to help developers and regulators design, analyze, track and configure energy projects. Additionally, the TSPEAR toolkit allows the user to run impact analyses of proposed wind turbines on existing air surveillance radars using the developed modified radar models. The toolkit provides users the ability to enter, visualize, analyze and share siting details and constraints for their wind energy projects. The toolkit allows users to add and edit project, site, and individual turbine details and to use assessment tools to analyze those project details against constraints that the project may encounter. The toolkit includes secured project database, geographic mapping, and constraint assessment tools that a user may access at any time, from virtually any location, using web browsers to access this functionality. Integrated geographic data includes standard GIS data as well as NOAA NEXRAD and TDWR constraint overlays, airfields, the U.S. wind turbine database, military sites, and models for the CARSR, ARSR-4, ASR-9, and ASR-11. The toolkit includes a Radar Assessment tool that computes several key parameters that ultimately determine a proposed wind plant development's Radar Score, scoring each turbine visible to radars in a development. This allows wind developers to conduct exploratory project assessments before submitting specific plans to government agencies for approval.

U.S. Wind Turbine Database

Owner	**Lawrence Berkley National Laboratory**
Point-of-Contact	Ben Hoen bhoen@lbl.gov (845) 758-1896
Developer	Lawrence Berkley National Laboratory
Users	DOD / Wind Industry
Classification	Public
Status	In service
Website	Unavailable at time of publication
Description	The U.S Wind Turbine Database (USWTD) is an updated database of the U.S. Geological Survey (USGS) installed wind turbine database that was completed in 2014. The USWTD database was created by combining publicly-available data sets from the Federal Aviation Administration (FAA), USGS WindFarm data from a prior effort, online sources, and data privately held by AWEA and Lawrence Berkley National Laboratory (LBNL). The locations of all turbines were visually verified to within plus or minus 10 meters using high-resolution imagery. The USWTDB currently includes data on 57, 657 wind turbines from 43 U.S. states, plus Guam and Puerto Rico as of Q1 2018. The USWTD also includes a viewer that allows users to visualize, inspect, interact, and download the most current USWTDB through a dynamic web application. The USWTDB Viewer replaces an earlier web application called WindFarm and includes many enhancements. There are 22 distinct fields contained in the USWTD.

Wind Farm Impact Tool (Radar Toolbox)

Owner	**Department of Defense**
Point-of-Contact	Robert Heaton Robert.heaton@navy.mil
Developer	Regulus
Users	Air Force & Navy / FAA
Classification	OUO
Status	In service
Website	http://www.regulus-group.com/services/radar-toolbox
Description	Previously known as the Air Force Tool Box and originally designed for FAA and Air Force use in assessing DASR performance. The Wind Farm Impact Tool, a Windows-based analysis program, was created to assist in radar system installation, performance analysis, and optimization. It was designed to operate on Windows 2000/XP/Vista/7 systems. Version 12.03 is the version by Regulus Group that includes the wind turbine analysis tool. Version 12.05 was modified/created by SPAWAR Atlantic for Navy use and to correct the issue with the Line-of-Site calculation which rejected turbines, and adjusted RCS values. Version 13 of Radar Toolbox allows the user to capture, manipulate and analyze All Purpose STructured Eurocontrol SuRveillance Information EXchange (ASTERIX) target and weather data files, verify system alignment, locate permanent echoes, analyze PAT Log Files, capture and view Monopulse Secondary Surveillance Radar (MSSR) reply data, create MSSR Transparent Mode Command (TMC) files, and create and manipulate Target Range Azimuth Gate (RAG) Maps. The various features of Radar Toolbox are organized into a number of Tools. Each Tool operates mostly stand alone, reading data from one or more files, displaying or summarizing the data or manipulating the data to create one or more output files. Source: http://www.regulus-group.com/services/radar-toolbox

Energy Zones Mapping Tool

Owner	**Argonne National Laboratory**
Point-of-Contact	Jim Kuiper jkuiper@anl.gov (630) 252-6206
Developer	Argonne National Laboratory
Users	Energy Developers
Classification	Public
Status	In service
Website	https://ezmt.anl.gov/
Description	The Energy Zones Mapping Tool (EZMT) is a free online mapping tool to identify potential energy resource areas and energy corridors in the United States. This web site provides information about the project, background on the energy resources, and details on the data layers used in the tool. There are also links to policies and regulations, printable maps, documents, and related links. The Tool contains the following features: • Nine energy resources: Biomass, Coal, Geothermal, Natural Gas, Nuclear, Solar, Storage, Water, and Wind • Flexible modeling of power plant and corridor siting factors such as slope and land protections • Tools to generate and analyze potential corridor routes • Searchable database of policies and regulations The EZMT contains 324 GIS data layers compiled from a variety of sources for the purpose of screening-level analysis, and each has a limit to the scale, currency, and accuracy of the data. The back-end tool contains raster models that compute a composite score based on user-specified layers and can generate a heat map based on these various layers of information. Currently, the mapping tool only contains data for the eastern half of the United States. Source: https://ezmt.anl.gov/

High-voltage EMI Modeling Suite

Owner	**Idaho National Laboratory**
Point-of-Contact	Carl Kutsche carl.kutsche@inl.gov (208) 526-5835
Developer	Idaho National Laboratory
Users	DOD
Classification	OUO
Status	Non-operational
Website	NA
Description	Model to predict EMI generated by high voltage transmission lines. Can be used to evaluate siting of energy projects near military activities. The focus of this model is: • Electromagnetic Interference (EMI) caused by power lines • Determine impact zones geographically • Level of data integrity very high, based on validated models HEMI is undergoing beta testing.

Solar Glare Hazard Analysis Tool (SGHAT)

Owner	**Sandia National Laboratories**
Point-of-Contact	Cliff Ho ckho@sandia.gov (505) 844-2384
Developer	Sims Industry
Users	DOD / Federal & State Governments
Classification	OUO
Status	In service
Website	https://share.sandia.gov/phlux
Description	The Solar Glare Hazard Analysis Tool (SGHAT) is a tool to evaluate solar glare and receiver irradiance. The SGHAT website contains four tools: 1. The Solar Glare Hazard Analysis Tool that determines when and where solar glare can occur throughout the year from a user-specified PV array as viewed from user-prescribed observation points. 2. The Empirical Glare Analysis Tool empirically quantifies glint and glare from reflected light and assess the potential impact (e.g. temporary after-image, retinal burn). 3. The Analytical Glare Estimation Tool will analytically predict the potential impact (e.g. temporary after-image, retinal burn) of observed glare. 4. PHLUX Mapping Analysis Tool empirically determines the irradiance distribution on a central receiver. No flux gauge needed - simply upload photos and fill in the details, and the tool does the rest. 5. The Reflectivity Calculator Tool calculates the reflectivity of a receiver using only raw photos and details like location and heliostat characteristics. SGHAT analysis functionality is now restricted to military, state, and federal government users only. Maintenance and monitoring of the SGHAT application ends Dec. 31, 2017.

4. REFERENCES

1. Gilman, P., Husser, L., Miller, B., Peterson, L., *Federal Interagency Wind Turbine Radar Interference Mitigation Strategy*, Department of Energy, Washington, DC, January 2016.

2. Department of Defense, *DoD Siting Clearinghouse Office of the Assistant Secretary of Defense for Energy, Installations, and Environment*, Accessed June 2017, http://www.acq.osd.mil/dodsc/

3. Department of Energy, *Wind Energy Technologies Office*, Accessed June 22, 2017, https://energy.gov/eere/wind/wind-energy-technologies-office

4. Federal Aviation Administration, *Mission*, Accessed June 2017, https://www.faa.gov/about/mission/

5. National Oceanic and Atmospheric Administration, *About Our Agency*, Accessed June 2017, http://www.noaa.gov/about-our-agency

6. Bureau of Ocean Energy Management, *Renewable Energy*, Accessed June 2017, https://www.boem.gov/Renewable-Energy/

7. Department of Homeland Security, *About DHS*, Accessed June 2017, https://www.dhs.gov/about-dhs

8. Department of Homeland Security, *Air and Marine Operations Surveillance System (AMOSS)*, July 22, 2013, https://www.dhs.gov/sites/default/files/publications/privacy_pia_cbp_amoss_aug2013.pdf

9. Diffendorfer, J.E., Compton, Roger, Kramer, Louisa, Ancona, Zach, and Norton, Donna, 2017, Onshore industrial wind turbine locations for the United States (ver. 1.2, January 2017): U.S. Geological Survey Data Series 817, https://doi.org/10.3133/ds817

10. American Wind Energy Society, *AWEA U.S. Wind Industry Map*, Accessed October 2017, http://gis.awea.org/arcgisportal/apps/webappviewer/index.html?id=eed1ec3b624742f8b18280e6aa73e8ec

11. Department of Defense, *DoD Preliminary Screening Tool*, Accessed October 2017, https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action=showLongRangeRadarToolForm

12. Bureau of Ocean Energy Management & National Oceanic and Atmospheric Administration, *Marine Cadastre*, Accessed October 2017, https://marinecadastre.gov

13. Sandia National Laboratories, *Siting and Barrier Mitigation*, Accessed October 2017, http://energy.sandia.gov/energy/renewable-energy/wind-power/wind-turbine-siting-and-barrier-mitigation/

14. Federal Aviation Administration, *Obstruction Evaluation / Airport Airspace Analysis*, Accessed October 2017, https://oeaaa.faa.gov/oeaaa/external/portal.jsp

15. Natural Resources Defense Council, *Renewable Energy and Defense Geospatial Database*, Accessed October 2017, https://www.nrd.org/resources/proactive-planning-tool-renewable-energy-development

16. *Silversphere Energy Siting Toolkit User's Guide*, Peak Spatial Enterprises, April 1, 2015

17. USGS, *The United States Wind Turbine Database*, In beta, Accessed February 2018, https://ngmdb.usgs.gov/windBeta/

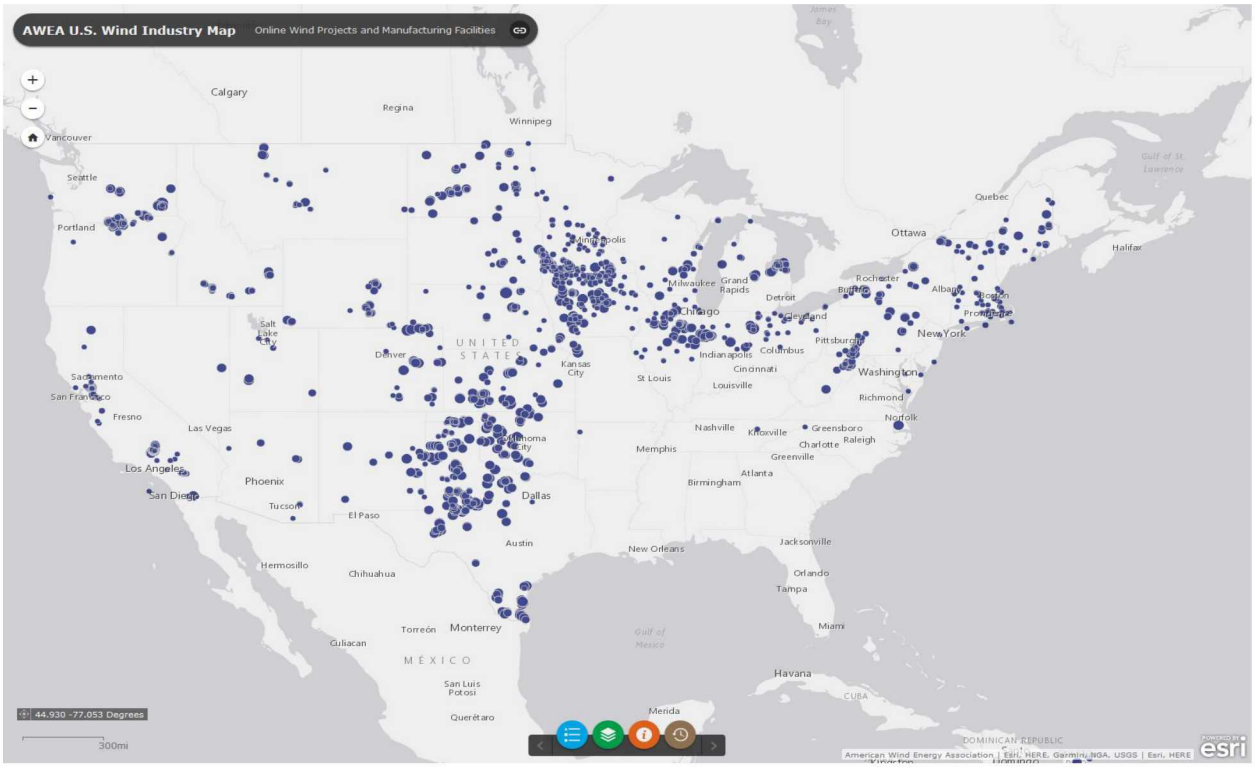
18. Regulus Group, *Radar Toolbox*, Accessed November 2017, http://www.regulus-group.com/services/radar-toolbox

19. Argonne National Laboratory, *Energy Zones Mapping Tool*, Accessed November 2017, https://ezmt.anl.gov/

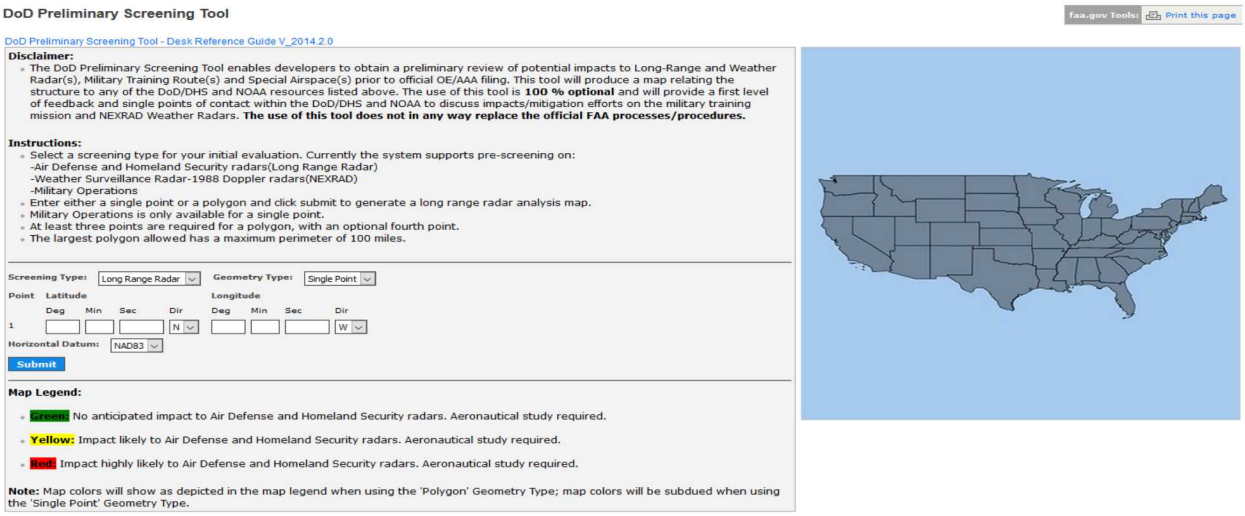
20. Sandia National Laboratories, *Solar Glare and Flux Mapping Tools*, Accessed November 2017, https://share.sandia.gov/phlux

APPENDIX A: MODEL SCREENSHOTS

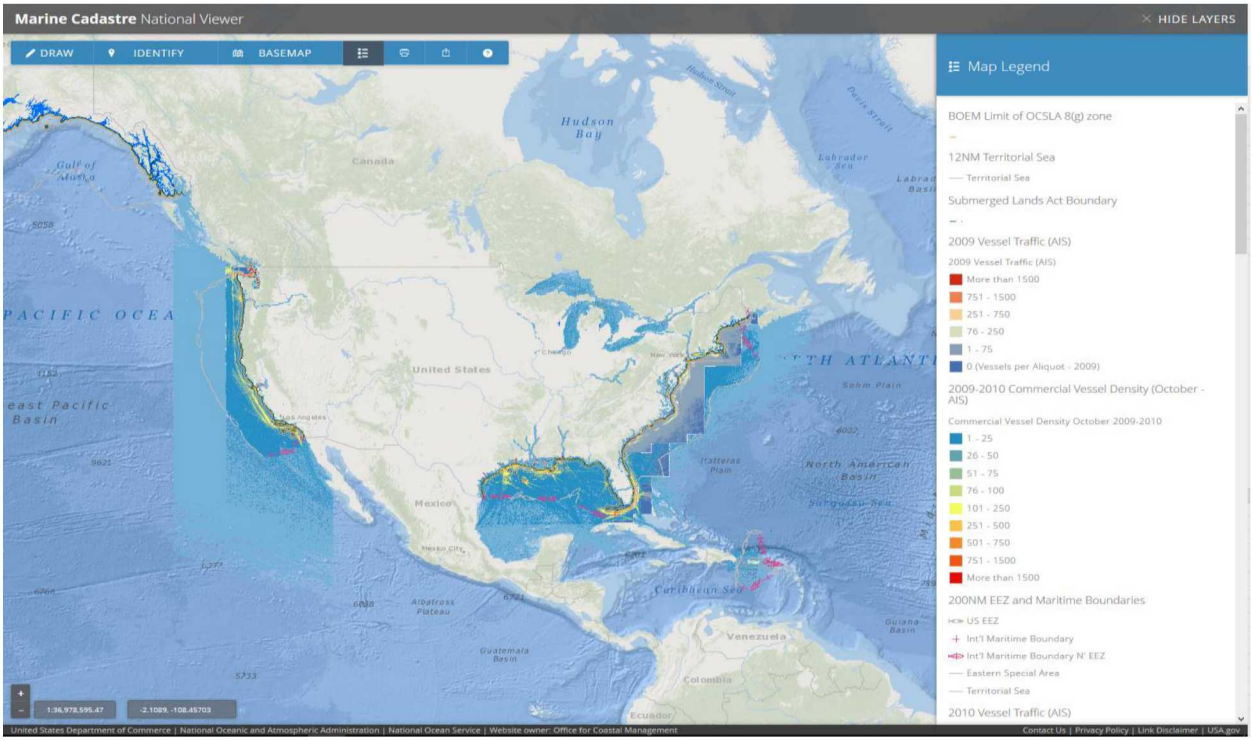
AWEA U.S. Wind Industry Map

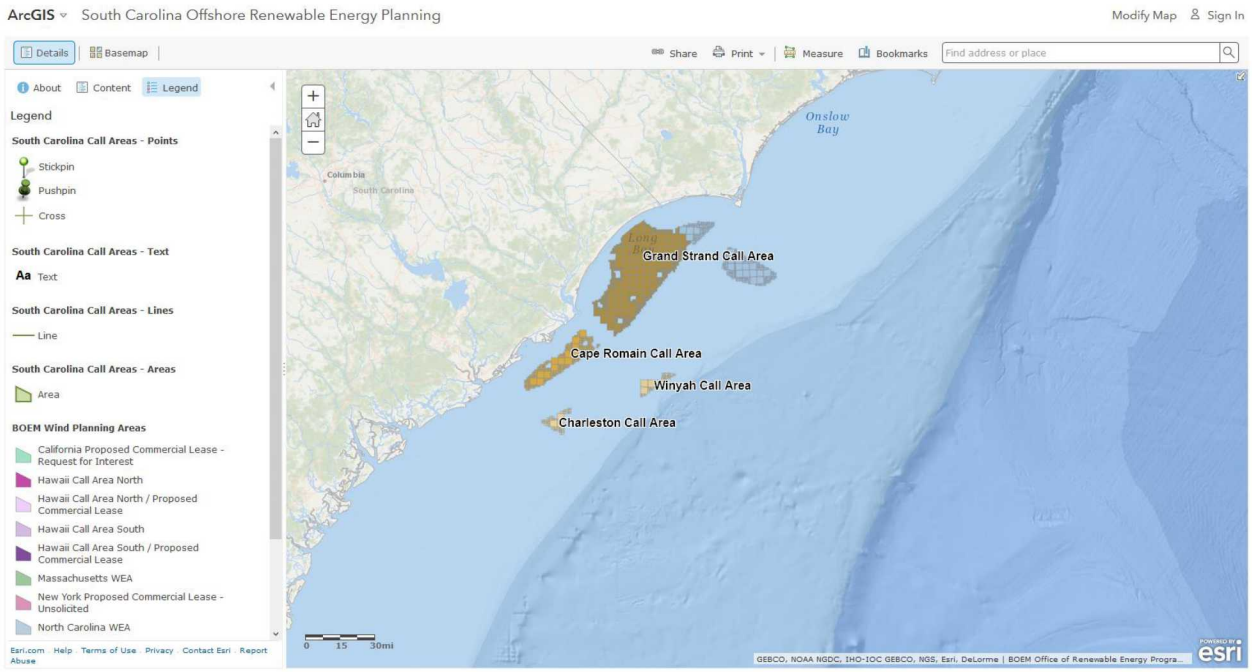


DOD Preliminary Screening Tool

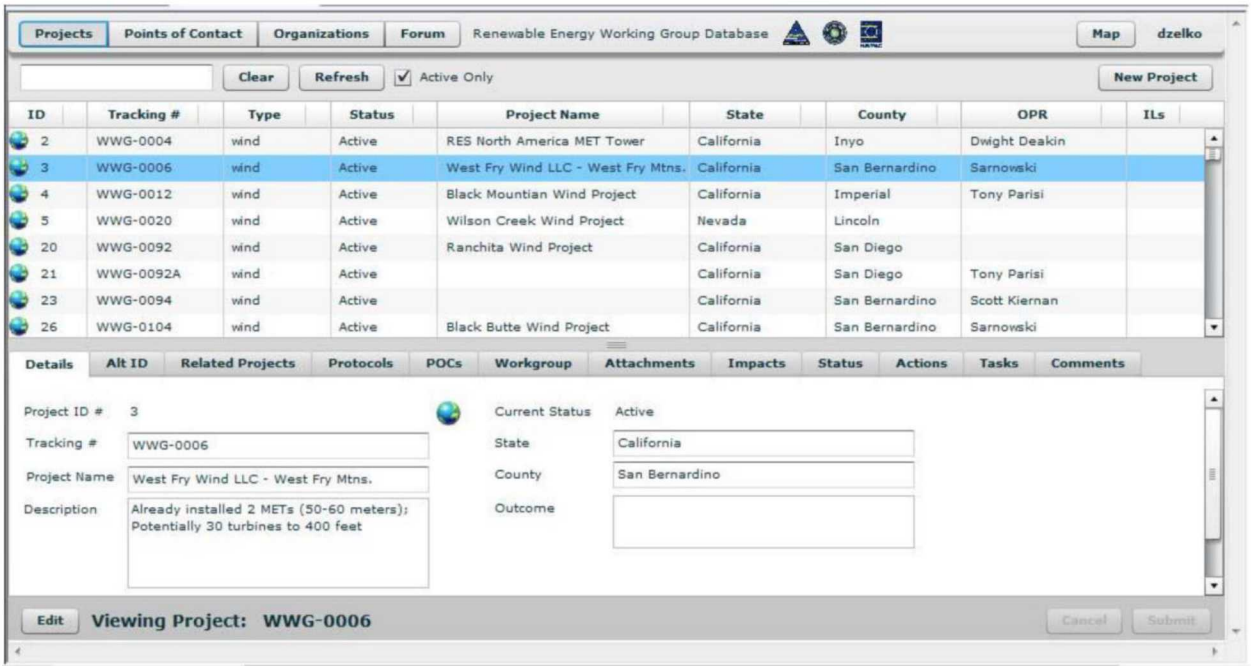


Marine Cadastre



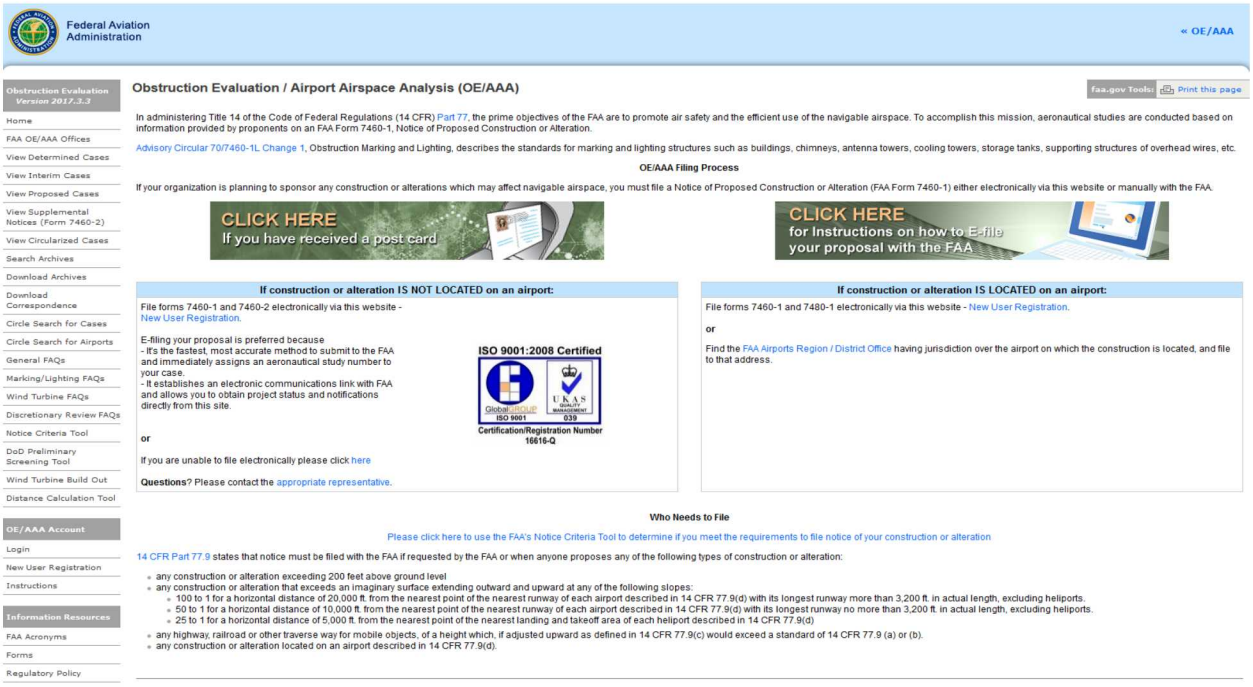


Mission Compatibility Awareness Tool

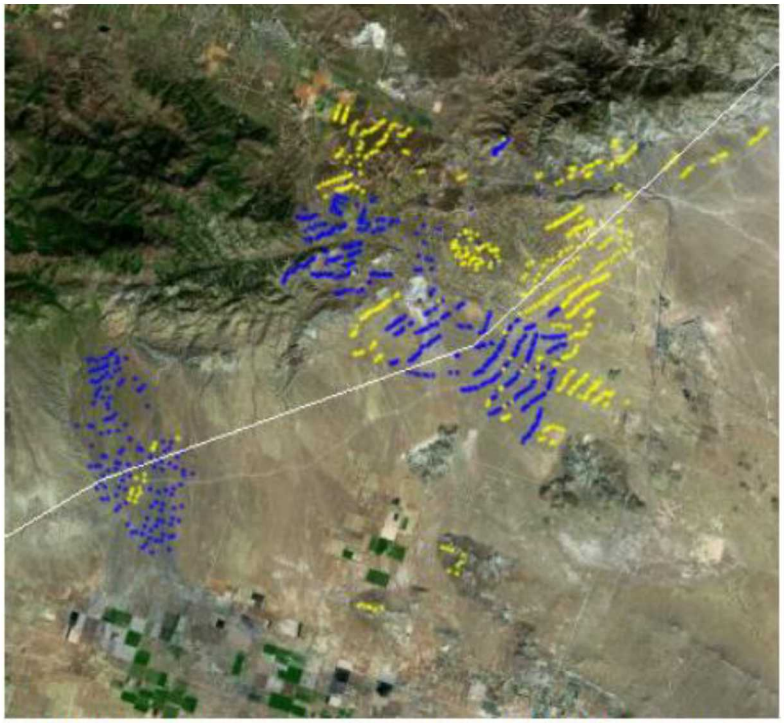


NOAA Public NEXRAD Screening Tool

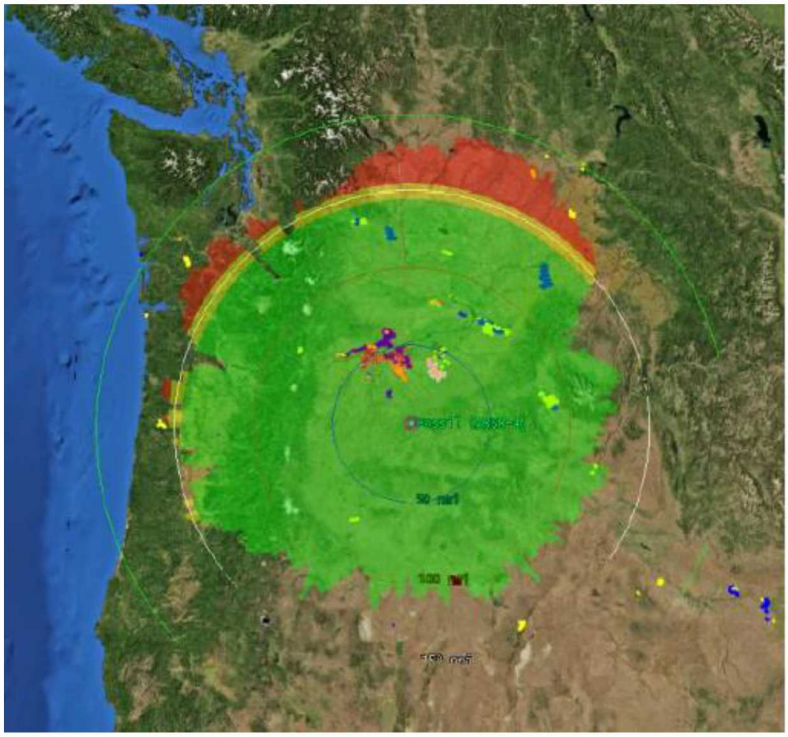
Obstruction Evaluation / Airport Airspace Analysis



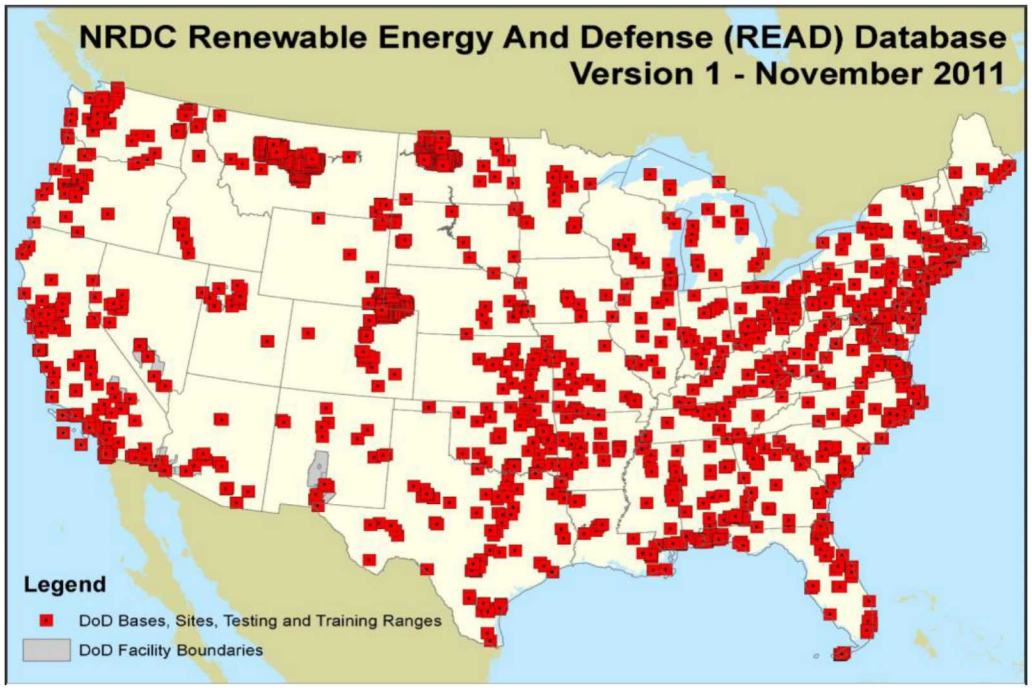
Radar Obstruction Evaluation Model/Simulator - (ROEMS)

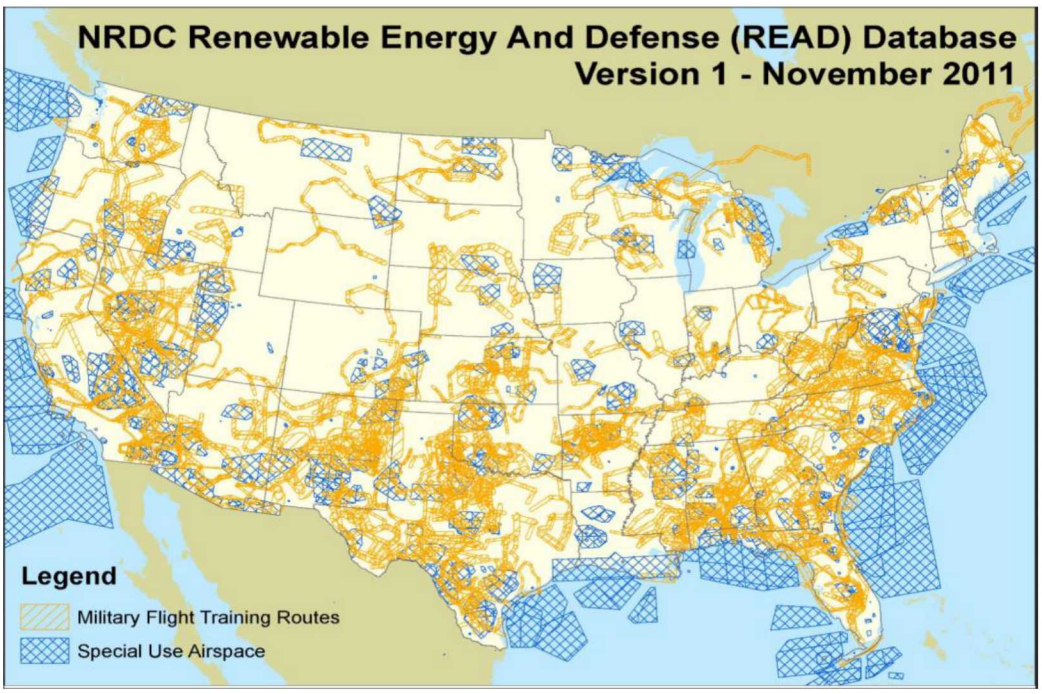


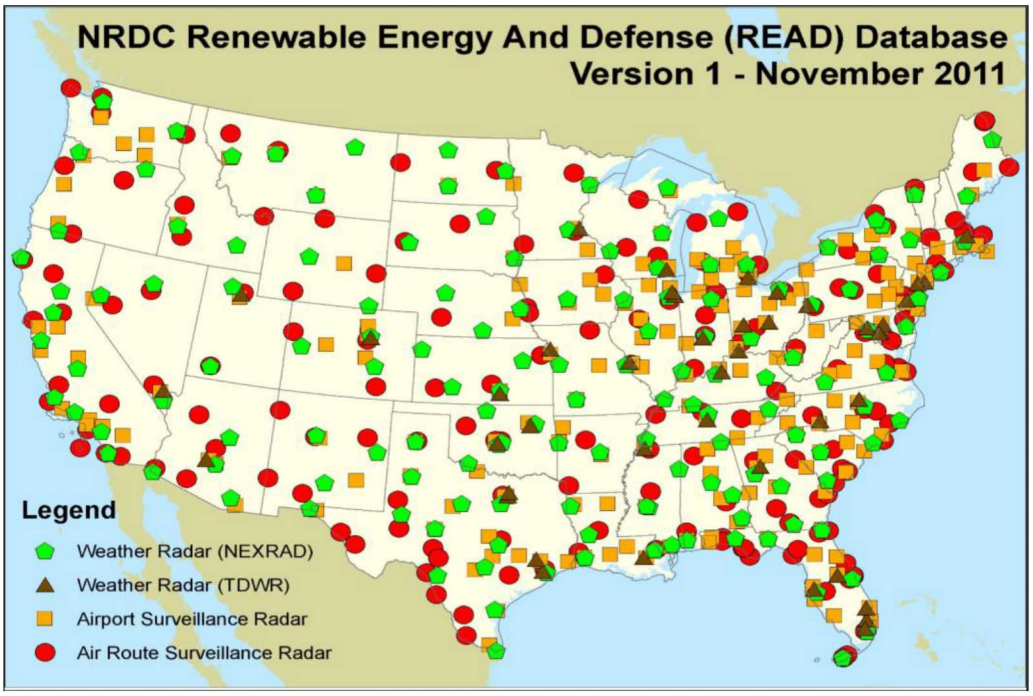
EXISTING turbines shown in blue, PENDING turbines shown in yellow.



Renewable Energy & Defense Geospatial Database

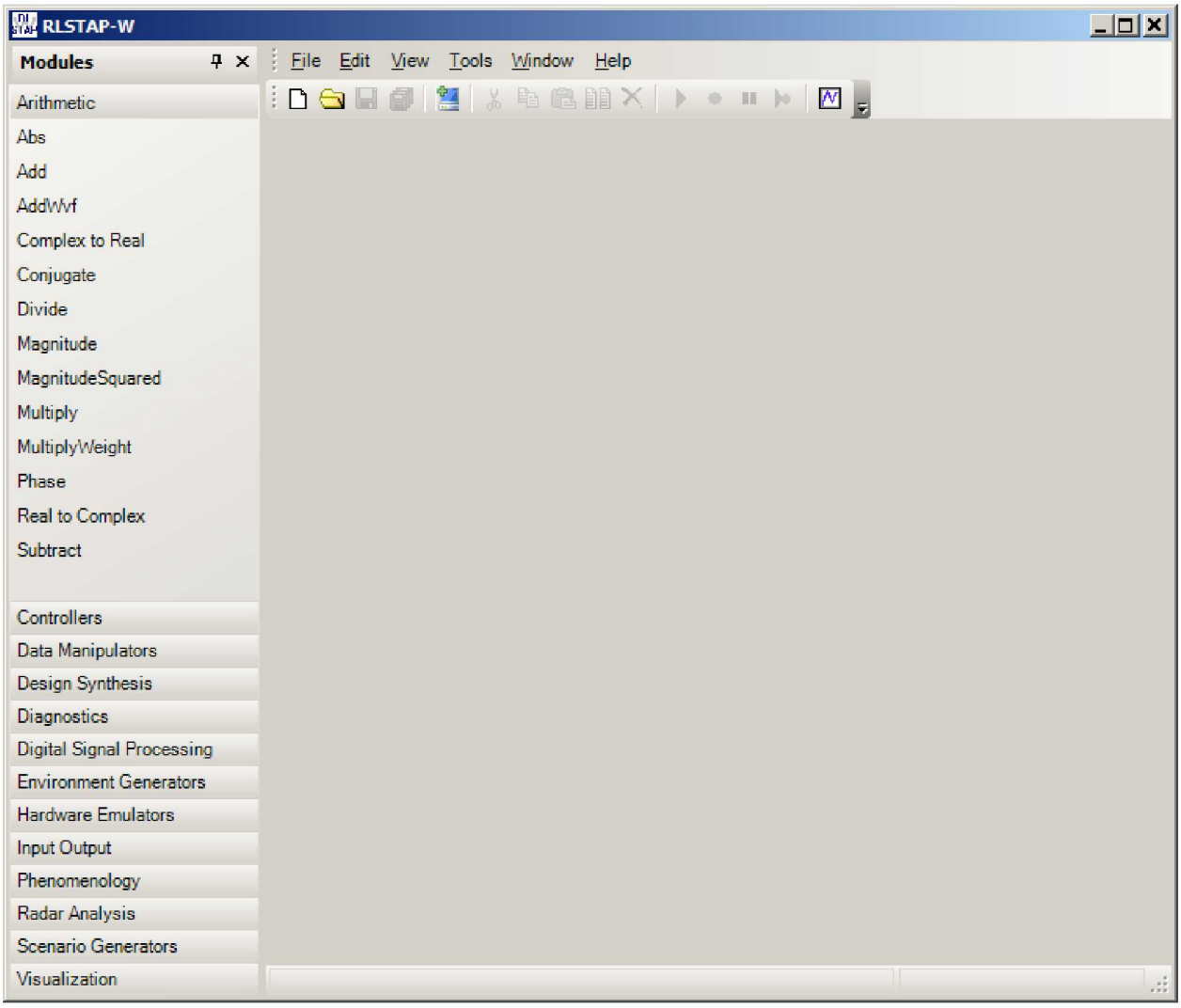




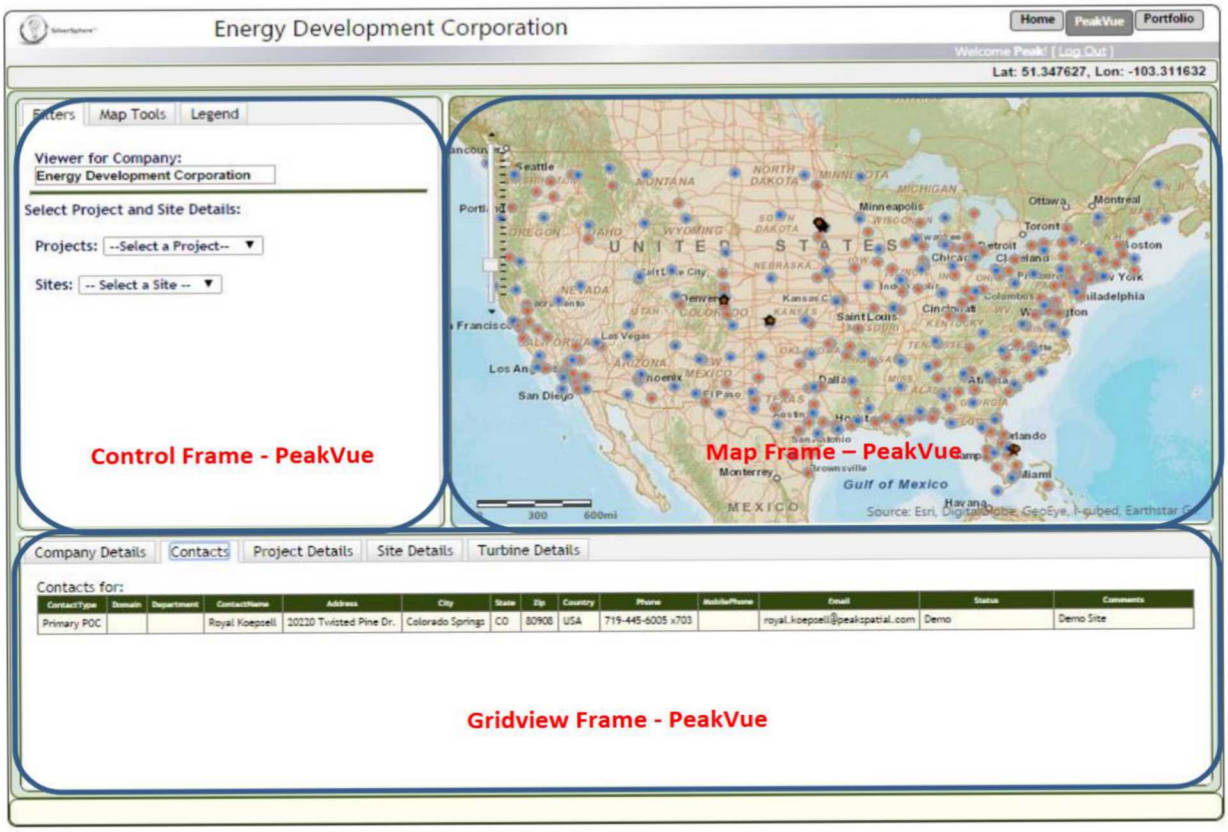


Risk of Adverse Impact on Military Operations and Readiness Area Maps

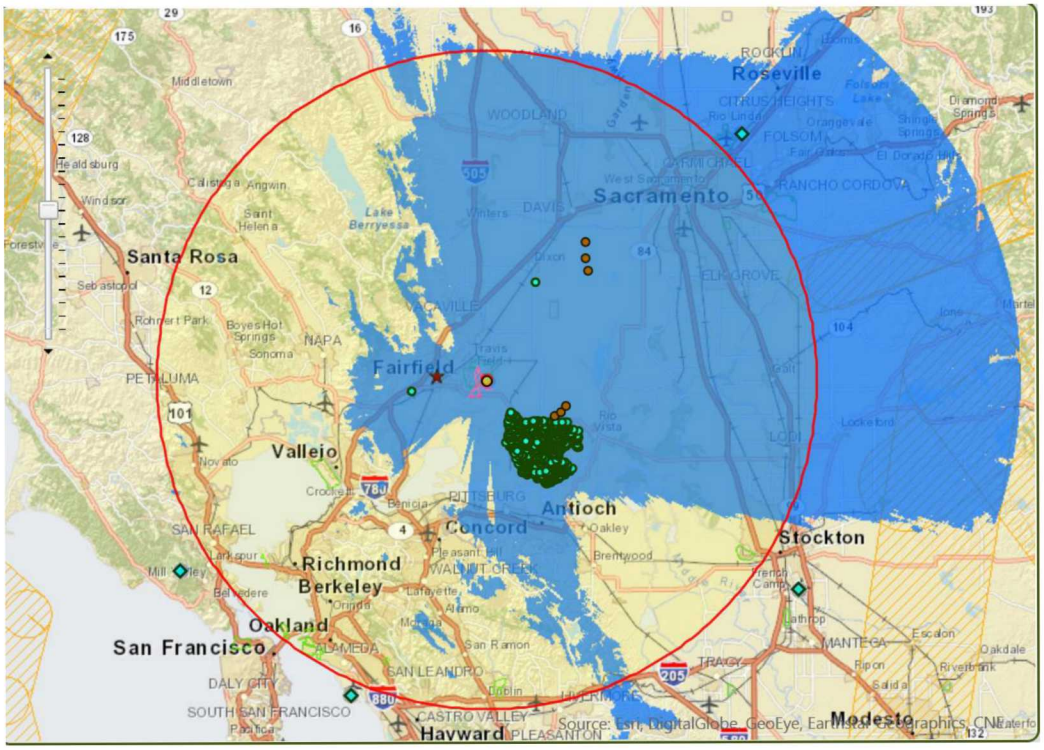
Research Laboratory Space-Time Adaptive Processing Tool

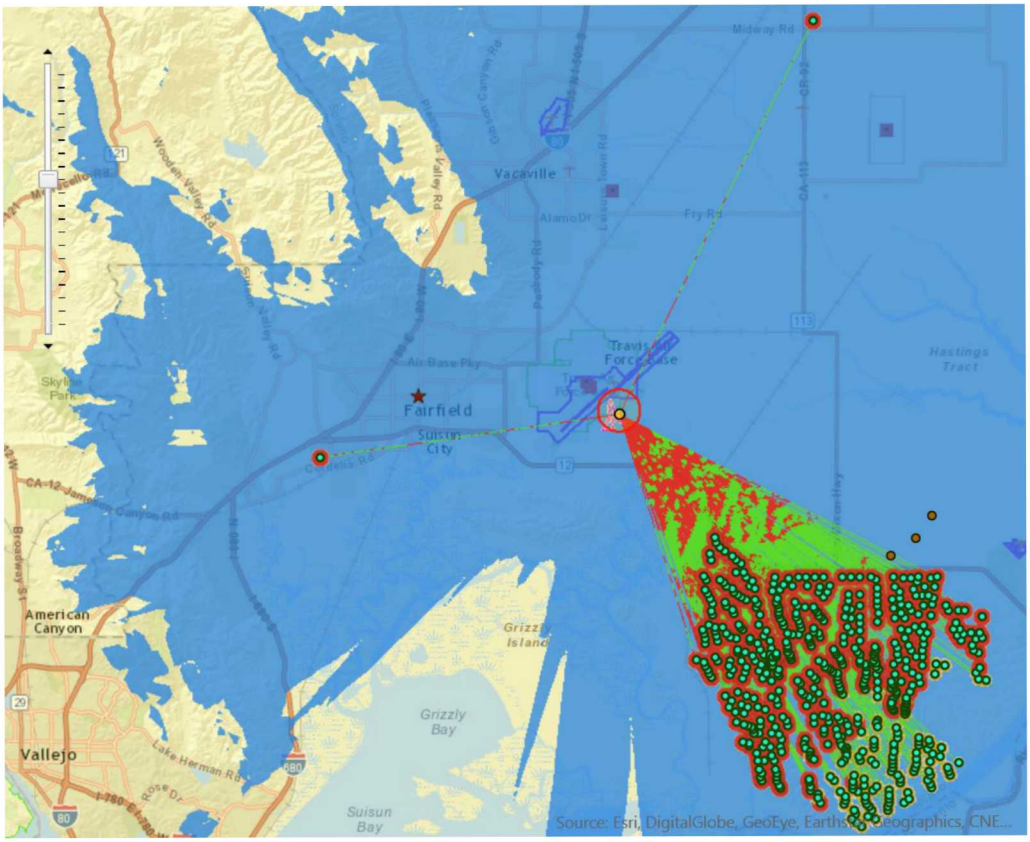


SilverSphere™ Energy Toolkit

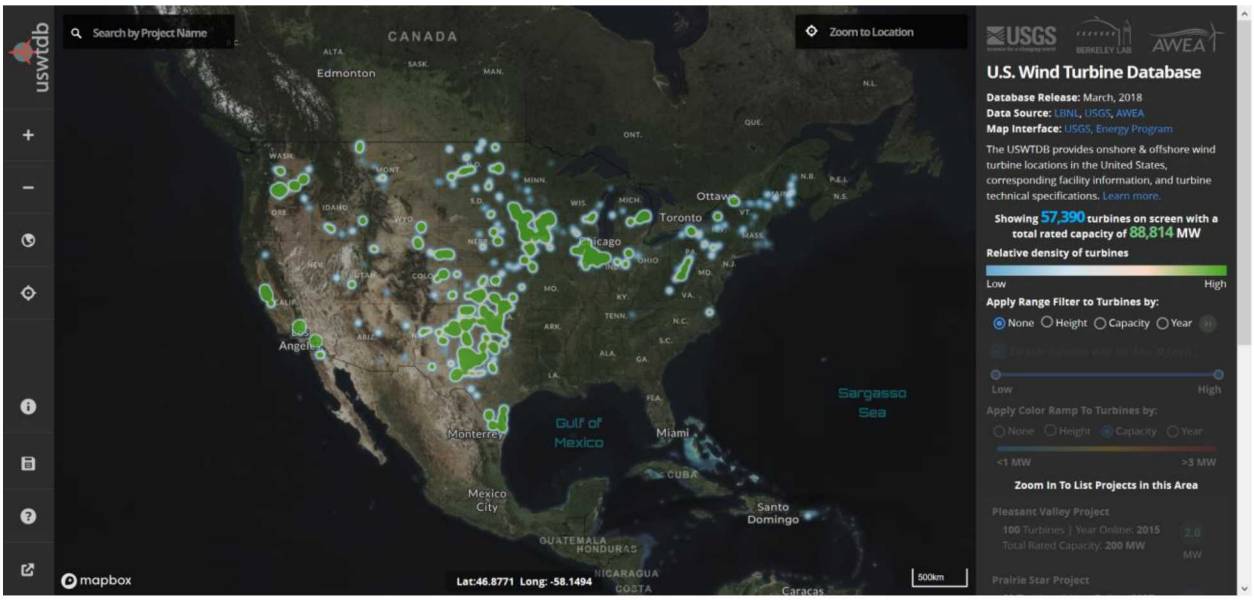


Tools for Siting, Planning, and Encroachment Analysis for Renewables

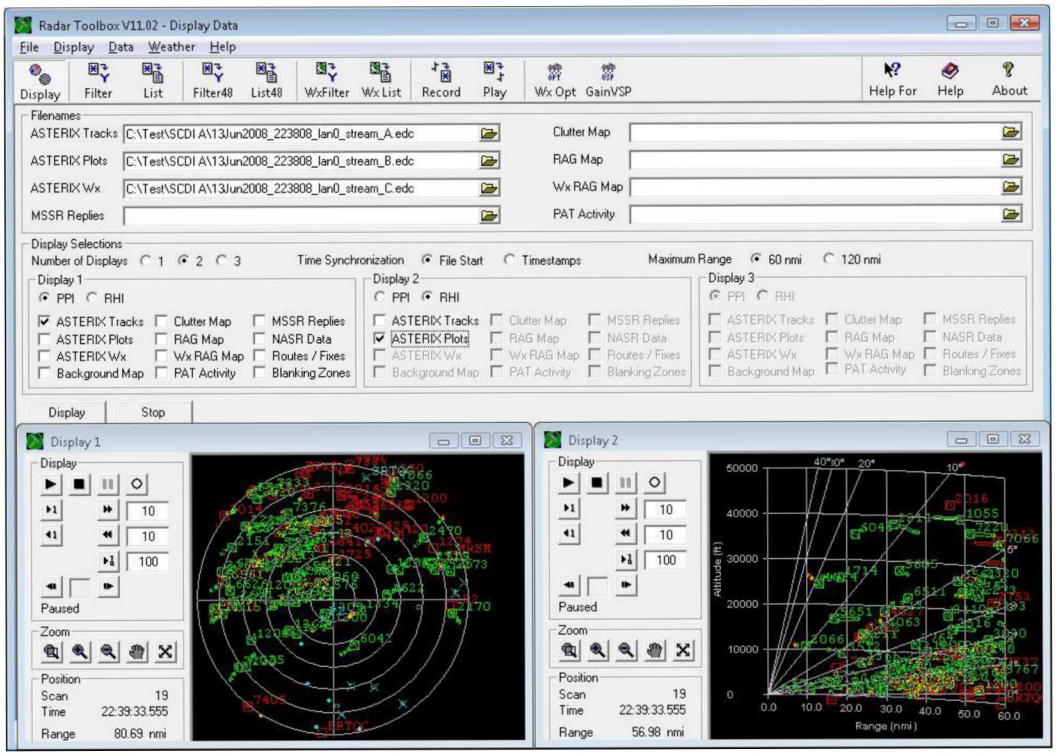


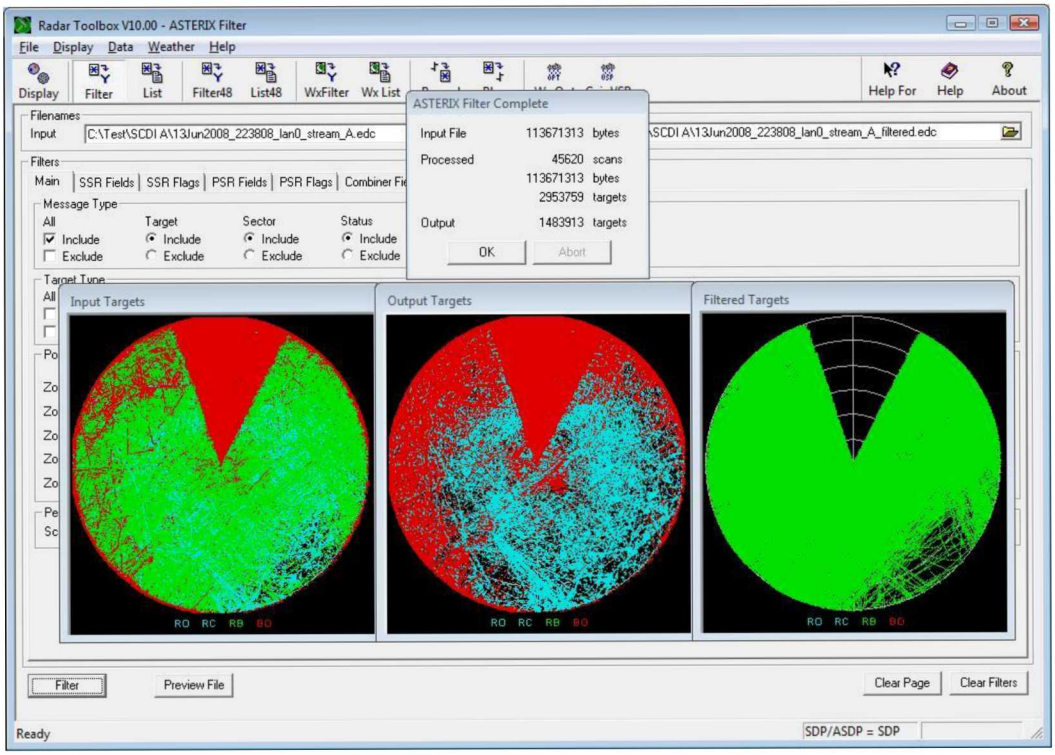


United States Wind Turbine Database



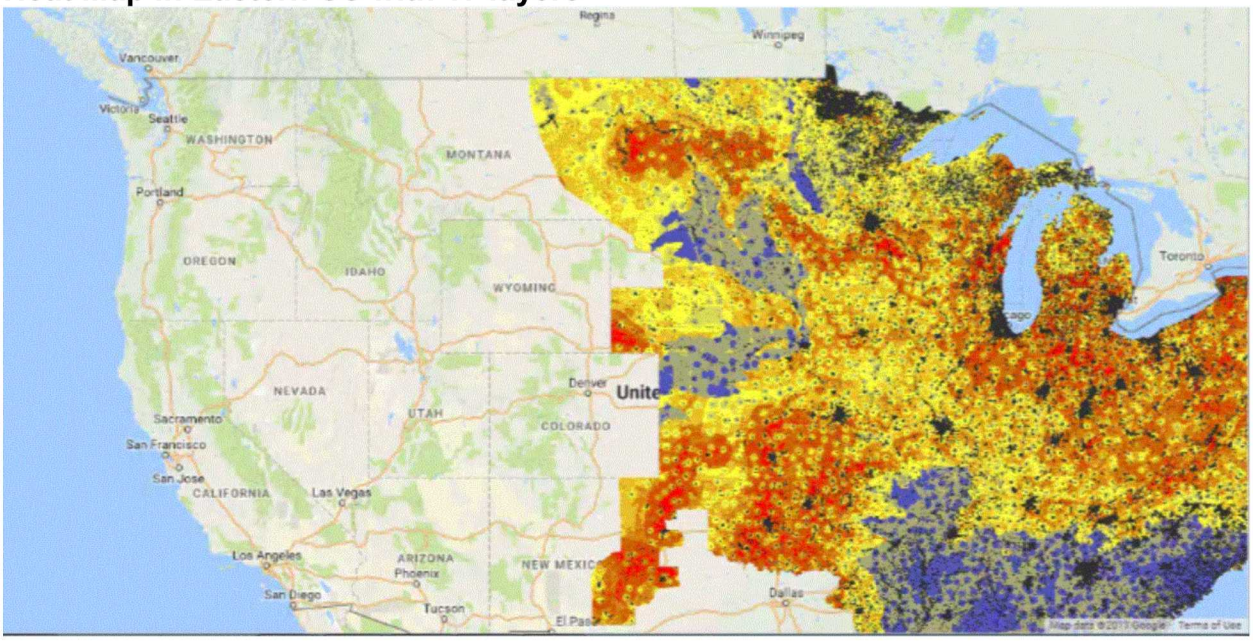
Windfarm Impact Tool (RADAR TOOLBOX) Version 13.02



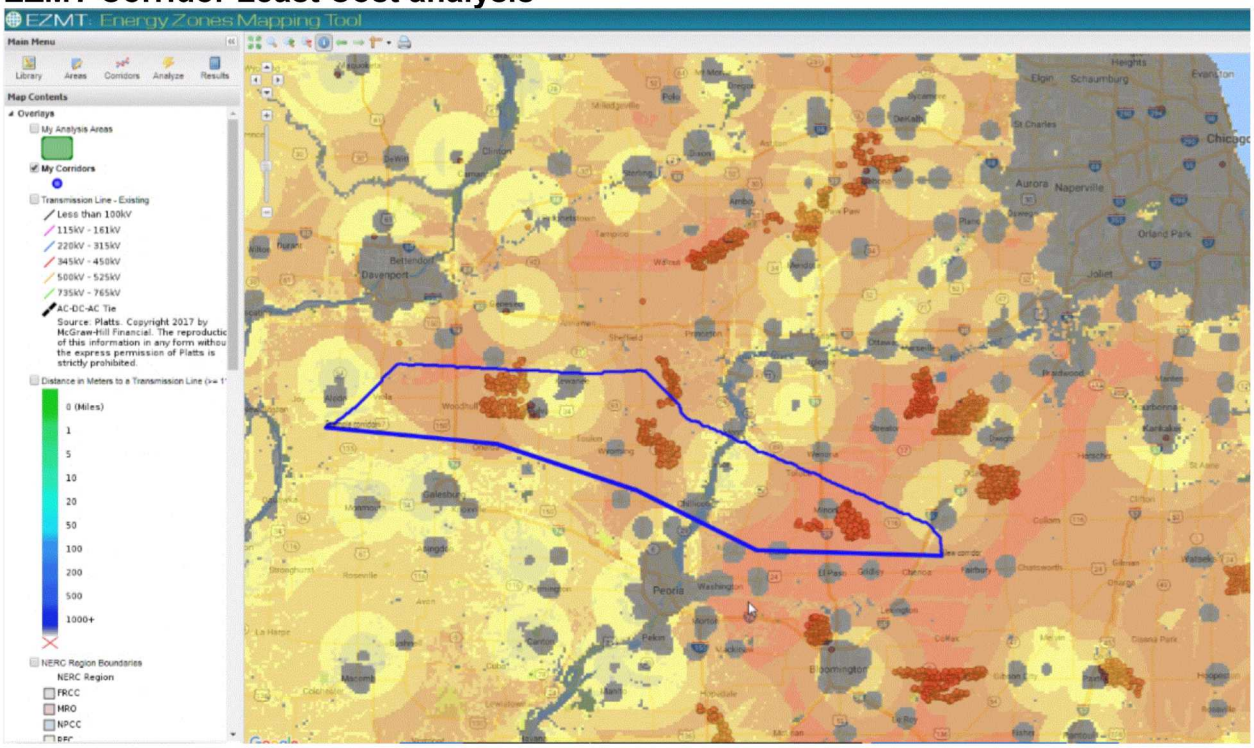


Energy Zones Modeling Tool

Heat Map in Eastern US with 17 layers

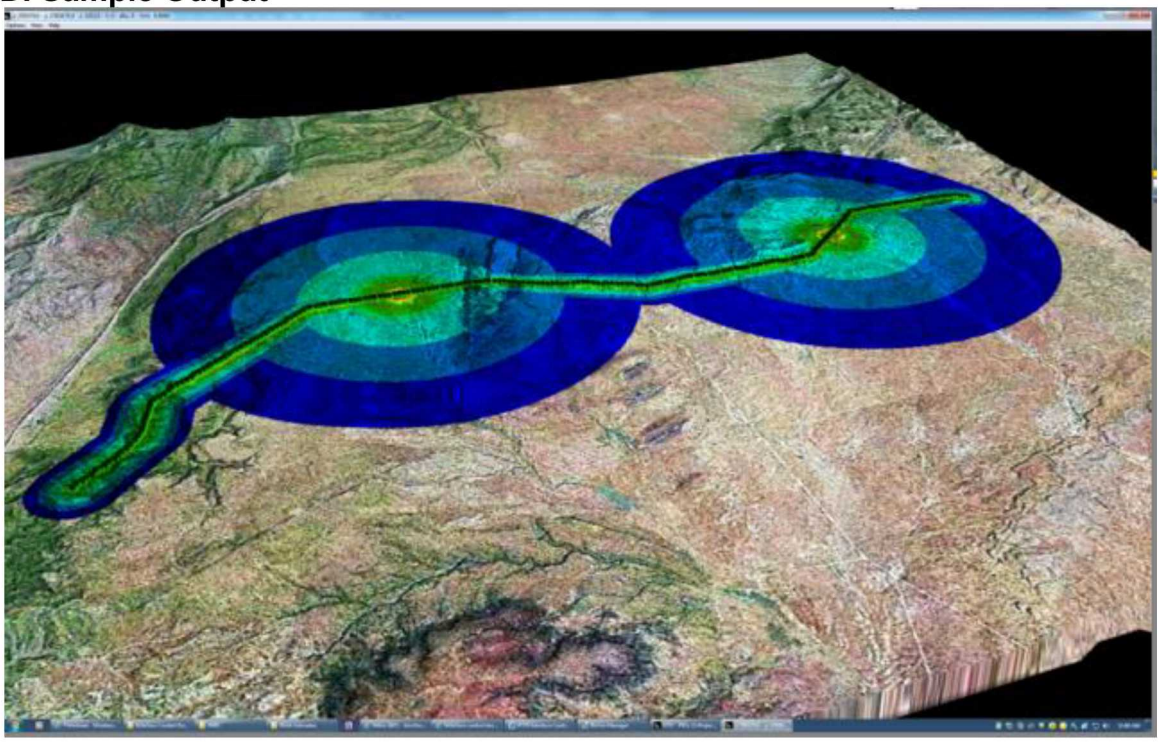


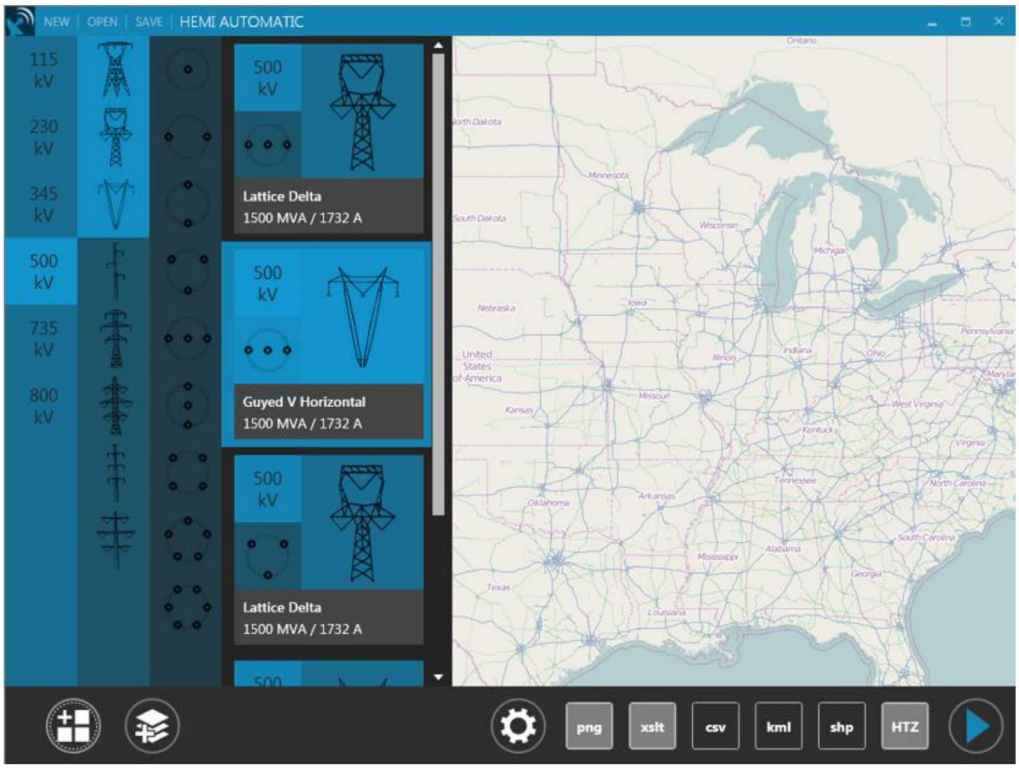
EZMT Corridor Least Cost analysis



High-voltage EMI Modeling Suite (HEMI)

ATDI Sample Output

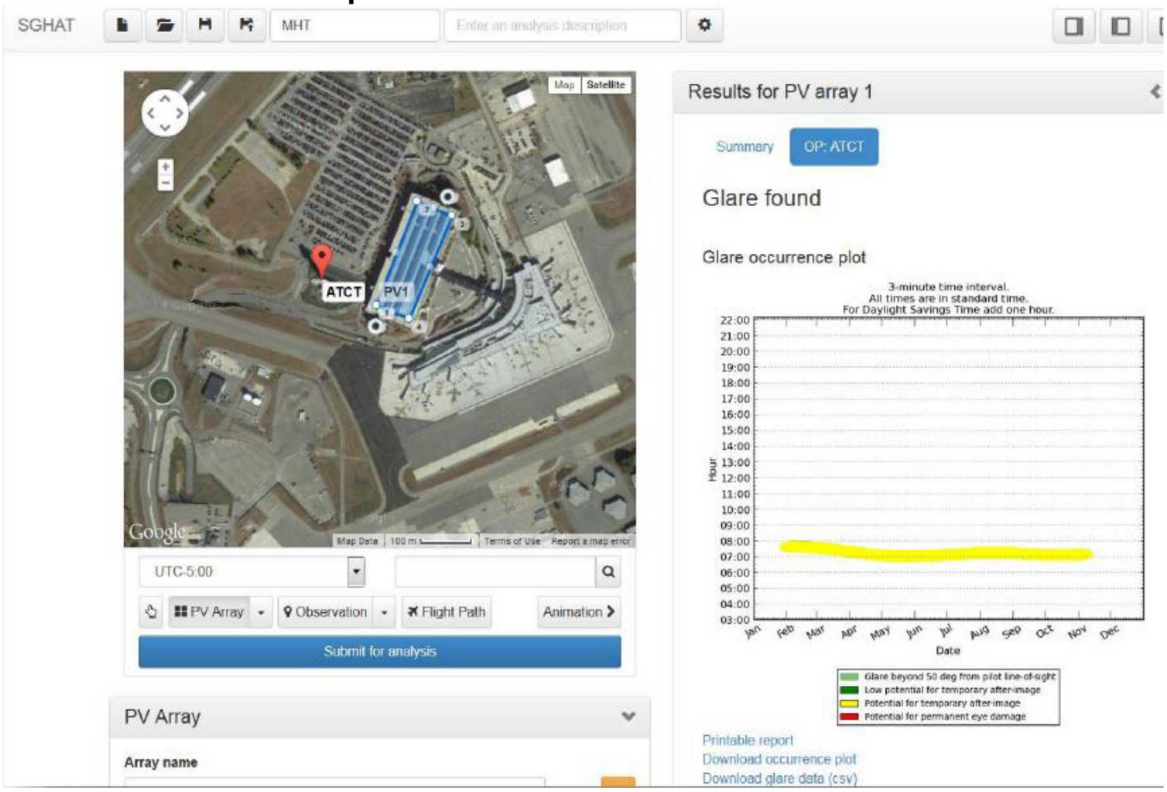




Solar Glare Hazard Analysis Tool

Observation points approaching Runway

Glare Occurrence Plot Report



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