Summary of Second Test Results for the Interagency Field Test &Evaluation of Wind Turbine – Radar Interference Mitigation Technologies
PUBLIC RELEASE

ASR-11 Campaign at Abilene, TX
Test: October 18-28, 2012. Report: March 2013

Purpose of this Fact Sheet: This document includes background information and a summary of the second of three tests on the effectiveness of mature private sector technologies in mitigating electromagnetic interference from wind turbines on air surveillance systems. This fact sheet contains publically-available information from the second technical test report but excludes proprietary business information from private sector companies and sensitive national defense and security information. The fact sheet also omits information from the report about the test procedures that would provide an unfair competitive advantage to companies involved in later tests. Accordingly, the full report is labeled under Department of Defense distribution procedures as: "Distribution Statement B: Distribution Authorized to U.S. Government Agencies only (Test & Evaluation, Proprietary)."

Program Justification: Wind turbines present a source of interference with our nation's radars. The effects of this interference are of concern to flight safety, homeland security, and national defense. Furthermore, to meet the nation's objectives for increased renewable energy and the associated benefits, the number of operating wind turbines in this country is expected to continue to grow in coming years.

Goals of the Program: Supported by directives from Congress, the Administration established the Interagency Field Test and Evaluation (IFT&E) program to investigate and address the concerns of growing interference of wind turbines on our nation's air surveillance radars. The program has three goals: i) characterize the impact of wind turbines on existing air surveillance radars; ii) assess near-term mitigation capabilities proposed by industry; and iii) collect data and increase technical understanding of interference issues to advance development of long-term mitigation strategies to determine future research and development priorities.

Program Description: This program is a two-year effort, funded and supported by Department of Energy (DOE), Department of Defense (DOD), Department of Homeland Security (DHS), and Federal Aviation Administration (FAA). There are three flight campaigns in the effort at a long-range radar Common Air Surveillance Radar, a short-range Airport Surveillance Radar (ASR, in this case, an ASR-11), and a long-range Air Route Surveillance Radar (ARSR, in this case, an ARSR-4). Eleven different mitigation concepts are being assessed during these campaigns. Each two-week flight test campaign involves the collection of data from federally-owned radar systems, several types of government and private aircraft, a variety of wind-radar mitigation technologies, and wind turbines in the test area.

Laboratory Roles: The federal agencies used two national laboratories—DOD's Massachusetts Institute of Technology Lincoln Laboratory (MIT LL) and DOE's Sandia National Laboratories (SNL)—to manage the test and evaluation program because of their world-class expertise on radar and wind technologies, their ability to access and protect sensitive and proprietary data, and their credibility in providing objective and independent assessment for the tests and evaluations.

Test Participant Selection Process: SNL issued a public notification through a Request for Information to acquire information from radar developers, radar-related software producers, radar operators, turbine and turbine component manufacturers, service providers, and others on the availability of the marketplace to provide for and participate in a technology demonstration of Commercial Off-the-Shelf or other mature

technology mitigation capabilities. After a technical review of private sector proposals by a technical panel of Government and Laboratory experts, the Interagency Steering Committee invited ten companies to participate in the three IFT&E tests, evaluating a total of eleven mitigation technologies.

Purpose of Test 1: The purpose of this first test was to characterize the performance of a newly upgraded Common Air Surveillance Radar, a long range surveillance radar system, in Tyler, MN. The test was conducted under a wide range of wind turbine-related interference conditions to evaluate the effectiveness of different mitigation technologies in improving radar surveillance coverage in a test area with a high concentration of wind turbines. Three private sector companies that demonstrated their mitigation systems were: i) the C Speed Lightwave in-fill radar, ii) the SRC LSTAR(V)3 in-fill radar, and iii) the Raytheon Long Range Radar processing upgrade.

Purpose of Test 2: The purpose of this second test was to characterize the performance of the Airport Surveillance Radar (ASR)-11, a terminal airport surveillance radar system in Abilene, TX. The test was conducted under a wide range of wind turbine-related interference conditions to evaluate the effectiveness of different mitigation technologies in improving radar surveillance coverage in a test area with a high concentration of wind turbines. Two private sector companies demonstrated their mitigation systems: Terma with their Scanter 4002 radar and Booz Allen Hamilton with their RF Precision Nulling Device.

Site Selection and Timing: The agencies wanted the tests to take place in safe airspace in a location with a high concentration of wind turbines during times of year when wind turbine farms generate the greatest electromagnetic interference effects on radar systems. The Abilene ASR-11 is located within the line of sight of hundreds of wind turbines. The spring and fall seasons are the times of year when winds blow most consistently at high velocities. In order to fully assess the ASR-11 and the selected mitigation technologies using known targets (test program aircraft), the test area was chosen and test flights were timed to avoid disrupting the traffic pattern at Abilene. Additional data were leveraged from local air traffic as they provided targets of opportunity with little incremental cost to the government.

Flight Tests: Key stakeholders from the federal agencies provided guidance and support to MIT LL and SNL as they designed, executed, and analyzed the tests. The FAA provided extensive support in managing the flight operations and air traffic control, as well as technical support regarding the ASR-11 radar. DOD's 84th Radar Evaluation Squadron also provided technical radar support. DHS, DOD, DOE, and NOAA provided critical test aircraft, flight tracking, and air operations. Eleven different aircraft types were flown for a total of 55 test flights (166 hours) over nine days of testing. This flight data enables the Laboratory team to evaluate the radar systems' performance. Neither the government radar operators nor the test participants were provided with advanced information about the test program aircraft regarding their type, number, speed, altitude, or flight routes.

Scientific Instrumentation: MIT LL built an Adjunct Radar Analysis Processor, computer hardware that was attached to the ASR-11 to gather echo returns from the aircraft with radar frequency signal measurements (the In-Phase and Quadrature data), as well as detection messages, from the primary and secondary radar. These data were used to baseline the ASR-11's performance when aircraft flew over

wind farms and to compare the ASR-11's performance to the mitigation technologies. All primary test aircraft carried Global Positioning System (GPS) receivers and other equipment to analyze the ASR-11's and the mitigation technology's performance following the flight tests. These data were used to compare the performance of the ASR-11 and the mitigation technologies against actual flight data.

Wind Industry Involvement: SNL coordinated the data collection effort from wind farm owners in the Abilene area. Wind turbine characteristics and operating data including wind speed and rotation rate were gathered from 2,112 wind turbines in and around the test area. These data, when combined with the radar and flight data, enable the Laboratories to characterize the effects of wind turbine interference and predict effects on similar radar systems in other locations with a higher level of confidence.

Test 2 Participants: The test participants—Terma and Booz Allen Hamilton—each paid their own costs to participate in the evaluation and operated their mitigation technologies during the tests. The test participants provided data to the laboratories on their system's detection of aircraft over the test area at the end of each day. Their radar detections were compared to actual GPS data from test program aircraft to evaluate their technology's performance and potential to mitigate wind turbine interference.

Performance Metrics: The data from the tests were used to evaluate the radar system's performance based on widely accepted metrics for plots (probability of detection, probability of false targets, and accuracy of range and azimuth) and tracks (probability of track and false track, probability of track break and survival, and accuracy of range and azimuth).

Major Findings: The first important finding was in characterizing the impact of wind turbines on the ASR-11. For areas without wind turbines, the ASR-11 demonstrated an ability to detect aircraft better than its specifications. However, in the regions directly above and very near the wind turbines, the ASR-11 demonstrated a significant drop in ability to detect aircraft and also produced more false detection reports. These factors combine to detrimentally impact the ability of the ASR-11 to track aircraft as they fly over the local wind farms.

The findings regarding the mitigation technologies are not approved for public dissemination at this time.

Additional Benefits: The test data will provide additional insights and a deeper scientific understanding into the phenomenology of wind turbine interference on radar systems. The data will be used by government researchers to develop new mitigation technologies. The test participants will be able to use their proprietary information from the tests for product improvements.

Conclusions: The first and second of three planned IFT&E campaigns have been successful, meeting program objectives by providing a very extensive data set and much deeper understanding of the wind turbine-radar interference problem. This second set of tests provides important answers that can guide decisions for future wind development and air surveillance improvements. In addition, the program has been a model of government interagency and industry collaboration to address our nation's critical needs.

The specific assessments of the technologies evaluated are not included here due to sensitive private and government information concerns.

Next Test Campaign: The third IFT&E flight test campaign is scheduled for April 2013 in King Mountain, TX, and will focus on an Air Route Surveillance Radar (ARSR)-4 long range radar.

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