Fact Sheet on the First Test Results of Interagency Field Test &Evaluation of Wind–Radar Mitigation Technologies PUBLIC RELEASE

CARSR Campaign at Tyler, MN
Test Period: April 23-May 4, 2012. Report: October 2012

Purpose of this Fact Sheet: This document includes background information and a summary of the first of three tests on the effectiveness of mature private sector technologies in mitigating electronic interference from wind turbines on air surveillance systems. This fact sheet contains publically-available information from the first 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 report is labeled under DOD distribution procedures as: "Distribution Statement B: Distribution Authorized to U.S. Government Agencies only (Test & Evaluation, Proprietary, Contractor Performance Information), 31 October 2012, Other requests for this document shall be referred to the IFTE Steering Committee."

Program Justification: Wind turbines present a source of interference with our nation's air surveillance radars. The effects 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 grow substantially in coming years.

Goals of the Program: In response to directives from Congress and the White House, the Interagency Field Test and Evaluation (IFT&E) program was established 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 R&D 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 (CARSR), 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 will also be 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 decided to use two National Laboratories, Massachusetts Institute of Technology Lincoln Laboratory (MIT LL) and 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 assessments for the tests and evaluations.

Test Participant Selection Process: SNL issued a public notification through a Request for Information (RFI) 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 (COTS) 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 decided to invite ten companies to participate in the three IFT&E tests that will evaluate a total of eleven mitigation technologies.

Purpose of Test 1: The purpose of this first test was to collect data that characterizes performance of a newly upgraded CARSR, 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 (LRR) processing upgrade.

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 their maximum electronic interference effects on radar systems. The Tyler CARSR is located within the line of sight of thousands 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 CARSR and the selected mitigation technologies using known targets (test program aircraft), the test area was chosen in the part of the country with a low local spring air traffic utilization rate.

Flight Tests: Key stakeholders from the federal agencies provided invaluable 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 CARSR radar. DOD's 84th Radar Evaluation Squadron (RADES) also provided technical radar support. DHS, DOD, DOE, and NOAA provided critical test program aircraft, flight tracking, and air operations. Eleven different aircraft types were flown for a total of 53 sorties (138 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 including: type, number, speed, altitude, and routes.

Scientific Instrumentation: MIT LL built an Adjunct Radar Analysis Processor (ARAP), computer hardware that was attached to the CARSR to gather echo returns from the aircraft with radar frequency signal measurements (the In-Phase Quadrature data), as well as detection messages from the primary and secondary radar. This data was used to baseline the CARSR's performance when aircraft flew over wind farms and to compare the CARSR's performance to the mitigation technologies. All aircraft involved in the tests carried Global Positioning System (GPS) receivers and other equipment to analyze the CARSR's and the mitigation technology's performance following the flight tests. This data was used to compare the performance of the CARSR and the mitigation technologies against actual flight data.

Wind Industry Involvement: SNL coordinated the data collection effort from wind farm owners, specifically EDF Renewable Energy (formerly enXco), Xcel Energy, and others in the Tyler area. Wind turbine characteristics and SCADA data from the turbines including wind speed and rotor rotation rate was gathered from a large representative sample of 677 wind turbines in and around the test area. This data, when combined with the radar and flight data, enables the Laboratories to characterize the effects wind turbine interference and predict effects on similar radar systems in other locations with a higher level of confidence.

Test 1 Participants: The test participants—C Speed, SRC, and Raytheon—each paid their own costs to participate in the evaluation, operated their mitigation technologies during the tests, and all were very cooperative throughout the process. The test participants provided data to the Laboratories on their system's performance in detecting aircraft over wind farms at the end of each day of testing. Their radar detections were compared to actual GPS data from test program aircraft to evaluate their technology's potential to mitigate wind turbine interference.

Performance Metrics: The data from the tests was 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 characterizing the impact of wind turbines on the CARSR. For areas without wind turbines, the CARSR demonstrated an ability to detect aircraft better than its specifications. However, in the regions directly above and very near the wind turbines, the CARSR demonstrated a significant drop in ability to detect aircraft and produced more false detection reports. These factors combine to detrimentally impact the ability of the CARSR to track aircraft as they fly over the local wind farms.

The next important finding was evaluating the performance of the three different mitigation technologies. Raytheon's LRR upgrade was new software for the CARSR that changes the way it detects and tracks targets. The upgrade demonstrated an improved ability to detect targets, but only marginal improvements in tracking.

SRC and C Speed both demonstrated in-fill radars—these are shorter range radars intended to provide improved coverage just in the local area of the wind farm, and would augment the CARSR radar coverage. Both of these systems used alternative waveforms and processing to increase the ability to detect an aircraft around a wind farm. They were both very successful in providing much better detection in and around the wind farms than the CARSR. However, during the tests they also experienced a much higher false alarm rate in general.

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 of three planned IFT&E campaign was a success, meeting program objectives by providing a very extensive data set and much deeper understanding of the wind turbine-radar interference problem. This first set of tests provides important answers that can guide decisions for future wind development and air surveillance improvements. It 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 government information concerns.

Next Test Campaign: The second IFT&E flight test campaign is scheduled for October 2012 in Abilene, TX, and will focus on ASR-11 terminal radar.

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