

**UNITED STATES  
TRANSPORTATION COMMAND  
COOPERATIVE RESEARCH AND  
DEVELOPMENT AGREEMENT**

**“Assessment of Wind Farm  
Construction on Radar  
Performance”**

**Operations Working Group  
RESEARCH CONCLUSIONS AND  
RECOMMENDATIONS  
Interim Report  
to  
Joint Technical Working Group**

**January 20, 2010**

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## **Background and Introduction**

Three energy firms are proposing to construct 142 wind turbines within an established wind resource area (WRA) in Solano County, California. The proposed turbines will be located within a wind farm of approximately 833 existing turbines, the closest of which is located 4.65 nautical miles southeast of Travis Air Force Base (AFB). Over the past two years, FPL Energy Montezuma Wind, LLC (Montezuma Wind), Sacramento Municipal Utility District (SMUD), and enXco Development Corp (enXco) have undertaken the steps necessary to pursue appropriate and applicable zoning and permitting of their respective projects. It was during this local and federal review process that the 60<sup>th</sup> Air Mobility Wing (AMW) at Travis AFB expressed concerns that the proposed turbines could interfere with the base's ability to provide safe and efficient air traffic services to aircraft operating in the vicinity of the WRA. The 60<sup>th</sup> AMW's primary concern focused on the potential impact caused by wind turbines on the terminal surveillance radar used by air traffic controllers to provide radar services to aircraft.

Subsequent to findings of "no hazard to air navigation" by the Federal Aviation Administration for the three proposed projects, the 60<sup>th</sup> AMW invited the three energy firms to enter into a Cooperative Research and Development Agreement (CRADA) with the United States Transportation Command (parent command to Air Mobility Command, in turn parent to the 60<sup>th</sup> AMW). The objective of the CRADA was to determine the "projected impact of wind turbine development upon air traffic operations near Travis Air Force Base (TAFB), California". The CRADA's purpose was threefold. First, the CRADA was to provide a means to "obtain reliable, objective data to assess current air traffic operational radar coverage in the TAFB area". Second, to "run a simulation to assess the predicted air traffic operational impact potentially caused by proposed wind turbine development". Third, to "assess the operational impact upon the Travis AFB air traffic control areas of Shiloh III, Montezuma Wind and Solano Wind Phase 3 wind projects".

All three energy firms agreed to enter into the agreement in October of 2009. The CRADA was finalized in December of the same year and became the basis for the formation of a Joint Technical Working Group (JTWG) consisting of representatives from the Air Force Flight Standards Agency (AFFSA), Air Mobility Command (AMC), Westslope Consulting, LLC (Westslope), Montezuma Wind, SMUD, Travis AFB, as well as consultants that the participants invited/directed to participate on their behalf, including Idaho National Laboratories (INL), JDA Aviation Technology Solutions, URS Corp, and Volpe National Transportation Systems Center.

The JTWG was tasked to determine the impact from the proposed wind projects on air traffic operations at Travis AFB based on research conducted by two smaller, more focused, working groups, the Radar Working Group (RWG) and the Operations Working

Group (OWG). Upon completion of a baseline surveillance coverage study and predictive simulation conducted by the RWG, the OWG was tasked to determine the significance of impact resulting from the findings of the RWG on air traffic operations and make recommendations to the JTWG regarding the overall operational impact resulting from the three proposed wind projects.

### **Operations Working Group**

The OWG was founded under the auspices of the USTRANSCOM CRADA to provide an overall assessment and recommendations regarding the impact of the three proposed wind turbine projects on air traffic operations in the vicinity of the WRA. The group consists of representatives and subject matter experts from the AFFSA, AMC, 60<sup>th</sup> AMW, JDA Aviation Technology Solutions, and Westslope. Active members include:

Benjamin Doyle – JDA Aviation Technology Solutions  
Ron Morgan – Morgan Aviation  
Lt. Col. Brian Lindsey – 60<sup>th</sup> AMW  
Maj. Monty Harshner – 60<sup>th</sup> AMW  
Maj. John Flynn – 60<sup>th</sup> AMW  
1st Lt. Clifford Cochran – 60<sup>th</sup> AMW  
Geoff Blackman – Westslope  
CMSgt. Laurence Cole – AFFSA  
John Tigue – AMC  
Kevin Beebe – AMC

### **Methodology**

Under the CRADA the OWG was assigned two tasks. They were: 1) define the air traffic requirements for the airspace over and adjacent to the WRA; and 2) assess the findings of the RWG and make a determination regarding the level of significance of any impacts identified. The CRADA outlined these two tasks as follows:

#### **TASK 1: Air Traffic Requirements**

- The OWG defines the classification of airspace overlaying and in proximity to the WRA.
- The OWG determines the minimal and acceptable level of air traffic control service based upon federal guidelines outlined under the Code of Federal Regulations, FAA Orders and Air Force Instructions (AFI).
- The OWG identifies communications, navigation and surveillance system performance necessary to provide the level of service.

- If applicable, the OWG identifies deficiencies in policy.

#### TASK 2: Operational Significance Determination

- The OWG assesses the findings of the RWG and determines what air traffic services would not be available or may be degraded as a result of construction of the proposed wind projects.
- The OWG makes a determination and subsequent recommendation regarding the overall operational impact resulting from the proposed wind projects. OWG further recommends any mitigation efforts (if applicable).

In order to accomplish the two assigned tasks, the OWG conducted extensive research into the Code of Federal Regulations, FAA Orders, FAA Handbooks, AFI, Letters of Agreement between Travis AFB and the FAA and Travis operational procedures and training manuals, FLIP and Aeronautical Charts. The purpose of this research was to determine the classification of airspace overlaying and in proximity to the WRA. Additionally, this research aided in identifying the roles and responsibilities of Travis Air Traffic Control (ATC), Oakland Air Route Traffic Control Center (ARTCC), and pilots operating under both Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) flight plans. Particular focus was placed on aircraft equipment and ATC communication, navigation and surveillance requirements in accordance with FAA and Air Force standards.

In accordance with the RWG's findings, the OWG ruled out any impacts on aircraft utilizing active transponders. Wind turbines do not impact secondary radar signals in the airspace assigned to TAFB. Likewise, the OWG ruled out any impact on transponder equipped VFR aircraft and focused primarily on non-transponder aircraft operations.

#### **Study Findings**

The OWG determined that the airspace over the WRA is designated as Class E airspace as established under the Code of Federal Regulations with a floor of 700 feet above ground level (San Francisco Sectional Ed 83 Pub 27-Aug-2009). The FAA delegated the authority to provide air traffic services to Travis AFB within the Class D airspace (that airspace within 5 statute miles of the airport) and the larger, Class E airspace which overlays the WRA. The FAA establishes the minimum level of safety based on the classification of airspace. The FAA has determined that the level of service provided to aircraft within these classifications of airspace does not require radar service. There are no published minimum operational standards for surveillance coverage. The operational safety practices defined through federal aviation regulation operating procedures dictate an acceptable level of risk and safety for operations.

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Class E airspace is controlled airspace that imposes few requirements on pilots operating during visual meteorological conditions (minimum of 1,000 foot ceiling and three miles visibility). There is no minimum aircraft equipment requirement, pilots do not have to file a flight plan nor are they obligated to contact air traffic control for entry into Class E airspace. Pilots operating under these conditions are required to “see and avoid” other aircraft, terrain and obstacles. However, pilots may request air traffic advisories, which air traffic controllers must provide if their workload, radar presentation and equipment permits.

Travis ATC provides air traffic services to both VFR and IFR aircraft operating within its Class E airspace. To aid in the provision of this service and to meet its mission requirements, the Air Force procured and installed an Airport Surveillance Radar model-11 (ASR-11) terminal surveillance radar. This radar provides an increased level of safety above and beyond the minimum “see and avoid” operations standard in Class E airspace. Additionally, the radar enables air traffic control to provide services to a larger number of aircraft than would otherwise be provided in controlled airspace without radar coverage. This efficiency of operations and increased safety is paramount in the overall assessment of operational impact.

It is important to note the airspace over the WRA is complex. The radar downwind pattern and tactical arrivals into Travis AFB extend over the WRA at 2-4000 ft MSL and above. Air traffic controllers at Travis AFB provide service to aircraft flying in and out of Buchanan Field, located in Concord, and Rio Vista Municipal Airport. The initial approach segments of all three instrument approaches into Buchanan Field originate over the WRA at 2500 ft MSL. The missed approach segment for the RNAV (GPS) approach into Rio Vista involves a climbing left turn to 2000 ft MSL over the eastern third of the WRA. Due to its convenient location with no air traffic control interference, the airspace over the WRA is used by student pilots off Buchanan Field and Rio Vista for basic VFR training maneuvers. Also, IFR traffic between the Sacramento and Oakland VORTACs fly through the center of the WRA on Victor-6 as low as 2000 ft MSL. Most importantly, VFR aircraft not equipped with transponders and looking to circumnavigate San Francisco’s 30 nm Mode C Veil frequently transition through the area. These aircraft funnel through the corridor above the WRA (Oakey Gate) and are a primary concern of air traffic controllers working traffic through the WRA.

FAA established a minimum level of safety for Class E airspace that does not require surveillance coverage, degradation of radar coverage caused by wind turbines would not result in a reduction of safety below the minimum standard set by FAA. However, since radar coverage does exist, and that radar coverage increases the safety and efficiency of operations within the airspace, degradation of service could decrease overall safety and efficiency of operations, especially considering the particular

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configuration of the airspace over the WRA. Therefore, it was necessary to identify an acceptable level of degradation in radar coverage, more specifically the ability to accurately detect non-transponder equipped aircraft over the WRA.

In order to determine the level of acceptable degradation, the OWG first determined what services would be denied to pilots operating in proximity to the WRA if a loss or degradation of radar coverage was incurred. Since non-participating aircraft (aircraft that have not established two-way communications with air traffic control and do not have an active transponder) are not reliant upon air traffic control for services, the loss or reduction of surveillance coverage would have no impact on this type of operation. The one exception would be the issuance of safety alerts to non-participating aircraft. However, this would require the VFR pilot to be monitoring a guard frequency used by Travis ATC. While worth noting, the remoteness of this scenario warrants no consideration.

The separation of non-participating and participating aircraft was then considered. In accordance with FAA Order 7110.65, radar separation between participating and non-participating aircraft is not required in Class E airspace. Separation responsibility between these two types of operations is incumbent upon pilots who must comply with “see and avoid” procedures. It should be noted, however, that traffic alerts must be issued by air traffic controllers to participating aircraft if they are aware of a potential conflict (FAAO 7110.65: 2-1-6). Therefore, a loss or degradation of radar coverage could reduce controller visibility of non-participating, resulting in a negative impact on their ability to provide alerts to participating aircraft.

Today, Travis ATC provides radar separation and advisory services to all aircraft who request it, workload and radar performance permitting. However, current wind turbines degrade visibility over the WRA, a known operational limitation. This limitation of service is circulated to the Aviation community via a note on the VFR Sectional chart covering the WRA. Thus, additional wind turbine development that significantly increases the footprint of the existing WRA could result in additional loss of capability to provide air traffic advisory services to non transponder equipped VFR aircraft requesting them.

Moreover, current wind turbines present false targets which are difficult to distinguish from actual aircraft on the controllers’ displays. Travis controllers are required to issue traffic advisories against these false targets which results in an increased controller workload. The magnitude of the false target presentation is highly dependent upon prevailing wind conditions. An increase in the number of wind turbines could cause an increase in the number of false targets observed by the controllers. However, it should be noted that the number of false targets presently observed by the controllers’ will be significantly reduced, if not eliminated, after a correction to the STARS configuration.

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This correction was temporarily demonstrated by the RWG in December 2009, which clearly showed that the use of Track Eligibility coupled with existing STARS tracking algorithms was able to eliminate false targets even during significant wind activity over the WRA.

Finally, the OWG considered the number of non-participating aircraft likely to be operating at any given time within the lateral limits of the WRA. Initially, it was believed that there were a large number of operations in this area due to flight training at nearby Concord and Rio Vista airports. However, based on the data collection conducted by members of the RWG as part of the scope of the CRADA as well as during installation activities, the number of non-participating aircraft is now estimated to be minimal. The RWG found that approximately 30 primary only flight tracks occurred in October 2009 over the WRA. While weather conditions were favorable for VFR flight during this timeframe, it should be noted that October through March is a lull time for Travis ATC operations and summer traffic can be significantly higher.

Considering all these factors (the airspace classification, operational configuration, air traffic service requirements and traffic workload) the OWG determined that degradation of radar detection resulting from additional wind turbine development in the WRA could result in a degradation of radar services provided to non-participating aircraft, but, given the “see and avoid” requirement, would not constitute a significant degradation of air safety.

In its assessment of impact on air traffic operations, the OWG agreed that a minor reduction in probability of detection (Pd) over the WRA would not create an unsafe operating environment but would decrease the safety and efficiency of operations. While the FAA and the Air Force have a minimum engineering standard used for acquisition of the ASR-11, published in the Department of Defense (DoD) Operational Requirements Document III for Air Traffic Control and Landing Systems, there is no FAA or Air Force minimum operational requirement for Pd for radar services. Since there was no reference point from which to determine the demarcation between acceptable and unacceptable impact, the OWG took into consideration the type and frequency of operations over the WRA to determine a level of degradation of surveillance coverage that would meet operational needs of the Air Force. Additionally, the OWG considered what services would be lost as a result of that degradation and determined that in the best interest of safety and the efficiency of air traffic operations, an average degradation not greater than 5 percentage points below the established baseline values (current performance) of the Pd would be acceptable.

The RWG conducted a baseline data analysis on data collected in October 2009 to determine the Pd for aircraft operating below 4,000 and 10,000 feet over the WRA. This effort analyzed the effect of the existing wind turbines on the ASR-11 at Travis and

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found that the average Pd, seen at the scope by air traffic controllers, is 80.3% below 4,000 feet and 84.2% below 10,000 feet. By comparison, the ASR-11 Pd in similar airspace surrounding Travis was 92.4% below 4,000 feet and 93.73% below 10,000 feet, based on a May 2009 data collection.

The RWG then conducted a simulation of the three proposed wind turbine projects to determine what the Pd would be once they were constructed. According to the results of this study, under a worst case scenario, where complete loss of primary detection over each individual wind turbine is assumed, it is likely that a cumulative reduction of 3.5 percentage points in Pd will occur over the WRA below 4,000 feet and 3.2 percentage points below 10,000 feet. It should be noted that there was insufficient primary traffic (i.e., non-squawking aircraft) to measure the drop in Pd using best case assumptions. Therefore, the best case drop is assumed to be zero percentage points (i.e., no impact). The airspace adjacent and above the WRA delegated to Travis AFB starts at 700 feet AGL and extends upwards to 10,000 feet MSL. Therefore, the most relevant data from the RWG's analysis is from the surface to 10,000 feet MSL inside of the WRA.

As alluded to above, while collecting the radar data for this study, the RWG identified a configuration error in the STARS automation system that, has been corrected resulting in a substantial reduction in the number of false targets displayed on the scope.

### **Recommendations**

Information and data for this report was obtained from subject matter experts from the United States Air Force, wind energy developers, and technical experts from the aviation industry involved on a daily basis with quality of radar and airspace operational requirements. These individuals represented a broad range of job assignments from executive leadership positions to very technical science and operational skills. Political, operational, and economic considerations were discussed in addition to a focus on technical issues.

The airspace affected by development in the WRA is Class E airspace. This classification of airspace places very few requirements on pilots or air traffic service providers. This is not to say that certain requirements do not exist for both parties. For example, pilots are required to keep transponders "on" if the aircraft is so equipped and the transponder is operating properly (14 CFR Part 91.215). An example of a requirement on the part of the air traffic service provider is the issuance of a safety alert on non-participating aircraft that are in the flight path of a participating aircraft. This later example requires that the controller sees the aircraft on radar or receives a position report via radio from the pilot.

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History shows that the quality of air traffic control services provided by Travis AFB is excellent, acknowledged as excellent by local pilots, and the record of incidents in the airspace above and adjacent to the WRA is close to non-existent.

The RWG evaluated both baseline (data recorded October 2009 from Travis AFB) and simulation data. The overall result of this work indicates that the construction and operation of the three identified projects would not reduce the Pd more than the 5 percentage point margin identified by the OWG to protect the safety and efficiency of operations in proximity to the WRA.

*Therefore, the OWG concludes that, for the three projects evaluated for this report, the construction and operation of wind turbines will not significantly impact the mission of Travis AFB or the safety of aircraft operating in the airspace delegated to Travis AFB by the FAA.*

The working group determined that the analysis, simulation and findings presented exceeded the level of due diligence necessary to assess the impact of the three proposed turbines. However, opportunities exist for additional mitigation that may result in improvements to the Pd over the WRA.

Although false target generation has been resolved through properly configuring the STARS settings, Travis controllers should continuously monitor the scope's presentation and immediately identify any recurrence. Special vigilance is warranted through the next windy season.

Gap-filling and post-construction validation studies by the RWG should proceed in accordance with the CRADA. Gap-filling will determine whether additional feeds into Travis' STARS using Stockton ASR-11 and McClellan ASR-9 feeds will provide an improvement in Pd at the controllers' displays. Once the additional feeds are installed, the ASR-11's performance should be re-analyzed. This work should be conducted during seasonally higher winds and traffic loads, the month of July being preferred.

Additionally, a study should be considered to determine whether the overlapping radar coverage of the Stockton ASR-11 in the South sector of the airspace controlled by Travis ATC could be used instead of the Travis AFB ASR-11. The Stockton ASR-11 may be less susceptible to interference from the WRA given that part or all of the wind turbines in the WRA are masked by the terrain/curvature of the earth. If the addition of overlapping radar coverage is ultimately implemented, radar coverage over the WRA should be re-baselined.

Post-construction validation should include a re-baselining of the Travis ASR-11 performance. Once validated, this methodology should be used to evaluate future

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proposed wind turbine projects against the standard recommended by the OWG (October 2009 baseline – 5 percentage points).

Additionally, Travis AFB should work closely with the local Flight Standards Office on outreach to the General Aviation community, specifically with respect to radar limitations over the WRA and the impact they have on ATC services available and to FAR requirements governing the use of transponders.. Airfield visits performed under Travis AFB's Mid-Air Collision Avoidance program is one excellent avenue for this effort.

### **Conclusion**

The working groups charged with evaluating the impacts of the three proposed projects targeted at construction and operation in the WRA completed an exhaustive review. This study was focused on mission requirements of Travis AFB and the safety of the airspace above and adjacent to the WRA. The results of this study are that there should be no significant impact due to the construction and operation of these projects. All minor impacts are manageable and fall within the expected levels of safety and risk for the airspace being evaluated. Worst case predicted radar impacts fall within the informal standard for operational efficiency of air traffic control radars in both the US Air Force and the FAA.