Advances In Avian Radars For Protecting Birds At Challenging Wind Energy Sites

Presented at WINDPOWER 2012 by T. Adam Kelly, Jesse Lewis, Tim West, Dr. Karen Voltura, & Jenny Davenport (DeTect, Inc. Panama City, Florida USA)

ABSTRACT:

Radar has become an important tool for gathering unparalleled information on bird activity at proposed and existing wind energy developments sites. Several issues have hindered the potential usefulness of traditional Avian Radar Systems at sites with challenging terrain and high ground clutter, and recently, wave clutter as wind energy develops offshore. Recent advances in several radar, including both Doppler and solid-state radar, and frequency diversity processing are now available to significantly reduce clutter, when used alone or in combination with other technologies.

The addition of frequency diversity and Doppler processing to Avian Radar Systems has been greatly aided by the transition to modern solid-state radars. Solid state radars use transistors instead of the traditional magnetron transmitter, and their coherency along with known wave phases and high-quality equipment, enable solid state radars to produce better imaging under difficult conditions with high clutter. Solid state radars are an ideal host for Doppler, and when these signal processing techniques are used together the reduction in clutter is amplified and can now produce super-high resolution data in which clutter is confined in both range and azimuth. This not only reduces clutter but prepares the radar data to be more easily decorrelated using other technologies such as Frequency Diversity, further decreasing clutter. Together, all these radar technologies now allow us to detect birds at sites with strong background clutter such as waves offshore and challenging terrain.

The Raptor Issue: Concern over raptor collisions at wind turbines has increased dramatically, particularly for Golden Eagles and California Condors in the western United States as wind energy continues to expand into the range of these species. Radar can be a useful tool to monitor raptors and provide options for mitigation of mortality, but many sites with potential or known raptor issues also have environments that present challenges for traditional avian radar systems. These challenges include landscapes with significant elevation changes and vegetation with high-water content, both situations that produce high ground clutter that inhibits detection of bird targets.

OBJECTIVES: The objectives of the radar tests were to:

1. Validate that solid state and Doppler radar technology are able to adequately reduce ground clutter for detection of single targets in high-clutter environments .
2. Apply these advanced radar technologies to mitigation strategies using Avian Radar Systems for raptor detection.

METHODS: Several advanced radar technologies were tested for proposed wind energy projects at locations that produced heavy ground clutter on radar images when traditional avian radar configurations were used. These new radar technologies were applied to determine optimal configurations to both minimize heavy ground clutter and maximize detection of targets such as birds and bats.

Desert Site - The first site was in the Sonoran Desert of the southwestern United States and contained abundant vegetation with high water content (Figure 1). This unique vegetation produced prolific ground clutter with a traditional S-band (10-cm wavelength), 30-kW magnetron horizontal surveillance radar. Therefore, a 5.5 meter solid state (instead of magnetron), X-band (instead of S-band) horizontal surveillance radar was used (Figure 2). The new radar also used enhanced pulse compression and a Doppler processor with 32 Doppler filters (16 inbound and 16 outbound).

Mountainous Site – Several additional sites were located in the mountains of southern California (Figure 3). The high-relief and elevation changes again created prolific ground clutter on a traditional avian radar system using magnetron horizontal surveillance radar. Both X- and S-band solid state horizontal surveillance radars was tested at these sites (Figure 4). These radars also used enhanced pulse compression and a Doppler processor with 16 Doppler filters (8 inbound and 8 outbound).

Figure 1. Vegetation with high water content that produced high-clutter environment at the wind farm site.

Figure 2. MERLIN XX25200e Avian Radar System with enhanced resolution.

Figure 3. Mountainous landscape produced intense returns of radar energy and a high-clutter environment at the wind farm site.

Figure 4. MERLIN system with both X- and S-band solid-state Doppler radar.

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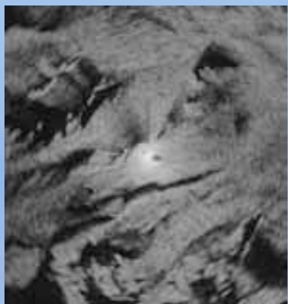
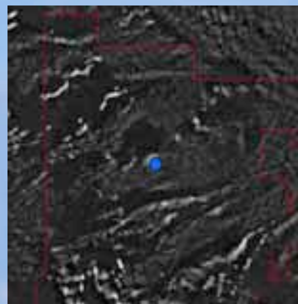
RESULTS:

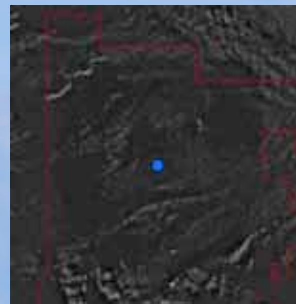
Desert Site - Changing the horizontal surveillance radar from a magnetron S-band to a longer 5.5-m solid state, X-band radar antenna allowed the azimuth resolution to increase from 2.0° to 0.45°. The addition of the enhanced pulse compression to the receiver increased the range resolution from 25 m to 10 m. This increased resolution confined ground clutter spatially, both in range and azimuth, freeing the remaining areas to detect and track biological targets. The application of Doppler processing to this system further filtered out stationary ground clutter.



(Above left) - Initial horizontal radar image from a magnetron S-band radar. Light areas represent extensive ground clutter produced by vegetation with high water content abundant at the test site; target detection and tracking was poor or impossible in these areas



(Above middle) - Horizontal radar image produced by an 5.5-m solid state, X-band radar with a Doppler processor. No Doppler filters were applied to this image, and white areas still show some areas with high ground clutter.

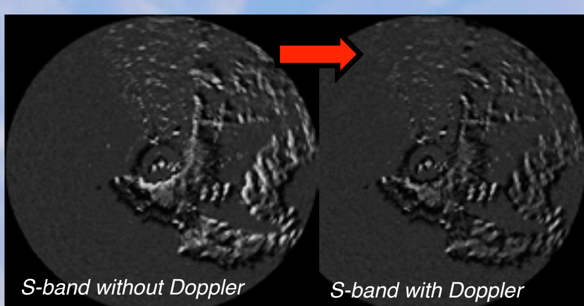


(Above right) - Horizontal radar image from a solid state, X-band radar, and Doppler filters applied to filter out stationary (zero velocity) targets.

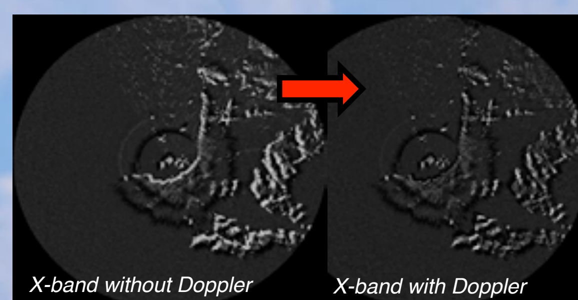
(Below) - Horizontal radar image showing ground clutter minimized by solid state and Doppler radar technology. This ultimately allowed biological targets to be detected in areas previously obscured by ground clutter. Both birds flying in the air, and humans walking on the ground, are labeled, and show how people walking on the surface of the ground can be detected up to 6.9 km from the radar.

California Condor are one of the several protected raptors currently at risk of colliding with wind turbines and potentially benefiting from new radar technology allowing detection of single targets in high-clutter environments prevalent throughout their range.

Mountainous Site – Both X- and S-band solid-state horizontal surveillance radars were tested at sites with high relief. The solid-state technology increased azimuth resolution which confined the areas of high ground clutter caused by radar energy bouncing off the surrounding hillsides. The enhanced pulse compression and the application of Doppler processing to this system further filtered out stationary ground clutter.



Left - Horizontal radar image from at a mountainous site using an S-band solid state radar with no Doppler filters (left) and all 16 Doppler filers (right). White indicates area with intense returns of radar energy from the surrounding hillsides; black indicates clear air; Right - Same as image pair to the left, but with X-band solid state radar.



CONCLUSIONS:

- New, advanced avian radar technologies now provide improved detection of birds in challenging environments. Specifically, the combination of solid-state radar technology and Doppler processing allows enhanced radar imaging that spatially confines ground clutter and allows bird targets to be detected in areas previously obscured by clutter.
- Reliable detection of single large bird targets in difficult terrain is a critical step in mitigation strategies using Avian Radar Systems to detect and protect raptors at risk of colliding with wind turbines.
- DeTect's MERLIN *SCADA*-R ™ is a radar-based mitigation system in which wind turbine(s) would be idled whenever a target with characteristics of the species of interest occurred within a pre-specified risk area around each wind turbine. This system, when used with the appropriate site-specific information, provides a valuable mitigation option for sites having Golden Eagles, California Condors and other raptors at risk of collision with wind turbines.
- Additionally, new long-range bioacoustic deterrent technologies successfully being used in conjunction with avian radar systems at industrial sites, such as Canadian Oil Sands tailings ponds, show promise for use in wind energy to humanely deter birds approaching wind turbines without loss of clean, renewable energy production.

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