DeTect's Visual Warning System (VWS) for Automatic Activation of Obstruction Lighting at Wind Farms

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Abstract

Wind farms are required by the FAA to install and maintain aviation obstruction lighting systems to provide aircraft a visual warning of the collision risk. Many stakeholders recognize the environmental and social impacts of obstruction lighting at wind farms and are exploring strategies to mitigate the impact on surrounding communities. In response, the FAA is developing regulatory guidance to allow wind farms to install obstruction lighting systems that are automatically activated when aircraft are present and deactivated when aircraft are absent.

DeTect, Inc. has developed the HARRIER Visual Warning System (VWS), a ground radar-based VWS using high-resolution, airspace surveillance with automated activation of wind farm obstruction lighting when aircraft are detected within defined perimeters. The DeTect system provides extended-range detection of cooperative and non-cooperative aircraft, including ultralight aircraft, with 360-degree coverage and detection up to 24 nm range. DeTect's VWS is multi-function capable and can additionally provide site security and bird detection for environmental monitoring and mitigation. The system was installed in 2012 at DeTect's first VWS installation in the western United States.

Objectives

First installation of the Harrier Visual Warning System in the western United States.

The primary objective for HARRIER VWS is to continuously monitor for approaching aircraft in the vicinity of a wind farm or other designated obstruction (power line, building, water tower, etc.), and when aircraft are detected to automatically activate obstruction lighting. Each HARRIER VWS radar sensor is capable of monitoring the airspace up to 12 nm from its location for ultralight aircraft and up to 24 nm for other aircraft, but only aircraft entering a custom configured exclusion zone will trigger the activation of the obstruction's warning lighting.

Examples of user defined exclusion zone criteria include:

- any aircraft entering within 3 nautical miles and less than 1000 feet in altitude, or
- any aircraft whose speed and trajectory is calculated to impact in less than 30 seconds.

Each of these scenarios is field programmable based on the regulations set forth by the governing body for a specific region (e.g. FAA, NavCanada, etc.).

Methods and Technical Specifications

HARRIER uses the marine frequency bands in S- (2920 to 3080 MHz) and X- (9210 to 9490 MHz) with low power density, solid state transmitters, which greatly minimize the likelihood of frequency conflict with other systems such as air traffic, weather radars and communications networks. HARRIER meets or exceeds all FCC, FIPS, IEC and most anticipated safety requirements/regulations. The FCC has approved the S- and X-band sensors used in HARRIER for land based use in all US locations and the HARRIER system has been tested by the USAF (USAF AF 2759), NASA and the Canadian government for EMC compliance. DeTect's HARRIER system is based on the MERLIN software and hardware platform developed to detect and track low, variable RCS, irregularly moving, low altitude targets. MERLIN is not a modified aircraft or ship tracking system and all detection and tracking algorithms were specifically developed and programmed to 'look' for and follow targets with these characteristics. The resulting MERLIN system is a highly sensitive sensor system that can reliably detect and track very small Radar Cross Section (RCS) targets. In addition, MERLIN has automated clutter suppression and Doppler processing to improve detection of low signal ratio targets at low altitudes near ground level (within a few feet) and in high, complex clutter environments. The tracking algorithms in MERLIN were additionally designed to correlate irregularly moving birds as they traverse the landscape making the system highly applicable to tracking of evasive targets, and for detection and tracking of other cooperative and non-cooperative airborne targets. DeTect's HARRIER radar processing software is user customizable to 'tune' the system to detect, track and display only targets within the user desired target class based on a variety of parameters that include size, speed, and track characteristics. The system is fully networkable and remotely controllable via low bandwidth wireless, satellite or fixed networks with real-time data display, data transmission, diagnostics, Health and Status Monitoring (HSM), and hardware and software control available to multiple remote users via a variety of communication and network protocols (includes complete remote system shutdown and "cold" startup capability).

Failsafe Operations and Communication Protocols

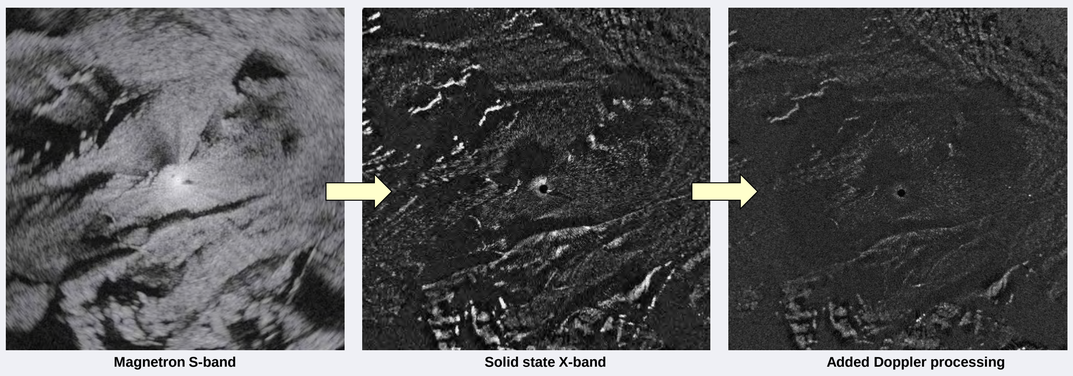
The Harrier VWS Radar System operates in a failsafe manner. The site's obstruction lighting control system will send the "activate lighting" signal to the obstruction lighting system controller to turn on the lights.

- The radar system connects to the site's existing lighting system controller via a fiber optic or other designated high speed network. The Harrier VWS System is allocated its own network address range that is not used by the rest of the site as part of the "firewall" protocol separating radar operations from a site's wind/resource management operations. Fiber optic is the preferred media for this data link to ensure: 1) isolation from lightning strikes and other electrical surges, 2) isolation of the HARRIER VWS network from the sites resource control network.
- The first command is a "heartbeat" indicator that will provide system status of the VWS and its network, and a failure in the Harrier VWS will turn the obstruction warning lights on (i.e. failsafe). When the heartbeat command is present, the Harrier VWS is operational and the state of the light control switch determines if the lights are activated. When the heartbeat command is absent, the Harrier VWS or network components are non-operational and the failsafe operation to power the light circuit is in effect (e.g. photocell for night only operation, or always on depending on the requirement for each specific obstruction).
- The second command is the "aircraft detected" indicator, which will activate the lights when an aircraft has been detected within the designated range of the obstruction.

The infrastructure for communications between radar and obstruction lighting may vary from project to project. In some cases, dry contract switches are used as the system trigger, while in other cases the system may communicate directly with the lighting controller via a specific protocol (e.g. MODBUS over TCP/IP). The infrastructure may include fiber, wire and even wireless (RF) configurations. Failsafe concept of operations will follow the same logic and principles no matter which type of infrastructure and/or communication protocol is deployed.

Case Study

Radar sensors- Minimization of ground clutter is important for allowing the detection of aircraft. Recent advances in several radar technologies are very effective in reducing high ground clutter in radar data including both Doppler and solid state radar. 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. In the images below, 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 targets of interest. The application of Doppler processing to this system further filtered out stationary ground clutter.



Magnetron S-band

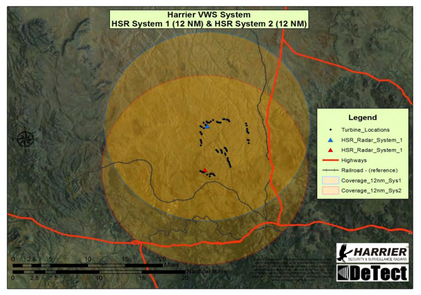
(Above left) - Initial horizontal radar image from a magnetron S-band radar. Light areas represent extensive ground clutter produced by vegetation with high water content abundant at the test site; target detection and tracking was poor or impossible in these areas.

Solid state X-band

(Above middle) - Horizontal radar image produced by a 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.

Added Doppler processing

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



A DeTect VWS system was installed at a wind farm in the western United States in 2012. The coverage map on the left shows the radar coverage for the location: 2 ground-based radars are located on site, one at a northern location and one to the south. Dual sensors increase coverage at the site for aircraft detection and provides equipment redundancy in case of maintenance or communication issues. The solid state X-band sensor was selected for this installation to manage clutter issues in the high relief location.

The image on the right is a screen shot of the HARRIER real-time display with risk zones and an aircraft track. The risk zone is determined by user requirements and in this case is set to 5 nm from the outermost turbines. The window at the top left of the image displays the status of the HARRIER radar system and the status of the obstruction lights. If the radar is offline the HARRIER status would be red and the obstruction lights would default to on. In this case the radar is online and HARRIER status is green, the aircraft is tracking within the detection zone and the lights are on. Once the aircraft target leaves the detection zone a countdown starts and the lights are turned off after a pre-determined time period.

Conclusions

DeTect's HARRIER Visual Warning System provides continuous 360 degree radar surveillance of the airspace around a wind farm automatically activating obstruction lighting when aircraft are detected at a defined outer perimeter.

- ***Long range capability provides margin of safety***
- ***Compatible with all turbines, communication networks & lighting systems***
- ***State-of-the-art Doppler solid state ground-based sensors***

HARRIER™ SECURITY & SURVEILLANCE RADARS

DeTect APPLIED RADAR TECHNOLOGIES