



DeTect offers a full range of production model avian radar systems for bird and bat pre-construction survey, post-construction monitoring and operational risk mitigation. DeTect's MERLIN system provides reliable, easily maintained and supported solutions for wind farms, landfills, airports, mines and industrial facility resource management.

Ornithological radar (avian radar) represents the state-of-the-art in quantitative methodologies for bird and bat survey, monitoring and risk mitigation.

Introduction

Radar systems are currently widely used to assess bird and bat mortality risk related to wind farms, new airports, communication towers and similar projects with bird and bat issues. Systems are also increasingly used for operational monitoring, risk mitigation, migratory research and habitat studies.

Ornithological radar (avian radars) represents the state-of-the-art in quantitative methodology for surveys and site monitoring, and the more advanced systems can provide large, highly reliable datasets for detailed analysis while eliminating deficiencies inherent in other biological survey methods. This introduction provides an overview of the current state of avian radar technology and includes a comparison of the various methodologies currently in use for bird and bat surveys.



MERLIN XS1030e Avian Radar System designed and manufactured by DeTect, Inc. of Panama City, Florida USA



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Bird & Bat Radar Systems

Since its advent in the 1940s, radar has been known to be able to detect and track biological targets (birds, bats, insects). Today, radar is currently widely used to collect data to assess bird and bat mortality risk related to wind farms, new airports, communication towers and similar projects, and for aviation safety, migratory research, and habitat studies.

Current systems consist of one or two commercial radars, some with ancillary equipment for enhanced functionality and automation. The commercially available marine radar with a "T-bar" type antenna is most commonly used due to its wide acceptance, low cost, broad beam coverage, ease of use, and robust, proven reliability. In recent years, advances in electronics have improved the ability to interface radars with computers to automate data processing and collection with specialized radar tracking and signal processing software.



Example of T-bar type marine radar originally developed for maritime weather and navigation.



RADAR ORNITHOLOGY OVERVIEW

Other types of radars have also been used for avian surveys, including parabolic-dish, pencil beam and conical beam radars, however these systems are less frequently used due to their high cost, limited range, limited beam coverage and/or high maintenance costs.

Operating Configurations

Most radars for ornithological applications include single or dual radar configurations with T-bar type antennas. For single radar systems, an X-band (3 centimeter wavelength) radar with 6 to 50 kilowatt (kW) radar power is operated in alternating horizontal and vertical positions for the survey, with the radar manually “tilted” by the operator periodically. In the horizontal position (the normal operating position for a marine radar), the radar sends out a fan-shaped beam 360 degrees around its location returning x-y

coordinates for targets detected within its range (usually 2-6 miles). The beam angle is normally around 20 degrees (depending on the manufacturer).

For vertical operation, the radar is tilted on its side operating in a windmill-type manner scanning horizon-to-horizon through the vertical plane using the vertical scanning method (Harmata et al., 1999). In this orientation, the radar scans a vertical slice through the atmosphere collecting data on target altitude across the scan width providing y (distance) and z (altitude) locational data on targets. For avian survey and monitoring, an X-band radar can reliably detect small bird targets up to one-half to two miles (mi) to either side of the radar and upwards of 5,000 feet (ft) above the radar (depending on the radar power and antenna length).

More advanced systems are increasingly available that utilize a two radar configuration consisting of a vertically operated X-band

Comparison of radars used for radar ornithology.

Radar Type	Advantages	Disadvantages
3D (air traffic, military)	<ul style="list-style-type: none"> Provides true 3D coverage Good resolution and range 	<ul style="list-style-type: none"> Expensive (very high; >\$1 million) Limited access (part of air traffic control network, restricted military technology)
Marine w/ T-bar antenna	<ul style="list-style-type: none"> Cost effective (low to medium cost) Proven technology and durability Extensive history of use for bird detection In dual configuration provides effective 2 ½ D coverage with height detection Good range for cost Broad beam width (vertical and horizontal) Covers airfield approach and departure corridors with wide beam 	<ul style="list-style-type: none"> Not capable of full 3D coverage
Marine w/ Pencil-beam/ Parabolic dish antenna	<ul style="list-style-type: none"> Cost effective (low to medium cost) Proven durability 	<ul style="list-style-type: none"> Limited use in bird detection Not capable of full 3D coverage Narrow beam with limited range and coverage No height detection Not capable of covering airfield approach and departure corridors
Marine w/ Conical Scan antenna	<ul style="list-style-type: none"> Cost effective (low to medium cost) Proven durability 	<ul style="list-style-type: none"> Limited use in bird detection Narrow beam with limited range and coverage Not capable of full 3D coverage Not capable of covering airfields approach and departure corridors
Microwave Scanning	<ul style="list-style-type: none"> Moderate cost 	<ul style="list-style-type: none"> Limited use in bird detection Limited range



VERTICAL & HORIZONTAL RADAR SCANNING

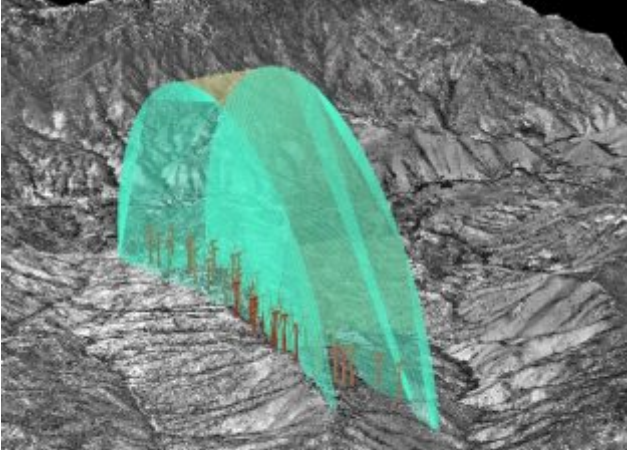


Illustration of the vertical scanning radar providing horizon-to-horizon coverage of wind farm turbines at a California project site.

radar (10-50 kW power) and a horizontally operated S-band (10 centimeter) radar (30-60 kW power). The X- and S-band radars use different frequencies and therefore can be operated simultaneously without interference, collecting data in both the vertical and horizontal directions continually with no “data gaps”.

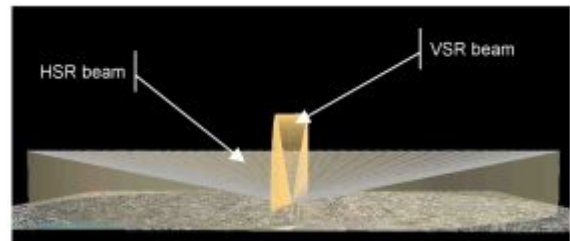
Depending on the radar power selected, these systems can reliably detect and track small birds up to 5,000 ft vertically and out to 2-3 mi horizontally (medium and large sized birds and flocks can be reliably detected and tracked up to 10,000 ft vertically and out to 6-8 nm horizontally).



Radar Data Processing Methodologies

Target identification, tracking, classification (target size or flock), and enumeration (counting) can be done manually by a skilled radar ornithologist, or automatically using commercial or custom developed radar software programs. Manual radar interpretation involves having a highly skilled radar ornithologist monitor the radar screen continuously throughout the survey period to identify bird target tracks in the “raw” (unprocessed) radar imagery.

Illustration of dual radar coverage. Horizon-to-horizon vertical (VSR) beam end view (orange) with 360 degree horizontal (HSR) beam coverage (gray).



The radar ornithologist monitors the radar screen to locate target tracks, verify them as probable biologicals (birds or bats) and manually record each track's time, relative size, bearing and speed for later tabulation and analysis. The radar in this instance becomes an extension of the biologist's ability to locate, count and track bird targets and

DeTect MERLIN XS1030e Avian Radar System with dual marine radars (system purchased by Babcock & Brown; operating 24-7 at the proposed Gulf Wind I windfarm site in south Texas, USA). The system operates on generator power with an external fuel tank installed next to the radar.



RADAR IMAGERY



greatly extends the distance the biologist can “see” (traditional visual surveys count less than 5% of the birds actually in the immediate environment).

Bird targets in the radar imagery will appear as moving “spots” on the radar display screen, as will other targets (such as insects and aircraft). Both moving and stationary interferences (such as ground clutter, tree lines, and buildings) must also be identified and excluded from the bird/bat count. The radar ornithologist must assess each target and determine whether it is a bird or bat that should be tracked and counted, or whether it should be rejected as a non-biological target or clutter. Some targets will also be occluded by the clutter and as a result cannot be “seen” or counted.

Automated bird detection radar systems use computer software to process, analyze and record the radar information, and can range in sophistication from simple computer-assisted post-processing of screen imagery (recorded screen captures as .bmp or .jpg images) to highly sophisticated, real-time radar target identification, tracking, enumeration, and clutter rejection computer algorithms.

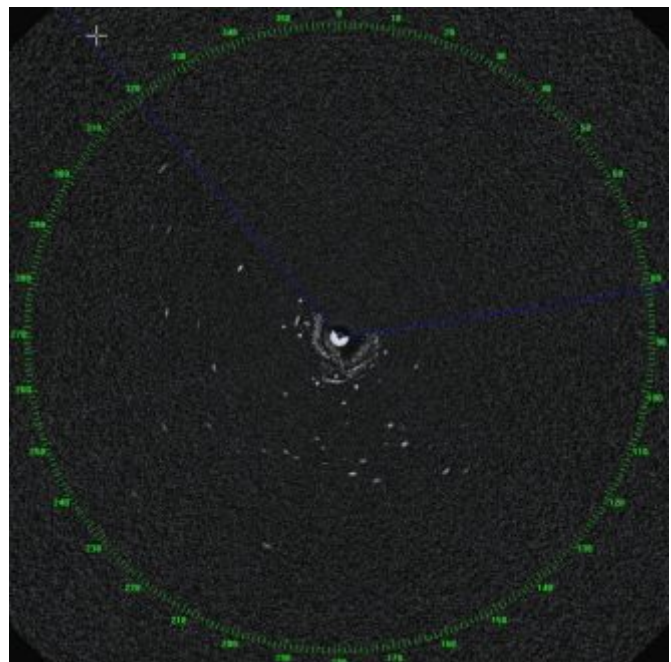
Computer assisted image processing, while more accurate and reliable than manual radar ornithology and standard visual field survey methodologies, is not as reliable nor as capable as the radar processing software

Standard marine radar display showing “raw” radar imagery for horizontally-operated S-band (left monitor) and vertically-operated X-band (right monitor). The dense solid areas are clutter from trees, buildings and radar sidelobe interference.

algorithms used in the more advanced avian radar systems on the market today.

Radar processing software can consist of standard or modified commercial-off-the-shelf (COTS) radar processing software packages (generally aviation, maritime or security radar software) or software that has been custom developed and programmed specifically for bird and bat target detection, tracking, classification and enumeration, and for suppression of clutter and other non-biological interferences inherent in radar data. In the

Raw (unprocessed) marine radar screen image from an offshore survey site. The white “spots” in the image are birds moving over the water. The concentrated white at the center is “clutter” interference from the metal oil platform on which the radar is mounted. The lighter white “static” throughout the image is sea clutter interference caused by the wave tops. The ‘pie-shaped’ area behind the blue lines is the area blocked by the oil platform where the radar cannot “see” (image from raw radar signal from MERLIN XS2530e at the Beatrice Offshore Wind Farm site off the Scottish coast in the North Sea).



ADVANCED RADAR SOFTWARE

most advanced bird and bat detection radar systems, the tracking software has been additionally designed to “look for” and track (follow) avian targets based on their unique behavioral characteristics.

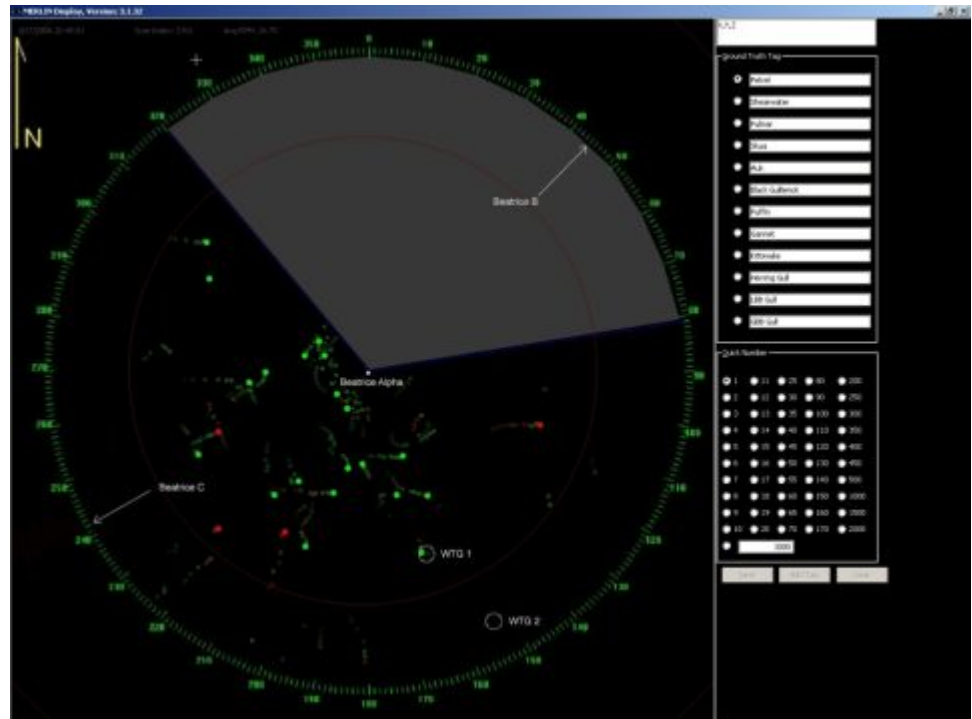
In addition to detecting and tracking bird targets, the advanced radar software programs can also classify targets by size, with the size of the target usually determined by the number of pixels representing the target in the radar display - generally, the larger the target in pixels, the larger it is in real life. Processed bird tracks can be classified by the software into bird size categories: small (S), medium (M), large (L) and flock (F). These categories are qualitative classes that generally match with small, medium and large birds, but exceptions can occur. For example, two small birds in close proximity may appear to the radar software to be a single medium bird, but such exceptions are not statistically significant within the context of the overall survey. The flock category is used when

targets of large spatial extent are recorded which represent more than a single large bird and include multiple large birds flying in close formation, such as a flock of geese.

Target detection in the more sophisticated systems can also be optimized for bird, bat and bird, or bat detection and can be set to exclude certain target types (such as insects) based on the desired target type's various characteristics. Targets over a certain size that exceed the maximum size for a bird or flock of birds can likewise be excluded from the data, although there are systems that have the ability to display both bird and aircraft targets concurrently. New technology is also expected to shortly be available that will provide real-time differentiation of birds and bats as well as some level of species identification using advanced wing beat modulation measurement techniques.

As the level of the avian survey sophistication and technology has improved, the capability, reliability and accuracy of bird

MERLIN processed avian radar image of the raw data in the previous example processed with the MERLIN avian radar software with clutter removed and bird targets converted into clear symbols (red and green “dots”) with history tracks (target trails). The display also includes site specific underlay map to assist in user orientation and interpretation of data in real time.



DATA ACCURACY & PRECISION

and bat surveys has likewise increased. Bird or bat surveys utilizing radar-based methods provide highly accurate quantitative counts. Radar techniques more accurately reflect the true conditions of the environment and result in counts 8-14 times higher than traditional visual survey methodologies as the radar can physically “see” birds that the visual observer cannot (higher resolution); and can “see” birds in all radar beam directions simultaneously (multi-directional).

Automated computer processing systems are also more reliable and accurate than a human radar operator as the human operator simply cannot physically identify, track and count all targets continually, particularly in a “target rich” environment, nor can he/she identify targets obscured by clutter. A computer-based, software driven system provides more reliable bird target identification, tracking and enumeration eliminating “operator fatigue” and individual observer bias inherent in manual methodologies.

Processing software developed specifically for bird and bat detection and tracking is superior to unmodified or modified COTS radar software as it has been developed specifically for the unique behavioral characteristics of birds and bats. An important issue to note is that due to the variation in precision and accuracy of the various methodologies, the data generated by one method is generally not directly comparable to another.

Illustration of level of data accuracy and precision for various



Data Display & Recording

An key advantage of the fully automated, software-based radar survey system for avian survey is the ability to monitor site conditions and collect data continuously in both daytime and nighttime conditions under a variety of visibility conditions. The ability of the radar system to detect, track and record bird targets at night is especially valuable as conventional visual survey methods are non-existent or very limited under these conditions.

Depending on the system used, bird detection radars additionally have the ability to collect data in weather including fog, mist, light rain and light snow. X-band radars though are highly susceptible to weather interference as precipitation (rain, snow, ice) shows up well in the X-band wavelength - even light rain events - obscuring birds in the radar signal. The S-band radar, however, is less susceptible to weather and can operate more effectively during precipitation events as well as provide superior detection over highly vegetated (high clutter) terrain.

There are bird detection radar systems available on the market with features that further enhance data collection during inclement weather periods that include blanking of data collection only in areas of the radar sweep actually impacted by weather. This functionality is critical to effective site surveys and risk assessment as, contrary to popular belief, birds do fly in weather,



RADAR DATA DISPLAYS



Typical dual radar system monitors with horizontal radar display on left and vertical radar display on right (from MERLIN Avian Radar installation at US Air Force Dover)

particularly when migrating, and such circumstances are when the birds are most vulnerable to collision with obstacles (birds can generally avoid what they can see, even at night, but avoidance during periods of low visibility at night is significantly decreased).

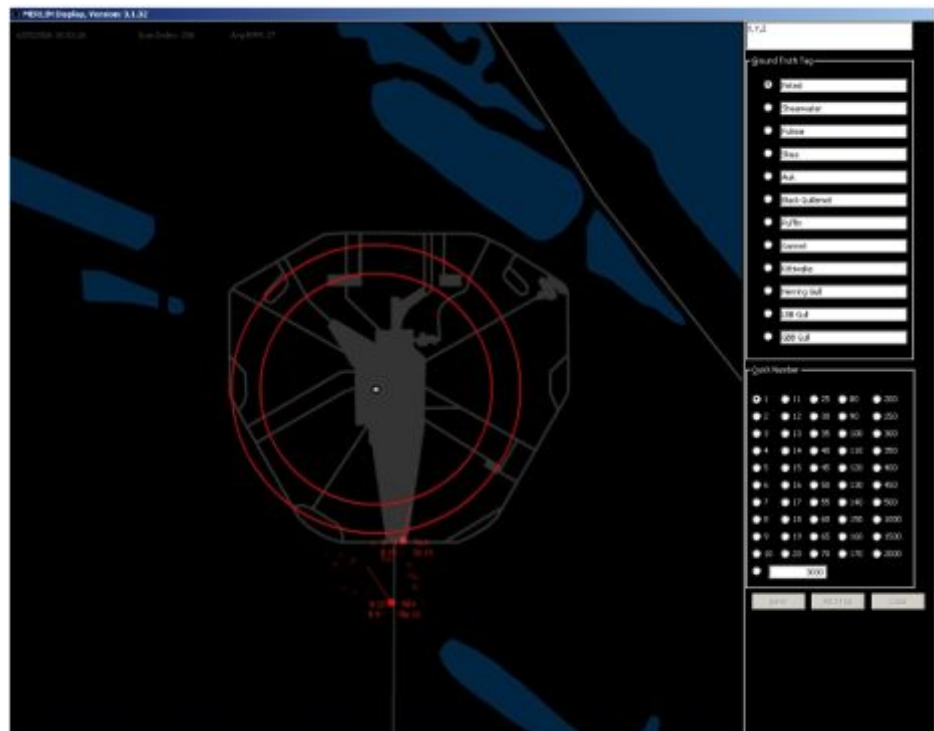
Automated radar systems can detect, track, classify and record bird targets displaying the information in real time while also recording bird target data to databases for detailed post-processing and analysis.

The more advanced systems will display the processed bird track position for the horizontal radar (x,y position) in a Plan Position Indicator (PPI) format with options to add site plan underlays. The vertical radar likewise displays bird target positions and altitudes (y,z) passing through the horizon-to-horizon radar beam sweep or passing along the beam.

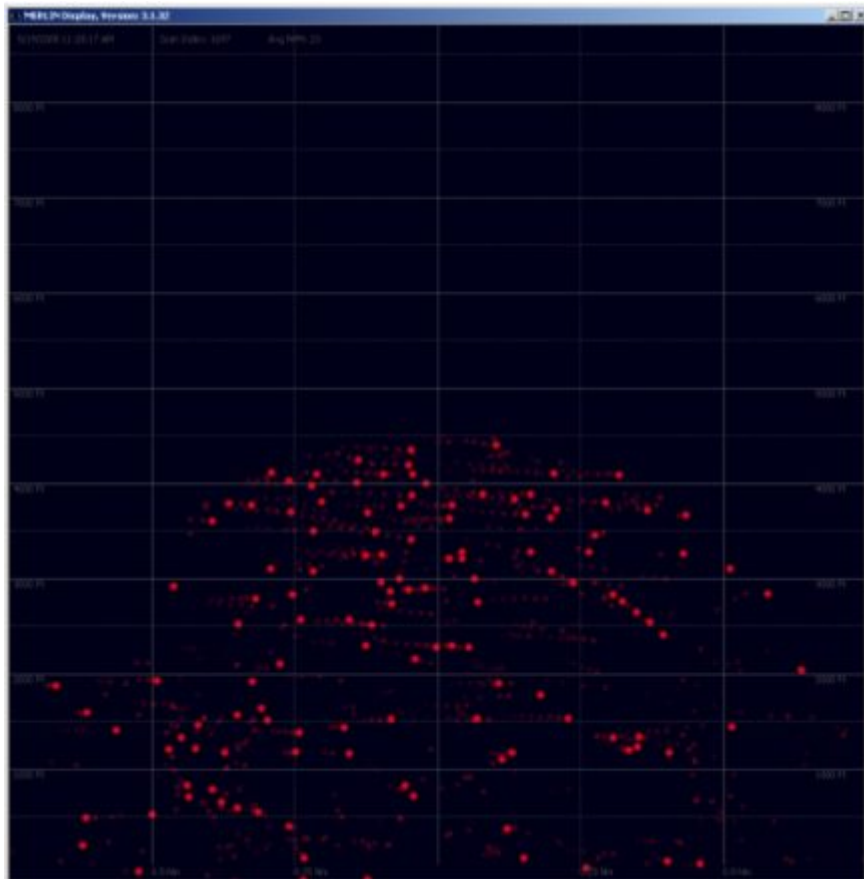
Typically the display from each radar is presented on two separate monitors set side-by-side at the operator station (at the radar and/or remote) and includes and other display features such as target trails, speed and heading tags, and other variables.

Some systems also have the ability to

Horizontal radar display from the MERLIN Avian Radar System installed at the NASA Kennedy Space Center. Targets in the lower center of the screen are Turkey vultures approaching shuttle Pad B with target size, speed, quality and bearing tags enabled (tags are attached to and follow each target as it is tracked by the system). The predictive heading feature is also enabled which attaches an indicator line that projects the expected path of the target based on its most recent tracks. MERLIN's unique "Groundtruth" bar is also shown to the right that allows an observer to mouse over and "click" on target on the screen that has been visually verified and append notational data to the target while it is tracked (such as bird or bat species, number, flight behavior, etc.).



SUPPLEMENTAL DATA



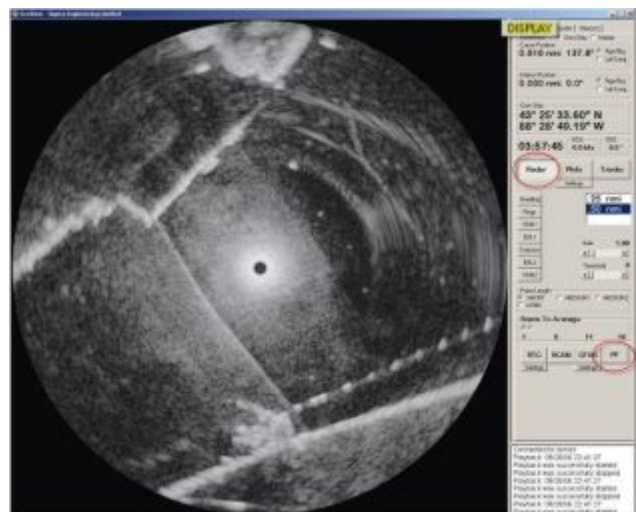
MERLIN Avian Radar vertical radar display showing heavy bird migration during the spring of 2004 in upstate New York during survey conducted for the Cornell Lab of Ornithology. Bird targets are red dots with target history trails with z (altitude) in feet up to 4500 ft above ground level and y (distance from radar) in nautical miles (nm) out to 0.75 nm to either side of the radar (the radar position is the bottom center of the screen). The vertical radar beam in this survey was aligned in the predominant migration direction and most of the targets are passing along the length of the beam.

record the raw (unprocessed) radar datastream for detailed off-site analysis and post-processing and as a permanent archive of the study. This functionality, however, requires large digital storage resources as the radars will generate 2-6 gigabytes (GB) of raw radar data per operating hour, and the function is not available on many systems.

Additional data is also collected and used in processing and analysis and in quality control/quality assurance. Supplemental information includes weather, visibility, insect activity, species, and radar groundtruthing (visual verification of bird target tracks). Verification data can include time, species, bird size, number, location (relative to the radar), altitude, flight direction, and other relevant information.

Data Processing and Analysis

Raw radar data recorder screen and controls within the MERLIN Avian Radar System (includes high speed playback software).



DATA PROCESSING & ANALYSIS

Avian radar systems, particularly the advanced units, produce large, high quality, quantitative datasets on bird activity that can be used in modeling and developing risk assessments of projects. Processing and analysis includes correlation of groundtruth data with the radar data, additional post-processing of the raw radar data streams (including custom clutter suppression routines; particularly for offshore, over water surveys), and execution of custom data queries on the databases to develop data required to quantitatively determine risk.

Post processing consists of replaying the recorded raw radar stream and processing it through bird target tracking, clutter suppression, and data analysis software to remove ground clutter and other non-bird targets, provide target tracks by altitude, and classify targets by size. Each survey site varies in topography, ground cover, vegetation, buildings and other factors that generate radar clutter. Optimizing the clutter mapping in a data lab results in higher quality data as optimal clutter settings can be determine, tested, refined and applied based on additional detailed analysis. The target databases recorded by the radar can be queried and analyzed by radar ornithologists, biologists and statisticians to develop the data required for the models and risk assessment. For many projects such as wind turbine installations, these queries are usually restricted to a migration front defined by 0.5 kilometers (km) to either side of the radar for a total frontal width of 1 km (the generally recognized industry standard). Virtually any analysis can be generated from the processed data, but output usually includes bird target counts by size category under various visibility conditions, by time of day (dawn, day, dusk, night), altitude and period (day, week, total

Count totals of targets passing across the Rotor Swept Zone during the survey period used to calculate the theoretical wind turbine bird mortality risk (data extracted from vertical radar database of a MERLIN Avian Radar System at proposed wind farm site).

Bird Target Counts Over Survey Period by Size Under Good Visibility Conditions for Rotor-Swept Altitudes					
Altitude Band	Small	Medium	Large	Flock	Total
150	61,608	34,760	7,152	2,448	105,968
200	60,192	30,272	6,940	2,440	99,844
250	52,264	21,284	3,108	1,192	77,848
300	35,288	14,968	2,048	1,344	53,648
350	36,988	14,600	2,240	1,216	55,044
400	8,668	3,220	416	160	12,464
Totals	255,008	119,104	21,904	8,800	404,816

Bird Target Counts Over Survey Period by Size Under Poor Visibility Conditions for Rotor-Swept Altitudes					
Altitude Band	Small	Medium	Large	Flock	Total
150	23,308	10,704	1,904	160	36,076
200	22,524	10,740	1,804	364	35,432
250	20,796	9,504	1,420	336	32,056
300	11,924	6,860	944	388	20,116
350	12,068	6,364	772	272	19,476
400	3,316	1,636	132	48	5,132
Totals	93,936	45,808	6,976	1,568	148,288

survey) along with supporting statistical analyses. Results are generally presented in tabular and graphical formats for use by project scientists and regulators to assess risks associated with each project.

Examples of various data products are presented on the following pages to illustrate the types and level of detail that can be generated from the advanced avian radar systems (Graphical representations are supported by detailed data tables). Data from the radar can also be displayed in real-time or exported to various modeling programs such Geographical Information Systems (GIS) and Google Earth.



DATA EXAMPLES

Bird Target Counts by Altitude OFF Landfill Property vs. ON Landfill Property
(S = single bird targets, F = Flocks)

Altitude ft AGL	OFF Landfill		ON Landfill	
	S	F	S	F
3000	4	0	7	1
2500	15	4	4	1
2000	11	0	9	1
1500	19	4	8	4
1000	2	0	7	4
750	25	11	7	4
700	29	4	4	3
650	13	0	4	2
600	15	2	11	6
550	17	8	8	5
500	11	8	16	6
450	11	4	14	5
400	29	8	20	5
350	48	4	18	6
300	55	13	15	10
250	42	4	21	10
200	40	13	22	12
150	65	8	26	14
100	19	8	14	19
50	20	2	33	17
0	13	0	14	1
Subtotal	785	296	517	287
TOTAL	OFF	1082	ON	894

Tabulated daily count of single birds and flocks for radar sample areas On landfill versus Off landfill; daily analysis used to document effectiveness and compliance of the landfill bird control and habitat management program. (data extracted from vertical radar database of MERLIN XS2530i Avian Radar System at the Waste Management Outer Loop RDF, Louisville, Kentucky).

Summary Chart of Passage Rate of Bird Targets Across 1 km Wide Front by Visibility Conditions (data extracted from vertical radar database of a MERLIN Avian Radar System at proposed wind farm site).

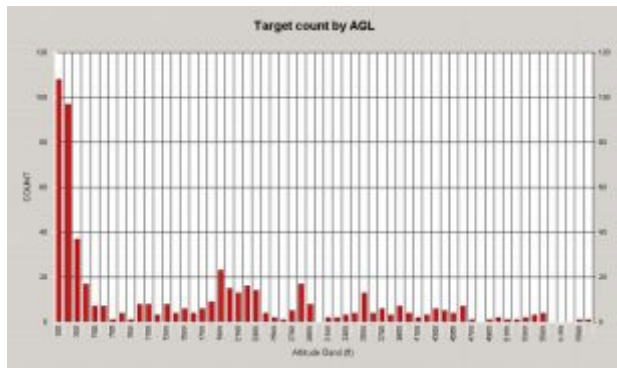
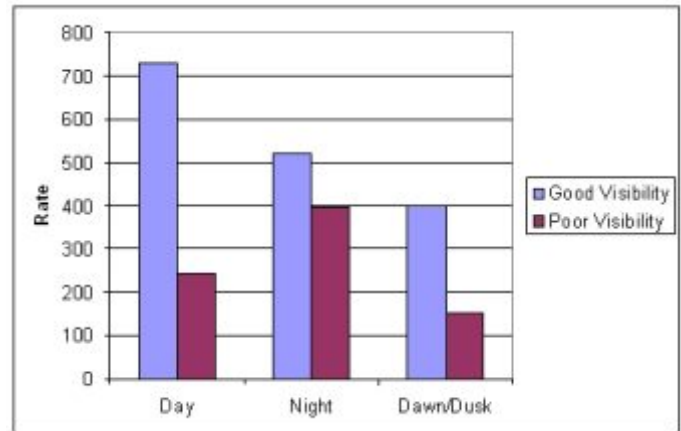
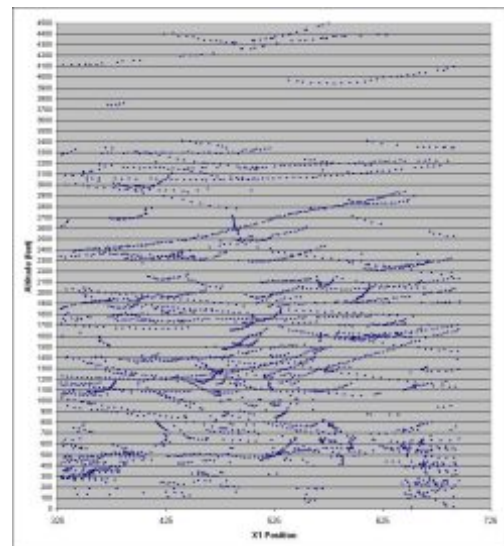


Chart of bird target count by altitude for a 24-hour period generated by MERLINChart® data report software from MERLIN Avian Radar System database (data from USAF Beale AFB, California MERLIN XS2530m system from January 2007).

One hour altitude track plot of vertical radar data for night spring migration over USAF Travis AFB, California (generated by MERLIN TrackPlot® software from MERLIN XS2530m Avian Radar System database).

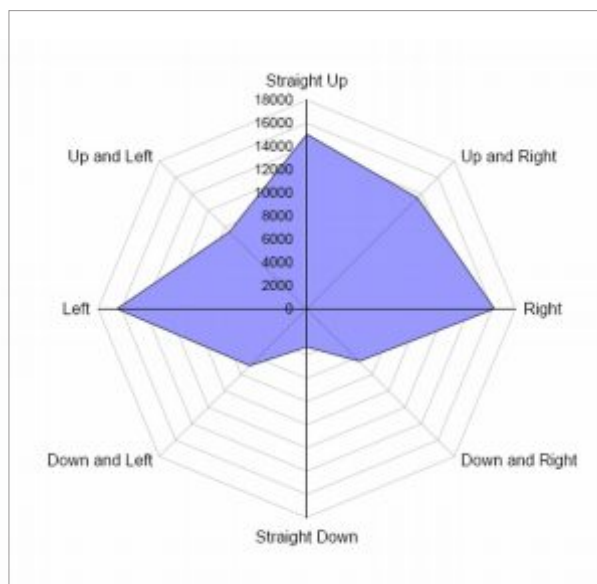
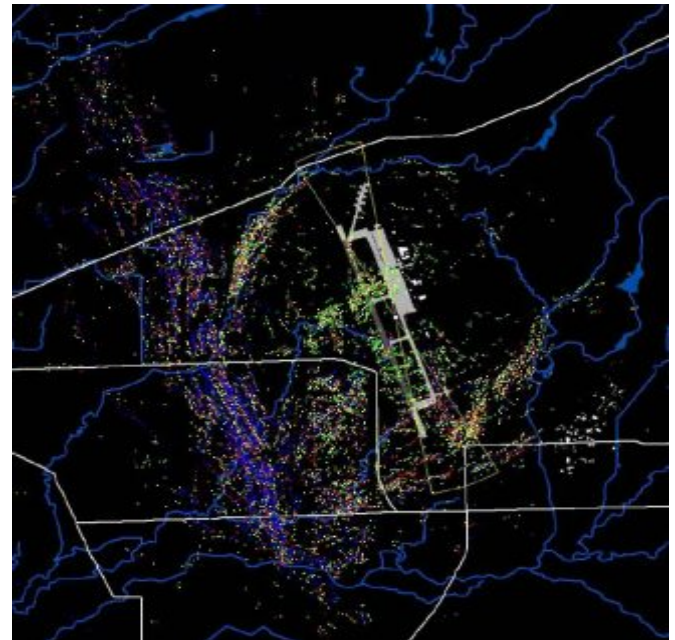


DATA EXAMPLES



Chart of bird target count by hour of the day by size of bird for a 24-hour period generated by MERLINChart® data report software from MERLIN Avian Radar System database (note: peak activity periods for the dawn and dusk time periods for local wintering birds; data from USAF Beale AFB, California MERLIN XS2530m from January 2007).

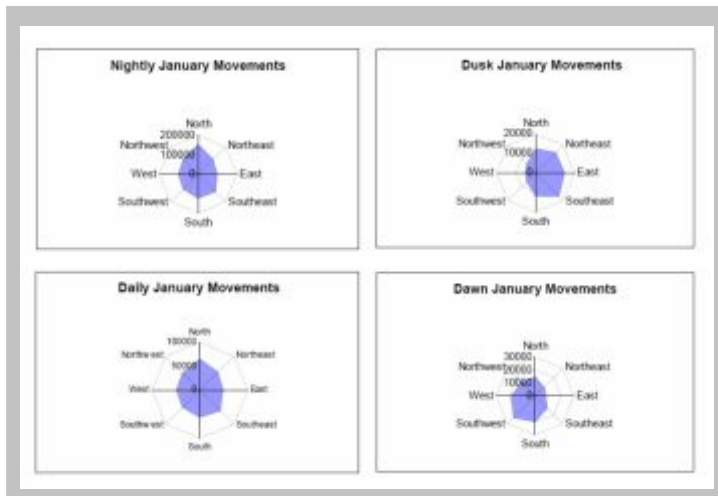
One hour plot (0600-0659) of bird target data from horizontal radar at military airfield. Heavy movement of waterfowl can be tracked along west side of the airfield from north to south ending in rice fields with medium sized birds crossing the runways from east to west (generated by MERLINChart® data report software from MERLIN XS2530m Avian Radar System database for USAF Beale AFB, California survey site from January 2007).



Direction of flight analysis for bat targets over 4 week period at Wisconsin wind farm survey site in 2005 (generated from MERLIN standard SQL database queries).



DATA QUALIFIERS



Periodic directional histograms of MERLIN horizontal radar data from wind farm survey site (generated from MERLIN standard SQL database queries).

Data from avian radar systems report bird targets recorded by the system that are within the line of sight of the radar (within the beam) as determined by the operating software in accordance with the program parameters defining a track. With respect to both the vertical and horizontal radar data, it should be noted that each “track” counted does not necessarily represent an individual bird, as a bird could have (and indeed have been observed to) flown in and out of the radar beam repeatedly, action which will be recorded by the system as multiple tracks. Accordingly, the data from radar surveys can be said to more accurately report “bird or bat activity” at the survey site and within the project zone and is not a count of individual birds.

Additionally, with respect to the reported bird tracks, the total number of bird tracks for a particular survey - as measured in tracks crossing a 1 km wide migration front - may not be directly comparable to other sites

using numbers of birds on a km-wide front due to the previously discussed variances between survey methodologies and radar systems. Factors to be considered in any cross-survey comparisons must include the data collection altitudes, methodology and equipment, survey length, and survey period all of which must be considered and allowed for in any comparison between studies.



MERLIN™ Avian Radar Systems

The MERLIN™ Avian Radar System is the most capable and proven system available for conducting bird and bat surveys, mortality risk analysis, and migratory studies, and for long-term and operational monitoring and risk mitigation.

MERLIN applications include:

- ❖ Conducting risk assessments for siting of new projects and expansions of existing sites
- ❖ Migratory studies & research
- ❖ Habitat assessments & usage analysis
- ❖ Monitoring, control & risk mitigation of operating sites

MERLIN supports a wide range of projects with avian risk, control and management issues including wind energy projects (terrestrial & offshore), airports (military & commercial), landfills, and power plant and mine impoundments.

Dual Radar System

The basic MERLIN system configuration uses the dual radar configuration with a horizontally scanning radar (HSR) and a vertically scanning radar (VSR), both with T-bar type antennas, providing effective 2-½ dimensional coverage of the monitored airspace. The MERLIN unit for environmental survey and operational monitoring is typically installed with the rotation

plane of the VSR aligned to provide a frontal zone to track biological (bird or bat) targets entering or crossing the area of interest with an operational range of up to 3 miles. The HSR provides 360 degree surveillance of the area out to 8 miles (depending on radar power).

The HSR is an S-band frequency radar with the radar power and specific antenna length sized for each specific customer's application and use (30 and 60 kW power options). The high azimuth resolution and gain of the S-band radars used by DeTect reduce the power required, eliminate interference to other users of the spectrum and eliminate RF conflict issues with military and commercial airports. Higher angular resolution is also preferable to higher power for bird detection work at short ranges. The VSR is an X-band radar and the radar power and specific antenna length is sized for each specific

MERLIN dual radar, mobile avian radar system purchased by the US Geological Survey National Wetlands Research Center for migratory research and habitat studies. The mobile MERLIN system is fully self-containing housing all components and systems on-board for a fully functional system.



DUAL RADAR CONFIGURATION

installation site or application with power options of 10, 25 and 50 kW available. The X-band antenna length is also tuned to minimize side-lobe interference during operation resulting in improved target detection.

The two radar units are mounted on towers on the trailer for mobile installations or on skids or concrete pads for fixed sites. The VSR is utilized for height measurement and enumeration of bird targets passing over the monitoring area providing y-z coordinates for targets in moving across or along the radar beam frontal zone. The HSR provides detection and tracking of bird targets 360° around the survey area providing x-y target data. The two radars combined provide detailed information on bird and bat usage of an area providing robust datasets for risk modeling and analysis as well as real time data for operational monitoring, control and risk mitigation.

MERLIN XS2530i Avian Radar System installed at the Waste Management, Inc. Outer Loop DF in Louisville, Kentucky (2004) providing monitoring and operational support for the landfill bird control and habitat management program. The system operates 24-7 providing real-time bird activity information to bird control staff via wireless, mobile display and daily comparative bird population analysis for On versus Off landfill areas.



MERLIN XS2530f fixed installation on offshore research platform in the North Sea off the Dutch coast (2003) used to collect 2 years of bird data for siting of offshore the Norzeewind wind farm.

Radar Towers

The standard MERLIN radar towers are tri-pod construction of marine-grade aluminum. For mobile systems the both towers can be retracted and secured for transport. When in functional position the towers do not require securing by guy-wires. Both radars are equipped with DeTect's proprietary dwell time controller (for target detection optimization) and speed monitor (to prevent excessive rotation and "windmill" over-rotation damage to motor gears).



RADAR TOWER OPTIONS



Typical NEMA-rated equipment enclosure for fixed installation sites. Includes back-pack side AC system for equipment cooling and internal environmental monitors.

The standard HSR tower is an extendable tripod, aluminum tube-within-tube design with inner slide bushings and includes T-bar screws at the top of each leg of the tripod for locking the tower position for both transportation (retracted) and operation (extended, 16 ft AGL maximum standard). The tower is designed to be self-supporting without guy-wires for operation, however does include integrated eyelets for support cabling or struts if desired. Each leg of the tripod includes integrated lubrication zerks at the retracted mid-point and at the top to permit maintenance lubrication of the legs and weep holes at the base to prevent any accumulation



X-band VSR radar in operational position with slider extended.

of water within the tripod legs. Extension/collapsing of the tower is facilitated by means of an integrated electro-mechanical drive motor unit with an extension screw shaft. The drive can only be actuated by a keyed switch as a safety feature. All fasteners are stainless steel. Extended and custom tower configurations are also available.



HSR radar tower with screw jack and key activated extension/retraction switch. :

Standard Mobile System

The standard mobile MERLIN configuration includes a DOT or country-of-delivery compliant, heavy duty, marine grade aluminum, dual axle trailer platform (23 foot length) with Alumibrite® diamond plate decking; torsion suspension with electric brake; an integrated insulated equipment/operator cabin (6 w x 8 l x 6 h foot) constructed of structural insulated panels; and AC system (with heat option). MERLIN is engineered to provide a high quality, robust, low maintenance system, even in adverse environments, and includes a full three-year parts and labor warranty on all components.

The MERLIN system is manufactured by DeTect in Panama City, Florida USA and meets or exceed all US and International standards for trailer systems and commercial electrical and mechanical systems.



Standard 2007 MERLIN Avian Radar System Environmental Series build (side view) with radars and levelers retracted, stowed and locked for transport.



Standard 2007 MERLIN Avian Radar System Environmental Series build (back side view) fully deployed with radars and weather mast extended to operating positions.

MERLIN XS2530ex Avian Radar System with extended 42 ft height tower (scissor) option purchased by the Government of the United Kingdom Central science Lab, York, England for wind farm surveys and migratory research.



MERLIN FEATURES



Standard 2007 MERLIN Avian Radar System Environmental Series build (front view) with MERLIN GPS/Compass mount (top right corner), weather system mast (retracted, top right corner), and optional aerodynamic nosecone.

Standard 2007 MERLIN Avian Radar System Environmental Series build (front view) with radars retracted and locked for transport and optional on-board 6.5 kW diesel generator system.



Standard 2007 MERLIN Avian Radar System Environmental Series build (door side of cabin view) with rain gauge (upper left) and keyless code-punch entry lockset.





Close-up view of optional 6.5 kW diesel generator power system with rain shield.

Close-up view of optional underdeck fuel tank and filler cap. Standard commercial power connection point shown in rear of photo.



All system equipment is rack mounted in vibration and shock damped computer rack and housed in the environmentally controlled and monitored operator cabin.



MERLIN Operating Software

The raw radar data is processed in real-time by the MERLIN Avian Radar System with DeTect's proprietary MERLIN radar processing software that was specifically developed for bird and bat detection and tracking.

MERLIN allows operators to detect and track more targets more reliably, and at longer ranges, and is the most powerful bird and bat detection software on the market today.

The technology was originally developed as a real time bird detection and tracking system for the US Air Force and NASA for the critical aviation safety application and has been extensively tested and proven over the past five years on airfield, airport and environmental research applications throughout the US, Canada, Europe and Africa.

MERLIN includes custom routines to optimize detection of bird and bat targets and remove weather, static target, and other interferences. DeTect includes three years of annual MERLIN software upgrades with each system.

The MERLIN software is a suite of DeTect-developed, proprietary applications that separate the data processing, display and administrative tasks (display, remote display/control, data processing/analysis) into separate software modules. This architecture is superior from a software reliability and maintainability perspective and allows more efficient processing of data across platforms.

The MERLIN software is highly optimized to efficiently process the radar signals, display results and collect data in real time or at speeds faster than real time with recorded radar data.

The MERLIN software suite includes the five primary modules:

- ❖ **MERLIN Processor** base operating system providing radar signal digitization, clutter suppression and bat/bat target detection and tracking
- ❖ **MERLIN Administrator** controls system set-up and configuration
- ❖ **MERLIN Display** - display configuration and display
- ❖ **MERLIN Communicator** display distribution, remote control and remote data access
- ❖ **MERLIN Analyzer** database processing, analysis and reporting

MERLIN XS1030e Avian Radar System purchased by KAPPA wind consortium and delivered with Polish language version of the MERLIN software and operating system for long-term survey of the Jagnitkowo Wind Farm, Szczecin, Poland.



The MERLIN software and operating system language standard is English with internationalized foreign language versions available as an option (including Spanish, French, German, Polish, and Dutch).



MERLIN also has undergone extensive testing and is used routinely on DeTect's company-owned MERLIN radar units (five at present) that are available for short-term rental and long-term lease for aviation safety and environmental survey/monitoring projects. As DeTect is a significant end-user of its own MERLIN software, MERLIN is subsequently better designed for customer use as operating parameters are constantly being assessed and functionality improved by DeTect staff as additional operating experience is gained, user requirements determined, customer feedback received and technology advances.

MERLIN Administrator & MERLIN Processor

The core MERLIN radar data processing software MERLIN Processor and MERLIN Administrator - is installed on the computer network located in the on-board control cabin and processes the raw radar data to identify bird targets and track bird targets. The module is also capable of recording raw radar and

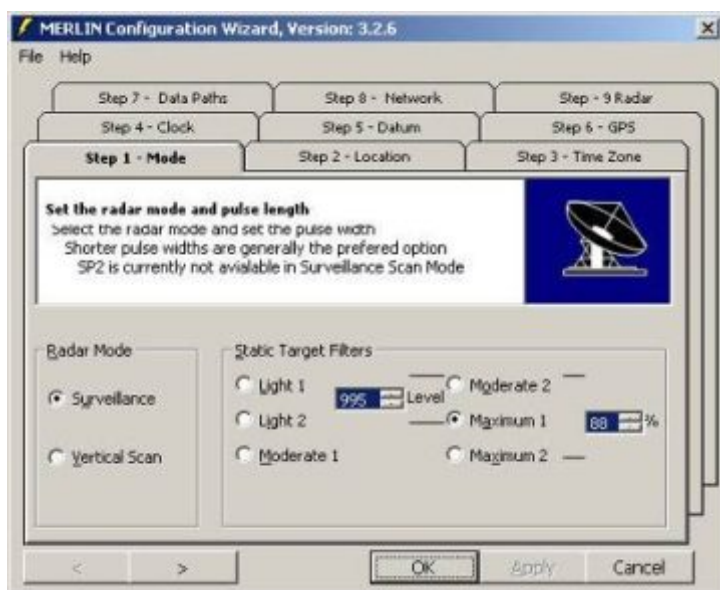
processed data for post-processing and recordkeeping purposes. System set-up and configuration changes are controlled through the MERLIN Administrator on-screen control panel that allows full on-board and remote control of the system operating parameters. The Administrator includes the MERLIN Configuration Wizard that allows set-up of both the X- and S-band operational parameters including operating mode, radar location, time and date, datum, GPS, data paths, network parameters and radar settings.

The Wizard can be accessed at the system equipment/operator cabin or equipment enclosure workstation or at a remote site via wireless, WWAN or LAN connection. The Administrator program is security access-controlled so that parameters can only be set/reset by authorized system administrators.

The MERLIN Processor application executes the radar data processing that includes identification and tracking bird and other targets, measuring and recording target parameters (over 70 parameters are recorded for each target with including target size, heading, bearing and speed); filtering and suppressing clutter; and, risk monitoring and alerting. MERLIN Processor is highly flexible and target detection and tracking can be user configured to detect and track a wide range of target types including birds, bats, insects, vehicles, aircraft and personnel.

In addition to target detection and tracking, the MERLIN software is able to statistically describe the clutter environment to optimize target detection in high clutter environments and continuously monitors a minimum of 255 discrete zones on the radar to detect the presence of weather or chaff. Weather is a specific operational issue with avian radars as moderate to heavy weather can “block” target detection, particularly on the X-band radar. Data collection and

MERLIN Administrator Configuration Wizard set-up screen



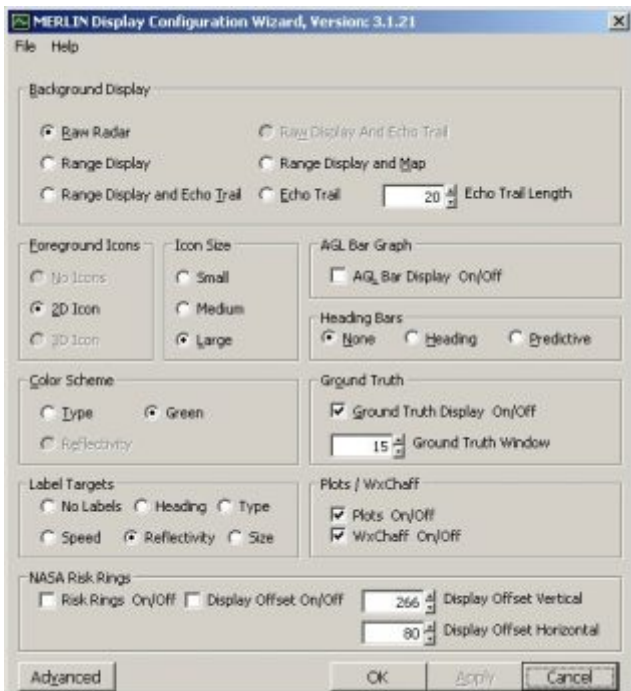
processing in MERLIN can operate continuously even during weather or chaff events with data collection suspended only for the specific zones occluded by the event. The S-band radar (horizontal plane) can provide bird detection during light to moderate weather (rain, snow, sleet) as the MERLIN clutter suppression algorithm is able to successfully suppress all but the most intense or fast moving weather. The X-band radar (vertical plane) is more susceptible to weather as it is a shorter wavelength radar, however MERLIN has been designed to suppress data only in that portion of the display that is affected by weather with the unaffected zones continuing to display and track targets. The advantage of this unique functionality of the MERLIN Processor software is that targets continue to be detected at the edges of and around weather. Cells with weather are also recorded to the database as part of the dataset generated by MERLIN.

MERLIN Display

The MERLIN Display module provides powerful user-selectable features to display the real time, processed radar data in a variety of formats and can be customized by DeTect to add user-specific functions and features. The MERLIN Display module has a variety of preset options and allows the user to quickly set up a display that meets each application's unique requirements and user needs with display features turned on or off through the MERLIN Display Wizard.

Real time display of the processed information can be viewed by users at the radar in the control cabin or at a remote connected site using the MERLIN Display software or MERLIN Communicator viewer application. The output from both radars(horizontal and vertical) can be displayed onto a single computer monitor (in separate windows) or each can be displayed on a separate monitor.

MERLIN Display Wizard main set-up screen



Horizontal Radar Display Features

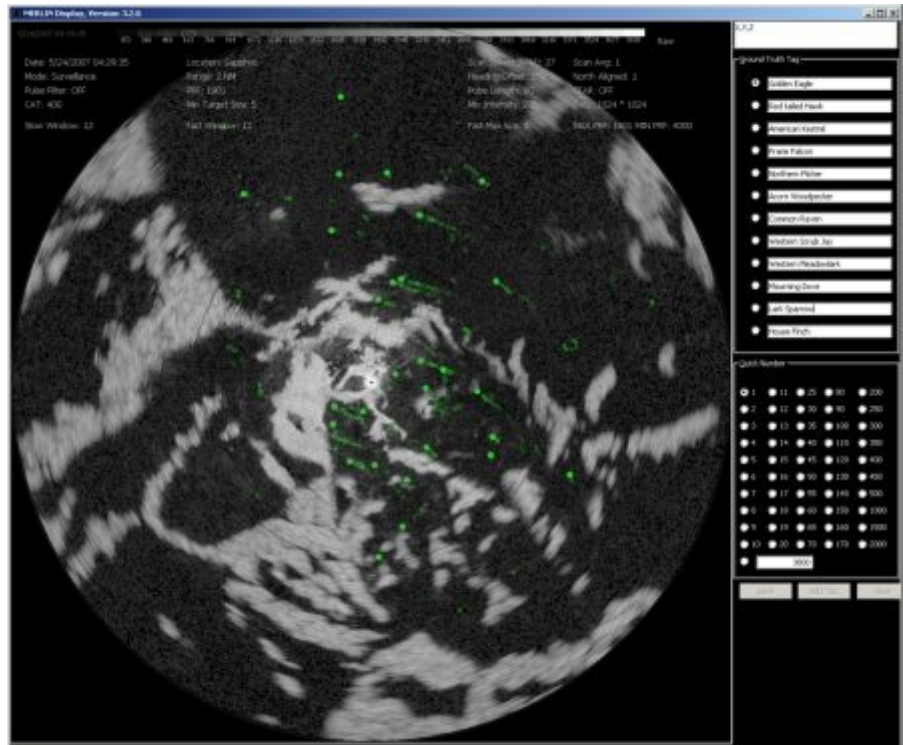
The HSR (horizontal radar) bird tracks are displayed in real-time in a plan position indicator (PPI) display view providing x-y location data for each target tracked by the system. The radar range setting (as set within MERLIN Administrator) is indicated in one nautical mile (nm) increment “range rings” as red or gray circles. Display options include the ability to view the processed data tracks with raw radar image or site specific underlay “maps” (provided by DeTect with each system or customer developed). Custom underlay maps for each survey site or project can be created using many basic graphics editing programs from line maps or aerial photographs and can include specific site features such as runways, roads, special resource areas (wetlands, woodlands, water



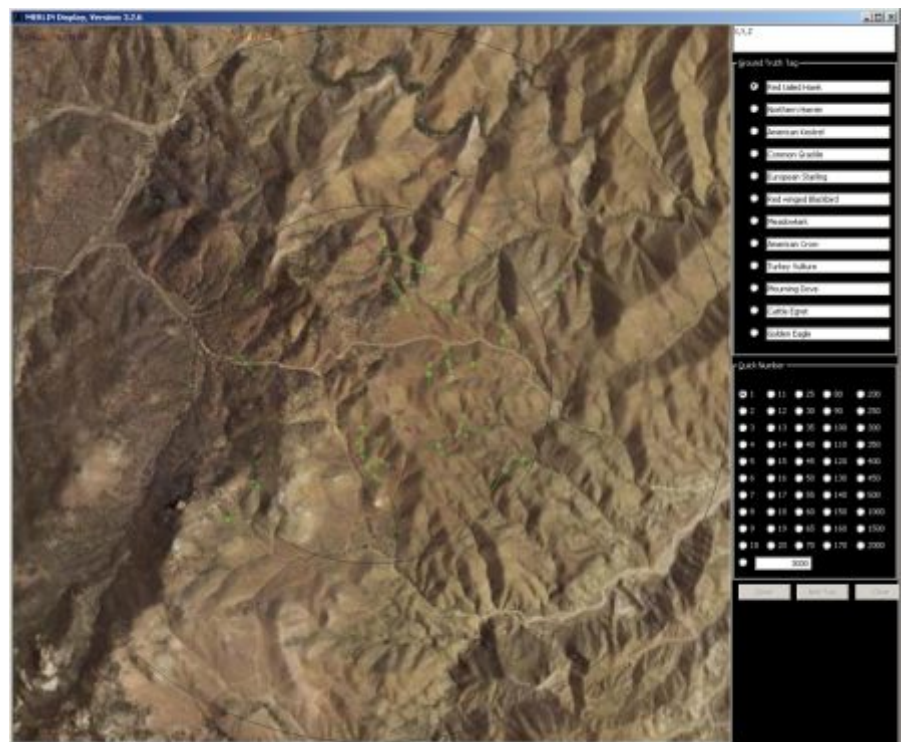
bodies) and structures. This customization results in a highly intuitive radar display that can be quickly interpreted by a non-expert user to assess bird and bat activity relative to the survey areas.

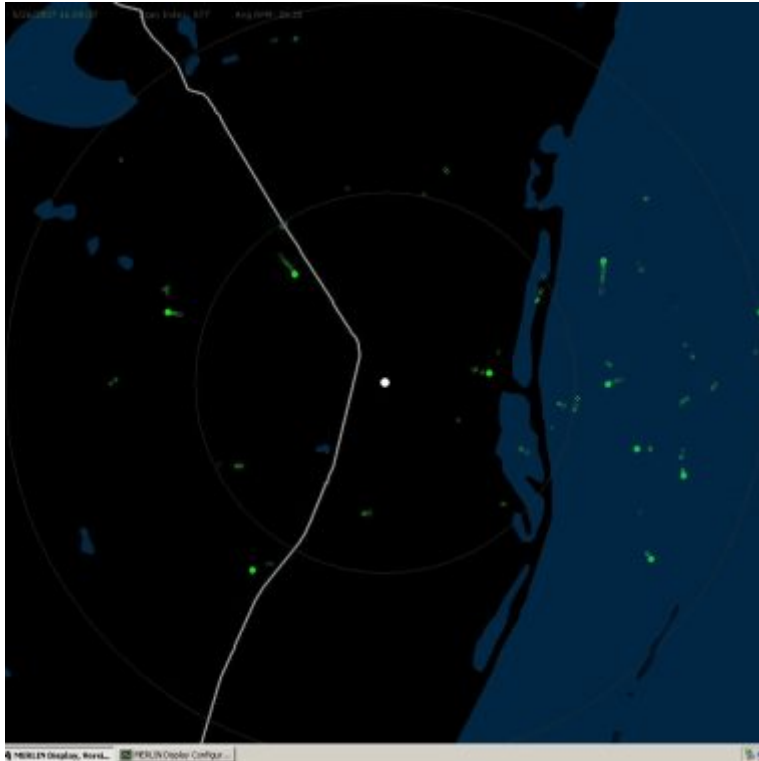
Bird, bat, aircraft and other target symbols can also be set by the user and includes track symbol size, color, target trails, speed, and heading bars (heading or predictive). Target tags (labels) can also be activated to display each target's characteristics such as speed, size or reflectivity, as it is tracked across the screen. The target tag display option is typically only enabled in "target poor" environments as the screen will become too cluttered, complicating condition assessment when a large number of targets are present on the screen.

The display includes a "groundtruth" bar along the right side of the screen that allows the user to record visual groundtruth data directly into the MERLIN database along with the standard data attributes for the specific target selected. Appended information can include species type, verification counts and notations selected from a pre-programmed, user customizable list within MERLIN (e.g. a list of bird species common to the site) or the user can override the standard list and type in specific



TOP: MERLIN horizontal radar display screen image with raw radar image underlay showing bird tracks with target trails enabled (data collected at proposed California wind farm site during spring migration by DeTect-owned MERLIN XS1030e Avian Radar System leased to Sapphos Environmental, Inc.). BOTTOM: The same data with full color aerial photo underlay.





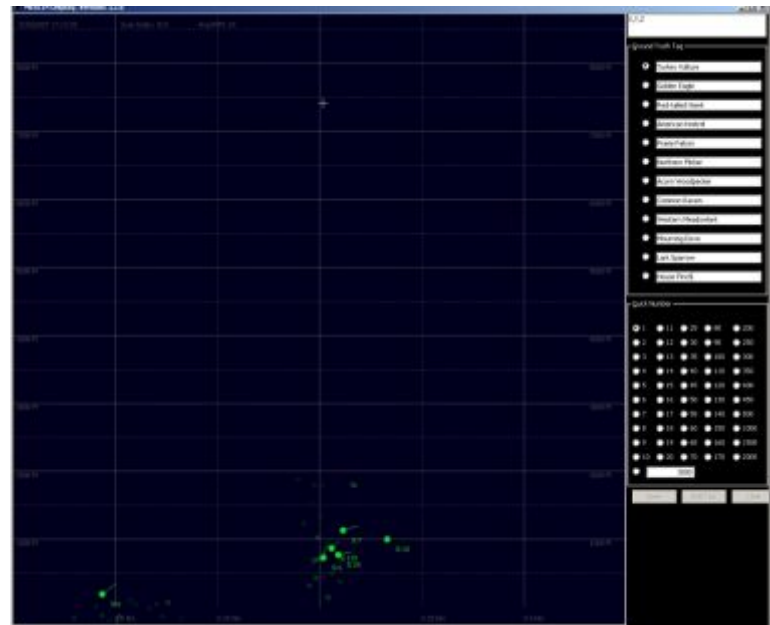
MERLIN horizontal radar display screen image with high contrast line underlay showing bird tracks with history trails (trails can be user set to show up to 20 historical tracks) on shore and over the adjacent bay (from MERLIN XS2530e Avian Radar System purchased by Texas A&M University for multi-year migratory study of the Texas Gulf Coast).

notes (e.g. new species observed, behavior notations, etc.). This functionality greatly expands the utility of the system as a survey and resource management tool, allowing for detailed statistical analysis of bird activity for the site (concentration areas, species statistics, etc.).

MERLIN vertical radar display screen image with showing bird tracks with size class tag and heading bars enabled (data collected at proposed California wind farm site during spring migration by DeTect-owned MERLIN XS1030e Avian Radar System leased to Sapphos Environmental, Inc.).

Vertical Radar Display Features

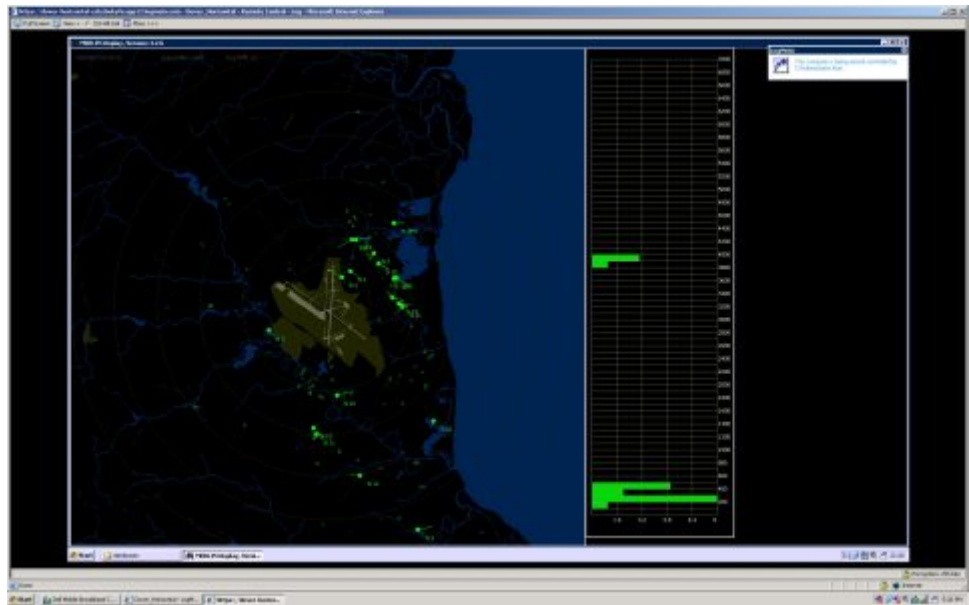
The VSR (vertical radar) is displayed on a second monitor with the left and right halves of the screen representing the vertical horizon-to-horizon “sweep” range of the radar. Grid indicators in 0.25 nm increments show the distance each target is from the radar location (y-data) and . Altitude axes are shown in 500 ft increments to the maximum range (z-data) and targets passing through the VSR radar beam or along the beam sweep can be observed and tracked. The VSR display screen also can be set to display target tags and trails and includes the Groundtruth Bar feature.



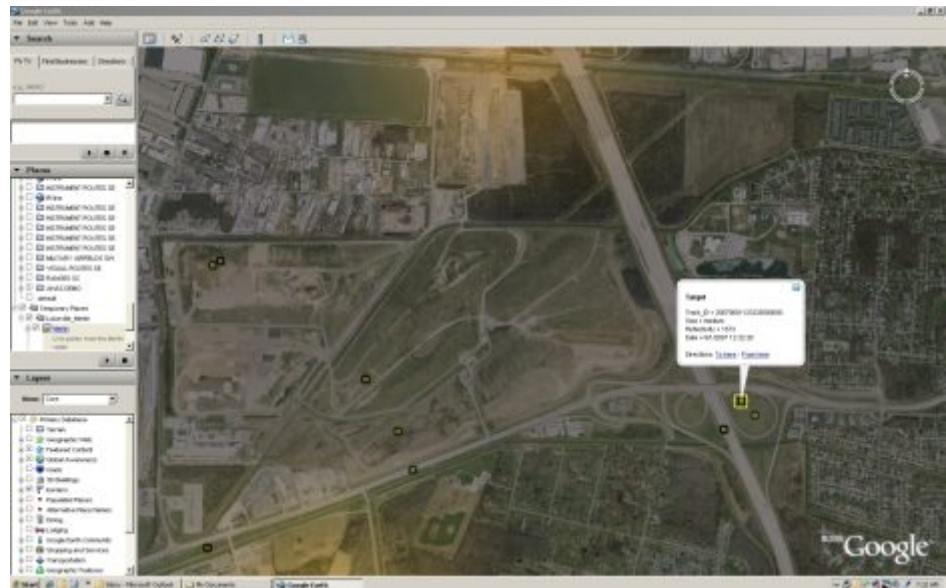
MERLIN Communicator

MERLIN is also equipped with display distribution and system remote administration/control software module MERLIN Communicator VNC which allows any MERLIN display to be sent to almost any fixed or mobile computer with a network or internet connection via a local area network (LAN), wide area network (WAN), wireless wide area network (WWAN) or satellite link, as well as full remote control of the system and access to system data.

The modular construction of the MERLIN Display software permits multiple displays of the same processed data to be run on a network without having to independently process the raw data stream on each computer with each display module reading the data from the main MERLIN data server computer.

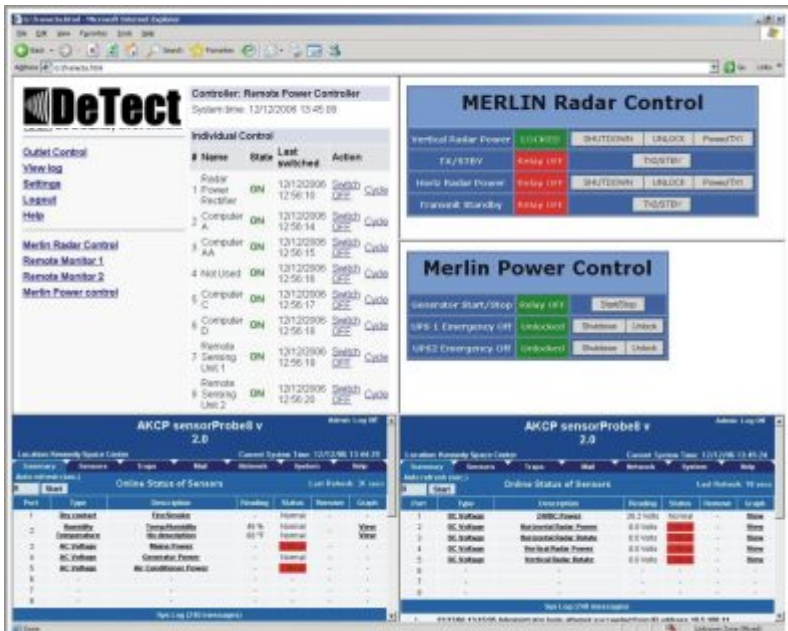


Real-time display of the MERLIN horizontal and vertical radar information can be viewed remotely through internet, LAN, WAN or WWAN connections using various proprietary and commercially-available clients including MERLIN Display, MERLIN VNC, PC Anywhere, LogMeln and Google Earth (remote display of HSR from USAF Dover AFB, Delaware with commercially-available LogMeln client).



Google Earth™ remote MERLIN display of real-time MERLIN radar data from the Waste Management Outer Loop RDF, Louisville, Kentucky. Google earth feature includes mouse over pop-up details on targets including ID, size and lat/longs.





The optional MERLIN Remote web application allows full remote control of the system including full remote system start-up/shut-down, complete system health monitoring and power system control.

On-board, satellite-based or cellular uplink remote access supports operation where network and/or internet access for remote control or data collection is not available or is too costly (e.g. remote field sites).

Secure, two-way links provides full remote data access, data transmission, remote display, control and communication between a field-located MERLIN and base or mobile locations. Monthly connectivity costs associated are comparable to typical high-speed cable Internet costs for most locations. Satellite connectivity is currently available for MERLIN installations in the U.S., Canada and Europe (other locations may also be available).



The MERLIN system can be delivered with optional satellite or cellular wireless data uplinks.



MERLIN Database & MERLIN Analyzer

All MERLIN system and target data is automatically written to the MERLIN database in a Microsoft Access® compatible format for data archiving, processing and analysis. Radar configuration, operational and locational data is recorded to a Metadata table to document the radar settings.

Bird and other target information is recorded to either a Vertical or Horizontal data table within the database with the fields in the two target information tables basically the same, with minor differences for spatial parameters that differ between the vertical and horizontal data. Over 70 data attributes are recorded for each track that include time, target characteristic, spatial parameters and other operating characteristics of the target and system.

All data is directly viewable in a GIS and standard and custom database queries are available from DeTect. Standard database queries are delivered with MERLIN in the MERLIN Analyzer module which include the TrackPlot® and MERLINChart® desktop software report analysis samples presented in the Avian Radar Introduction and Overview section of this document.

Optional Functionality

MERLIN has been designed as a modular system and includes a wide range of optional features and functionality. The systems are also expandable and scalable.

Expandability & Scalability

Virtually all MERLIN features (such as radar power) and functionality can be added at any time to increase system utility. In the case of radar power upgrades, DeTect will “buy-

back” used, lower power radars and provide a radar power upgrade to extend the operating range of a system. Other features, such as remote display and control can likewise be added at a later date as project funding becomes available. This flexibility allows for a lower initial installation cost with the ability to upgrade as the effectiveness and cost-savings generated by the system is demonstrated.

MERLIN WX & MERLIN LX Weather Radar Functionality

MERLIN can additionally operate as a weather radar system providing weather (MERLIN WX) and lightning detection (MERLIN LX) and notification. The system has inherent weather detection which is suppressed for bird detection. By addition of an optional, separate weather processor, the radar feed from the S-band (HSR) radar can also provide weather detection with 12, 16 or 19 nm range settings. The lightning detection sensor add-on component and advisory is integrated into the weather channel as an overlay onto the weather radar image.

Weather display can be grayscale or color with lightning strikes shown as color or contracting color pixels that fade over time. Other data produced includes lightning characteristics such as type of stroke and polarity, and lightning strike rates (Close Strike/Minute and Total Strikes/Minute for the previous hour on a Strike Rate Trend Graph). Alarms would also activate for Close Storm Alerts and Severe Storm Alerts (the Close Storm Alert activates if a thunderstorm is detected closer than a preset distance; the Severe Storm Alert activates if the number of lightning strikes per minute exceeds a preset limit).

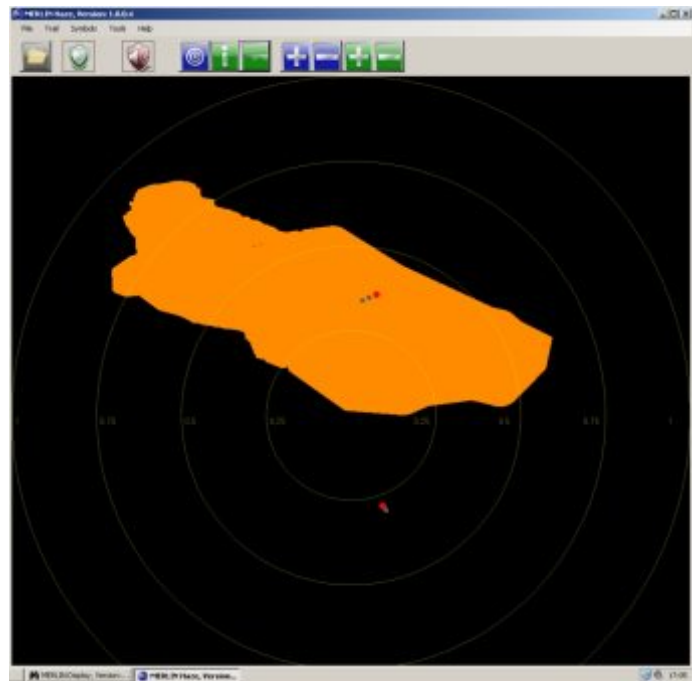


MERLIN detect & deter™

The MERLIN *detect & deter™* feature interfaces the MERLIN system with bird deterrent or mitigation systems to provide automatic bird control or risk mitigation. The *detect & deter™* software module allows automatic direction and activation of bird hazing devices (gas cannons, bioacoustics, lasers or long range acoustic systems) to keep birds from controlled areas such as impoundment ponds. When birds are detected and tracked by the system on a course to enter defined controlled areas, the system will automatically aim and/or fire the deterrents.

The *detect & deter* functionality is an add-on module to the MERLIN avian radar software platform and provides a wide range of control functionality supporting multiple, user defined independent monitoring zones, a wide range of deterrent acoustics (recorded .wav files including specific bird distress calls), and interface control with gas cannons and long-range acoustic devices.

The *detect & deter* software can also be used as a controller system for risk mitigation for high bird mortality risk projects such as wind turbines, delivering alerts (audible, visual, text message) to operators of high risk conditions as they develop or automatically idling turbines until birds pass through the area.



MERLIN detect & deter display screen for MERLIN X10d system operating at the PacifiCorp Jim Bridger Power Plant in Wyoming. The orange area in the buffer control zone of the impoundment pond and birds tracked by the MERLIN radar on a course to enter the control zone cause the system to activate bioacoustics located around the pond area.



MERLIN XS2530e Avian Radar Monitoring system installed on monopole at the Nordwindzee wind farm in the Netherlands. The system is solar powered and fully remote viewable and controllable from shore and provides continuous monitoring of bird activity at the operating offshore wind farm, sending alerts to wind farm operators when risk events are detected.



User Manual & Operator Training

MERLIN is delivered with full documentation for setup, operation, and maintenance. In addition, one week of on-site instruction in system operation and maintenance is provided at system start-up. The training also reviews methods for data post processing and database queries for report generation. A copy of the standard queries used by DeTect is provided in addition to reproducible copies of the user manual, course notes and other training materials.

Warranty & Technical Support

DeTect provides a 3 year full parts and operations support warranty on each MERLIN system and DeTect will replace any non-wear parts that fail in the first 36 months after delivery and start-up (excepting normal wear parts). The Warranty includes labor and parts (parts that wear due to normal operation are excluded; normal operation is defined as the manufacturer's rated life of the part). On-site maintenance support is provided for the computer workstations for three years. DeTect also includes three (3) years of system and software telephone and internet technical support which includes MERLIN software upgrades issued by DeTect over the support period.



About DeTect

DeTect, Inc. specializes remote sensing technologies and systems for aviation safety, avian survey & monitoring, airspace & ground security, weather detection and wind measurement supporting projects worldwide. DeTect is the world leader in development, deployment and support of radar systems for aircraft birdstrike avoidance, avian risk assessment and migratory research.

The company is a U.S. corporation (Florida) headquartered in Panama City, Florida, USA with divisional offices in Colorado and Kentucky, USA and representative offices in Canada, England and India.

DeTect professionals have proven track records in delivering cost-effective, workable solutions for high profile, diverse, complex projects offering the highest level of service and support. DeTect systems are used by:

- U.S. Air Force
- U.S. Air National Guard
- U.S. Army Corps of Engineers
- U.S. National Aeronautics and Space Administration (NASA)
- U.S. Environmental Protection Agency
- U. S. Federal Aviation Administration
- U.S. Fish & Wildlife Department
- U.S. Geological Survey (USGS)
- Government of the United Kingdom
- Government of Canada.

The company has supported projects for government and industry throughout the U.S. and Canada, and in the United Kingdom, Europe, Africa and Asia.

MERLIN Avian Radar System on Hoffman Wind Farm site, California during fall 2006 migratory survey.



DeTect products include:

- ✘ Aircraft Birdstrike Avoidance Radars
- ✘ Avian Survey & Monitoring Radars
- ✘ Airspace & Ground Perimeter Security Radars
- ✘ Aircraft Detection & Surveillance Radars
- ✘ NEXRAD Environmental Data Products
- ✘ Radar Wind Profilers
- ✘ Weather Radars
- ✘ Visibility Sensors
- ✘ Lightning detectors

DeTect services include:

- ✘ Bird-Aircraft Strike Hazard (BASH) Management
- ✘ Airfield & Industrial Bird & Wildlife Control
- ✘ Wind Energy Project Bird & Bat Impact Assessment & Risk Mitigation
- ✘ Radar System Solutions Engineering, Design & Development
- ✘ Environmental Planning & Analysis (NEPA) support
- ✘ Avian Radar Survey & Risk Assessment
- ✘ Data Analysis & Geographical Information Systems (GIS)

Staff & Facility Resources:

Professional staff resources include experienced engineers, scientists, biologists, and planners that are experts in remote sensing, radar engineering, system integration and environmental management. Our specialized expertise in BASH management includes a unique combination of top radar ornithologists, biologists, engineers, and programmers that provide DeTect clients with the most experienced team of experts in remote sensing of birds and bats in the world - with specific expertise in design, construction

and operation of bird/wildlife detection systems for aviation safety and environmental management.

Facility resources include over 26,000 square feet of office, laboratory and manufacturing space in Florida and Colorado to support design, development, assembly and testing of radar systems. Research resources include radar test sites in Florida and Colorado for components and software development, testing and calibration.

The Florida test facility is located at the end of the Panama City International Airport (IAP) runway which provides a "real world" test environment for the company's aviation products. DeTect radar systems are built to industrial and military (MILSPEC) standards and incorporate commercial-off-the shelf (COTS) components where possible in order to offer its customers lowered cost of acquisition, lower cost of ownership and ongoing technology insertion and upgrade opportunities over the life of the system.

Experience

DeTect systems have been deployed at facilities and projects worldwide with a proven record of exceptional performance, reliability and operability and over 100,000 hours of operating experience (click location on map below for information on each radar installation).

The USAF has purchased six MERLIN systems to date based on a documented record of reducing aircraft-birdstrike damage and NASA, after evaluation of technologies, selected DeTect's MERLIN system to support space shuttle launch safety.



CONTACT INFORMATION

Merlin 



MERLIN XS2530m Avian Radar System
USAF Tyndall AFB, Florida (2004)

MERLIN XS5060m Avian Radar System
,USAF Whiteman AFB, Missouri (2006)



MERLIN XS1030e Avian Radar System
Durban Airport, South Africa (2007)



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