LOCATING AVIAN RADARS AT CIVIL AIRPORTS

By:
David Mayer and Edwin Herricks
CEAT Airport Safety Management Program, University of Illinois
Department of Civil and Environmental Engineering
B114 Newmark Laboratory, MC-250
205 N. Mathews, Urbana, IL 61820
USA
Phone: (217) 244-0743; Fax: (217) 244-0743
dmayer2@illinois.edu

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INTRODUCTION

The site selection process is a critical element of eventual avian radar performance on a civil airport. Finding an acceptable site requires prioritizing identified needs and then carefully analyzing competing issues. From a wildlife detection perspective, the most important criteria for site selection are providing good detection capability for known critical areas on the airport. Critical areas are those locations where observational data suggests a high hazard potential due to site attractants or the actual use of the area known from observations. From a radar operations perspective, the most critical criterion is minimizing clutter interference for critical areas. These two factors can generally be accommodated by several locations. The final location can then be determined by considering infrastructure needs, such as the enclosures needed for the radar system (including towers or other structures required for the radar antenna), power supply, and the availability of high speed connectivity. Finding the correct balance between these components is the first step in bringing an avian radar system on-line at any civil airport, and each component creates unique challenges to the siting process. The process is further complicated by the requirement for Federal Aviation Administration (FAA) Form 7460 approval, which addresses issues of possible obstructions and frequency interferences and is required prior to the placement of the radar on the airport.

The University of Illinois CEAT has developed an avian radar site location process for use at civil airports that supports the deployment of radar units considering the needs of wildlife managers, the requirements of radar operations and issues of infrastructure. The primary focus of this paper is site selection procedures for avian radar system deployment at civil airports, considering:

- wildlife
- air traffic
- radar selection
- regulatory requirements
- locating the radar sensor
- clutter mapping
- infrastructure

These procedures are demonstrated using CEAT experiences deploying avian radar at Chicago’s O’Hare International Airport - and New York’s John F. Kennedy International Airport.

SITE SELECTION PROCEDURES

There are two major uses of information from avian radar systems. The first is strategic, mainly involving wildlife management, and seeks to understand the movement dynamics of birds on and around the airport. The second is tactical, mainly involving aspects of air traffic control, and seeks to reduce the risk of bird/aircraft collisions by using the understanding of bird movement in relation to typical aircraft flight paths.

Wildlife Considerations

When considering optimum radar location from the perspective of wildlife management, possible sites can be determined using the wildlife reporting records available from airports. These records, with geographic information system (GIS) integration, support analysis of an airport's landscape and land use to identify locations that may be attractive to birds. Such understanding of critical areas attractive to wildlife can be the basis for assessing needs and locating the radar to meet those needs. The experience of wildlife managers at Seattle-Tacoma International Airport (SEA) provides a good example of a possible procedure to identify critical areas. SEA wildlife managers developed a grid of their airport. All personnel involved with wildlife management were tasked with coding activity types to those grids to provide better location information for later analysis. The reports of patrol activities were then mapped on the airport grid map using a GIS. This geo-referenced data then provided the basis for analysis of wildlife activities by location and over time, providing an improved assessment of wildlife threats to aircraft safety.

Air Traffic Considerations

When considering optimum location from the perspective of air traffic control, radars must be located to provide surveillance of high hazard areas on the airport and in the approach and departure paths. Because most birdstrikes occur below 500 ft, it is necessary to locate an avian radar so that birds near the runway elevation will be detected. In addition, it is also necessary to provide surveillance of approach and departure paths, typically to a distance of 4 – 6 miles from the airport and to an altitude of 3000 ft. AGL.

Radar Selection Considerations

The considerations given to radar selection are related to specific technology issues and the volume of airspace covered by a radar sensor. Specific technology issues include the frequency of operation for the radar sensor: Radars in the S and X band (10 cm and 3 cm, respectively) are available as common off-the-shelf (COTS) marine radars, and new radars are being developed in the L band (23 cm) and in the millimeter range at 76 GHz and 94 GHz. In addition to frequency issues, new technology is providing solid state units that are expected to address issues of coherency and wave form control that will enhance bird detection. The volume of airspace covered by a radar sensor will be related to the antenna. Common configurations include slotted array antennas, which provide good range but limited altitude information, and parabolic dish antennas, which provide improved altitude discrimination but reduced volume of coverage. Another consideration when considering slotted array vs. parabolic dish antennas is an airport's clutter environment. In high-clutter situations, a parabolic dish antenna may offer improved detection because the beam is pointed into the air, avoiding ground clutter.

Locating the Radar Sensor

Clutter can vary depending on location of the radar, and radar location will directly influence the detection of bird targets. Although radar developers provide many methods for clutter reduction in avian radar systems, CEAT has come to understand that the best method of clutter management is clutter avoidance over critical areas.

CEAT has found that moving the radar sensor closer to ground level generally helps to reduce clutter for slotted array antennas, and lower locations may also improve the performance of parabolic dish antennas. This finding recognizes that the antennas used for avian radar systems were originally designed for use marine environments. As a result, much of the energy transmitted by the radar will be directed below the horizon. This is ideal for COTS marine radars where the primary use is to detect objects on the sea surface. For avian radar applications the energy directed at the ground leads to increased ground clutter interferences that reduces bird detection. By placing the sensor closer to the ground, the radar energy is less likely to encounter buildings and other structures that produce clutter.

Clutter Mapping

The beam patterns of both slotted array and parabolic dish antenna equipped radars produce reflections from ground surfaces, buildings, and other fixed targets that interfere with target detection and tracking. This “clutter environment” decreases the radar’s ability to detect and track avian targets. Thus, assessing the clutter environment when deploying radar is an important strategy for optimizing a radar’s effectiveness.

Although individuals with experience can suggest locations based on “eyeball” surveys, it is not possible to select exact locations for radar deployment without use of the radar on the airport to actually map the clutter environment. -.

Clutter mapping involves deploying the radar at different locations around the airport and collecting radar data from these locations. In the CEAT procedures raw radar data is recorded and images of the clutter environment are recorded. In addition the radar is operated for from 15 to 30 minutes to provide a record of bird detections at that location.

Regulatory Requirements

A number of regulatory requirements must be met before a radar can be deployed. These requirements have been established by the Federal Communications Commission (FCC) and the Federal Aviation Administration (FAA). The FCC requires that all radar operators must be licensed. Thus, an initial step in any radar deployment is application for a FCC license. This license is the first step to meeting FAA requirements for deployment of avian radars to civil airports. The FAA requires completion of the FAA Form 7460, which is used to review potentials for obstructions and interference with critical radio frequencies at airports. The typical process for Form 7460 approval from the FAA requires an exact location of the unit as a part of the application process. However, CEAT experience with radar deployments suggests that clutter mapping potential sites prior to final site selection is a more effective process. However, this strategy raises issues for the 7460 review process.

A number of solutions have been found to this quandary. In some instances, temporary permission is granted for radar use during limited time periods. This facilitates the movement of the radar to multiple sites on the airport to provide actual data about possible locations. After the temporary deployment of the radar, clutter mapping results can be reviewed and long-term radar locations selected. The radar is then be inactivated while the Form 7460 application is reviewed. If temporary permission is not available, then airport personnel must use their judgment to select a small number of locations and submit Form 7460 applications for each location. Deployment will be delayed if these initial locations are unacceptable, requiring testing of other locations. However, it is likely that one of the selected locations will meet minimal needs and full deployment can occur immediately after clutter mapping has been completed.

Infrastructure Considerations

To maximize the potential of an avian radar system, a site must have electrical power and support connectivity of the radar to a network that will allow remote control and transfer of large quantities of data.

Power is not accessible at all locations on the airfield and, in some cases, it can be cost prohibitive to be too far away from an available power source.

Obtaining connectivity is often the final step in placing a radar. A high speed connection is needed to utilize the system to its fullest . Such a requirement, while potentially problematic in the middle of an airfield, can be handled in a number of different ways. In some scenarios, the airport can be very accommodating with their internal network and will provide all the necessary connections and IT work to enable the radars to upload their data to remote locations. However, other airports are not as accommodating. Typically, radars are deployed with wireless bridges. This method allows the trailers to remain at their remote locations and connects them via wireless to a building on or off the airfield where connectivity can be obtained. With current technology this is the only solution to get high speed traffic off of the airfield to centralized servers where radar data can be processed. Using this wireless setup requires an additional 7460 application to ensure that the frequency used does not interfere with any aviation equipment in use on the airport. The wireless bridges are a full duplex system, allowing for high throughput. This requires two different frequencies between 5.250 and 5.850 GHz. These channels can be 5, 10, 20, or 40 Mhz wide depending on what other equipment may be in use on the airfield. Also, the link supports encryption, if security is a concern.

DEMONSTRATIONS OF SITE SELECTION PROCEDURES

Chicago's O'Hare International Airport

At Chicago's O'Hare International Airport (ORD), a clutter mapping exercise was initiated with a review of critical habitat areas with local wildlife biologists, and a total of 23 sites were selected for clutter mapping. The procedure at ORD called for observations from the ground and from the top of a utility trailer. The difference in clutter returns based on an elevation difference of approximately 10 ft (3 m) can be seen in Figure 1.

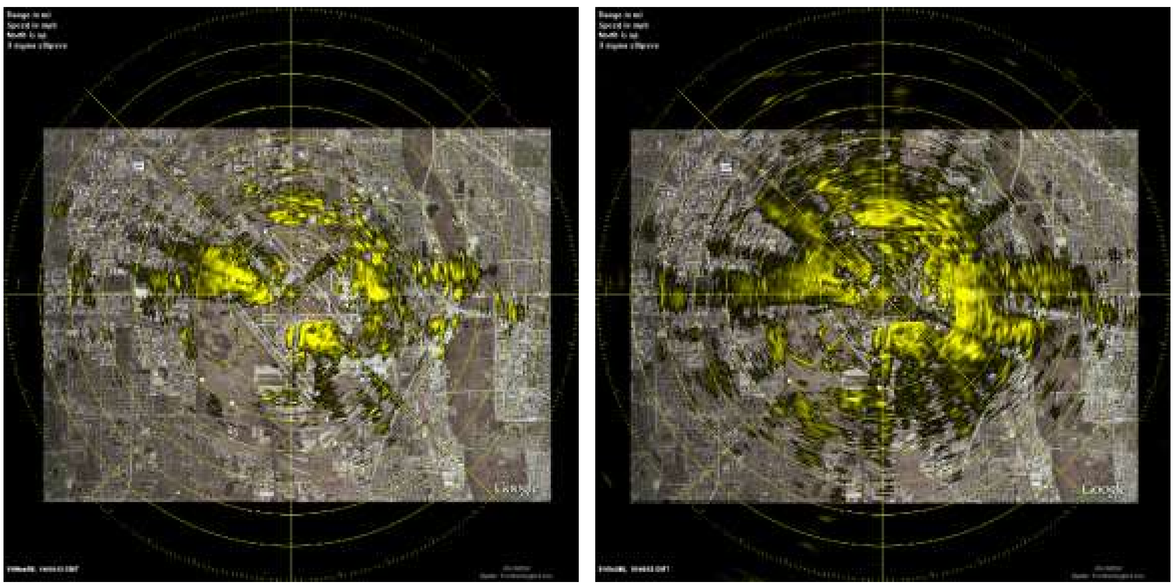

Figure 1. Radar Clutter Displayed with Scanner on the Ground (Left) and on Top of the Trailer (Right).

With 23 sites clutter mapped, ORD has the most locations clutter mapped in CEAT clutter mapping activities Figure 2. This has resulted in a very good understanding of the clutter environment at the airfield.

Figure 2. Aerial Image of ORD Showing Clutter Mapped Sites.

At ORD, clutter mapping resulted in rejection of a number of sites because clutter was assessed as severe and this clutter condition would compromise bird detection. An example of a rejected site is provided in Figure 3. In this figure, bright areas indicate areas of high clutter where detection and tracking of birds is problematic. Note that Figure 3 is a composite image of 10 scans, providing evidence that the clutter is due to fixed obstructions.

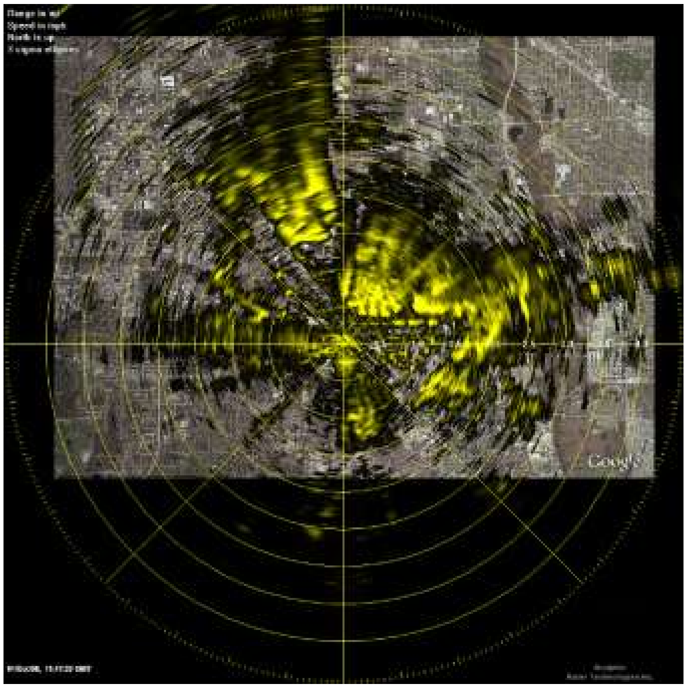

Figure 3. Clutter Mapping Indicates a Non-Ideal Clutter Environment at an ORD Site. Much of the airfield is covered in bright yellow radar clutter at this location.

In civil airport siting safety zones must be avoided.In the weeks that followed completion of the clutter mapping procedure at ORD, CEAT worked with ORD personnel to identify sites that avoided safety zones and where power and connectivity could be obtained. In this site possibility analysis, clutter mapping provided a triage. It was possible to reject unsuitable sites and identify optimal sites to provide a focus for assessment of infrastructure availability. Airport personnel were given a list of locations where the system would have good coverage of critical areas for both to wildlife management and aircraft safety management. One of the problems encountered at O'Hare is the O'Hare Modernization Program, which is a $7 billion project to modify traffic flow and increase capacity. This complicated the site selection process because the relative stability of the site also needed to be considered. Once infrastructure was located and deployment options discussed, information was gathered on the most used flight patterns to monitor. It was then possible to locate radars to provide optimum coverage supporting aircraft safety and wildlife management.

Clutter mapping at ORD revealed one location, Site 9, more suited to radar deployment than the rest. The site was relatively clutter free and had available infrastructure. Analysis of short-term operation of the radars indicated good bird detection when compared to most areas of the airport. This site was selected for deployment of two radar systems, a dual dish AR-2 system and a single array antenna AR-1 system. The clutter mapping for Site 9 is provided in Figure 4.

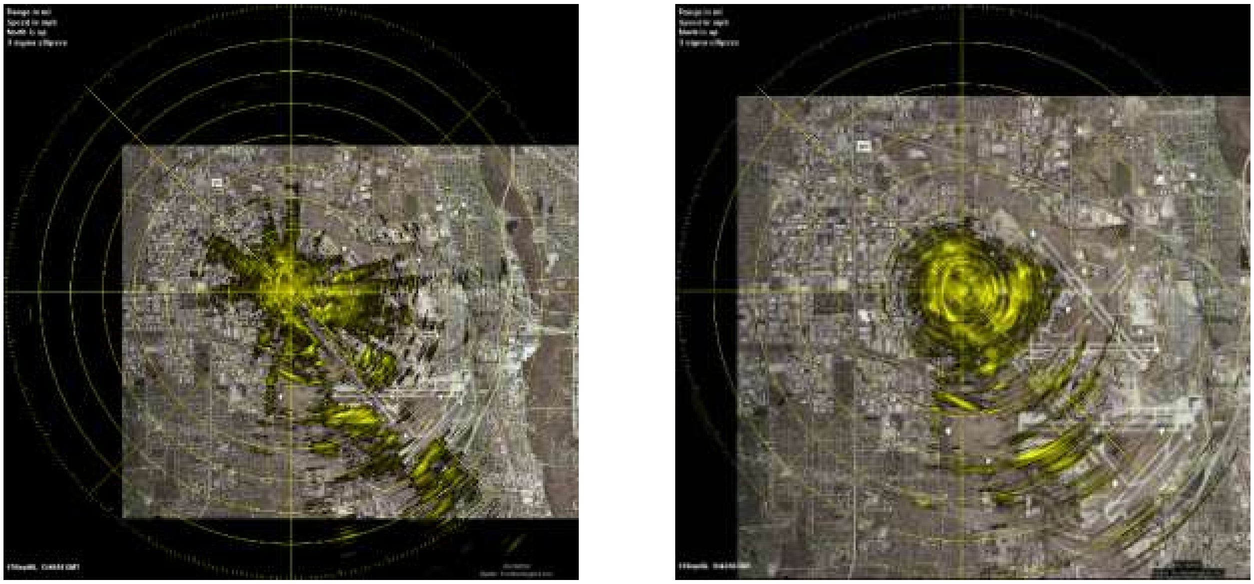

Figure 4. Clutter at the Current ORD Radar Location for
Array (Left) and Dish (Right) Antennas.

New York's John F. Kennedy International Airport At New York's John F. Kennedy International Airport (JFK), the experience gained in clutter mapping at ORD was applied to site selection. Meetings were held with wildlife biologists to identify critical coverage areas to support wildlife management. General runway use patterns were also reviewed to identify high priority runway coverage. After discussions with FAA personnel and a temporary 7460 approval for 13 sites was obtained, clutter mapping at JFK was initiated in May 2009. Sites for clutter mapping were selected based on areas of interest to airport personnel, as well as availability of power and connectivity for the radars. Using knowledge from the previous clutter mapping activities at ORD enabled a better selection of initial sites and cut down on the total number of sites that were selected to undergo clutter mapping.

Figure 5. A Google Map of JFK Showing Clutter Mapped Sites.

Clutter mapping took place during two campaigns, each lasting campaign a little under a week. At the completion of clutter mapping(Figure 5), five possible radar locations were identified and further field investigations were undertaken to confirm power availability and determine how radars could be deployed to maximize coverage needed for both air traffic hazard management and wildlife management.

Two sites were eventually selected based on power availability and ease of potential connectivity. Site 5 is located on the shore side of runway 31L, at near the midpoint of that runway. The clutter map for this site varied based on radar scanner elevation. When placed on the trailer platform, the slotted array antenna produced strong returns from the bridges to the west, airport buildings to the north and northeast, as well as more distant islands to the south and southeast over Jamaica Bay. When placed on the ground, a small hill tended to minimize spurious tracks from ground traffic and although there was evident sea clutter from Jamaica Bay, the overall clutter interference was less than observed from the rooftop location. The parabolic dish antenna showed weaker clutter returns than the slotted array antenna.

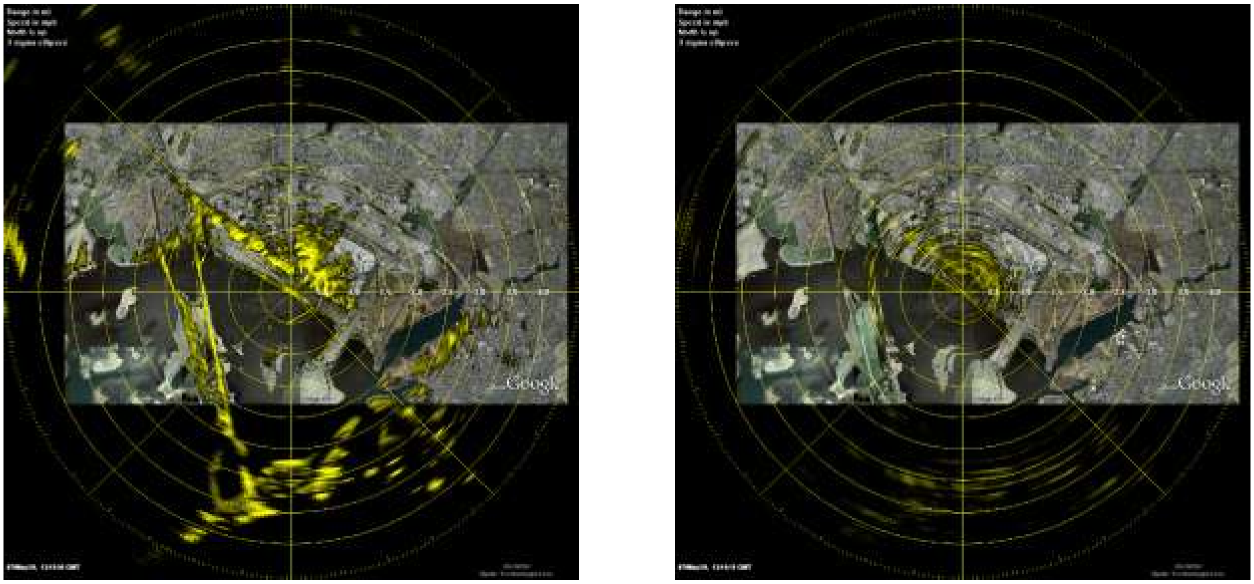

Figure 6. Clutter for JFK Site 5 for Array Antenna (Left) and Dish Antenna (Right)

At one point during the clutter mapping a large flock of Brant *Branta bernicla* flew over Site 5, across active runways, and departed the airport. The radar was able to track these birds from over the water to the southwest, all the way to the north side of the airfield. Tracks were also reliable along the Bergen Basin to the west of the airfield, providing an initial sense of radar detection potentials..

The second site selected at JFK is Site 12, located in the northeast corner of the airfield. It is just north of the 22L approach and just west of the burn pit. Clutter mapping and bird target observations indicated that both the parabolic dish and slotted array antennas, when placed on the roof of the radar trailer, provided good bird target detection from across Jamaica Bay. Changing antenna elevation did influence clutter, but was found to also reduce coverage along runway 22L and beyond to Jamaica Bay. Avian targets were detected consistently at 360 degrees around the radar.

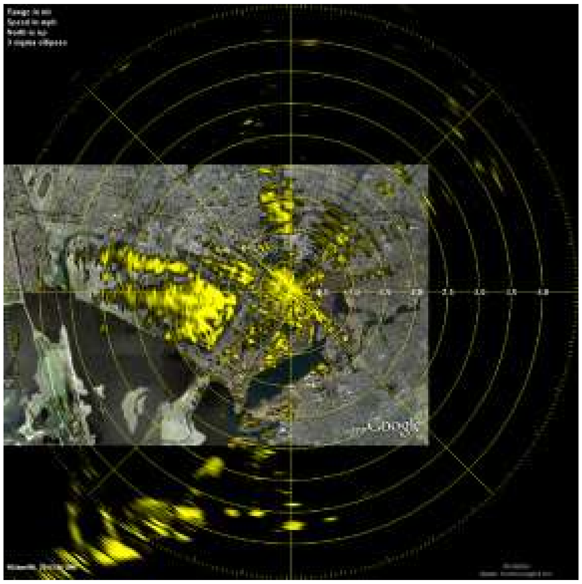
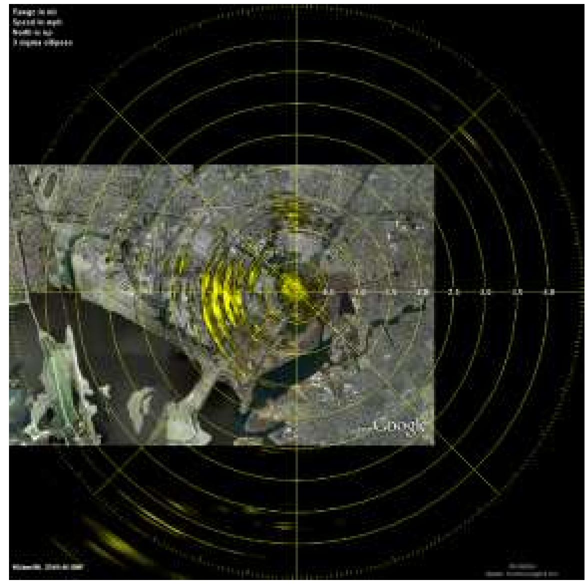

Figure 7. Clutter for JFK at Site 12 for Array Antenna (Left) and Dish Antenna (Right) Antennas

CONCLUSION

When placing an avian radar system on a civilian airport, there are numerous and not necessarily obvious factors that must be considered as sites for the radar are evaluated. The site must provide good detection capability for critical areas where observational data suggests a high hazard potential due to site attractants or actual use. For the radar to perform optimally, the desired location must also be clear of radar clutter and have unobstructed views of areas on the airfield that require radar coverage. Finally, infrastructure support, in the form of lines power and broadband connectivity, are needed for maximum utilization of the radar. Finding the correct balance between these components is the first step in bringing an avian radar system on-line at any civil airport, and each of these elements provide unique challenges to the siting process. CEAT experiences at ORD and JFK provide good examples of this process.