KENT STATE UNIVERSITY

2009 – 2010 FAA DESIGN COMPETITION FOR UNIVERSITIES

An Integrated System to Prevent Wildlife Strikes at Large Airports

Russell Mills – Team Lead
Bryan Beck
Timothy Becker
Skylar Edenhart-Pepe
Galym Gabbas
Michael Sciolino

Dr. Isaac Richmond Nettey – Faculty Advisor
Aeronautics Division, College of Technology
Kent State University, Kent, Ohio 44242

14th April 2010

KENT STATE UNIVERSITY

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Ms. Mary L. Sandy, Director
Virginia Space Grant Consortium
600 Butler Farm Road, Ste. 2253
Hampton, Virginia 23666

Dear Ms. Sandy:

Please find under cover of this letter, an important proposal for "An Integrated System to Prevent Wildlife Strikes at Large Airports" submitted under the Airport Operations and Maintenance Challenge–Innovative Approaches to Address Wildlife Issues at Airports Including Bird Strikes area, which is Challenge IA of the 2009-2010 FAA Design Competition for Universities.

"An Integrated System to Prevent Wildlife Strikes at Large Airports" represents the collective efforts of a student team comprising one graduate student, Russell Mills, who served as student lead and five undergrads in the persons of Bryan Beck, Tim Becker, Skyler Edenhart-Pepe, Galym Gabas and Michael Sciolino from the Airport Management (TECH 35340) class.

As course professor of the Airport Management class, it was a privilege to work with this team through multiple iterations to hone this proposal into a very important work of tremendous potential benefit to aviation safety in partnership with several practitioners from industry. Thank you for extending careful and favorable consideration to this important proposal.

Sincerely,

I. Richmond Nettey

I. Richmond Nettey, Ph.D.
Associate Dean, College of Technology and
Faculty Advisor, FAA Design Competition for Universities

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Research Team Leader (Graduate Student)
Russell W. Mills
PhD Student, Kent State University

Research Team Members (Undergraduate Students)
Bryan Beck
Timothy Becker
Skyler Edenhart-Pepe
Galym Gabbas
Michael Sciolino

Faculty Advisor
I. Richmond Nettey, PhD
Associate Dean, College of Technology
Kent State University

Executive Summary

On January 15, 2009, US Airways Flight 1549 Captain Chesley Sullenberger successfully landed an Airbus A320 on the Hudson River in Manhattan after the aircraft struck a flock of Canadian geese shortly after take-off resulting in the loss of thrust in both engines. While the landing of Flight 1549 on the Hudson River by Captain Sullenberger brought the issue of wildlife strikes onto the larger public agenda, aviation professionals have long realized the inherent dangers and costs associated with wildlife incursions at airports. Experts estimate that wildlife strikes have killed more than 219 people and destroyed 200 aircraft since 1988 (Dolbeer and Wright 2009; Thorpe 2003; 2005) and cost civil aviation over $625 million per year in the United States.

The major innovation of this proposal is to merge three existing wildlife mitigation technologies (*Merlin avian radar and detect and deter, Ultima* data logging system by Scarecrow Bio-acoustics and ASDE-X by Sensis) that will provide airport operations and air traffic control personnel with real-time information to render effective mitigation decisions. The integrated system to manage wildlife strikes at Part 139 airports outlined in this proposal will attempt to overcome critical limitations of existing wildlife management techniques used by the nation's airports. First, by developing a system that utilizes real-time data that allows airports to interface their existing wildlife dispersal techniques, this proposed system gives airport operators and ATC personnel increased flexibility and options in managing wildlife at airports. Secondly, the *Ultima* system's self-leaning species recognition software coupled with the development of a national level database (NWMD) on the effectiveness of various dispersal techniques on different species of wildlife will allow both FAA officials and individual operators to develop risk based approaches consistent with the FAA's implementation of safety management systems (SMS) to manage wildlife at the nation's airports that focuses on the likelihood and potential severity of accidents caused by various species. Finally, this integrated system will help reduce the long-term costs of managing wildlife at airports by allowing airport operators to use risk-based safety information to target their mitigation techniques. Based on the implementation plan and cost-benefit analysis conducted in this proposal, the proposed system could be fully implemented at 35 airports in the next two years and would pay for its approximate $8.7 million dollar cost per airport in a period of 4 years while reducing wildlife strikes by 20%.

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Section 1.1: The Scope of the Wildlife Strike Problem

On January 15, 2009, US Airways Flight 1549 Captain Chesley Sullenberger successfully landed an Airbus A320 on the Hudson River in Manhattan after the aircraft struck a flock of Canadian geese shortly after take-off resulting in the loss of thrust in both engines. While the landing of Flight 1549 on the Hudson River by Captain Sullenberger brought the issue of wildlife strikes onto the larger public agenda, aviation professionals have long realized the inherent dangers and costs associated with wildlife incursions at airports. Thorpe (2003) notes that the first wildlife strike in the United States occurred in 1908 when Orville Wright struck a bird outside of Dayton, Ohio. The first recorded fatal bird strike occurred in 1912 at Long Beach, California, when Cal Rodgers, the first person to fly across the United States, struck a gull and lost control of a Wright flyer (Thorpe 2005). While wildlife strikes have been present since the beginning of aviation in the United States, today, wildlife strikes by aircraft pose a greater threat to human health and safety than at any point in history.

Figure 1 illustrates that since 1990 there has been a steady increase in the number of both bird and terrestrial strikes by aircraft in the United States. Specifically, from 1990 to 2007, there were 79,972 bird, 1,737 terrestrial mammal, 253 bat, and 95 reptile strikes reported to the FAA. In addition, experts estimate that wildlife strikes have killed more than 219 people and destroyed 200 aircraft since 1988 (Dolbeer and Wright 2009; Thorpe 2003; 2005). Dolbeer and Wright (2008) estimate that wildlife-aircraft strikes, 98% of which involve birds, cost civil aviation over $625 million per year in the United States. Cleary and Dolbeer (2005) find that wildlife strikes result in 500,000 hours of passenger delay annually. Finally, Allan (2002) estimated that bird strikes annually cost commercial air carriers worldwide in excess of $1.2 billion. The evidence that wildlife strikes are increasing and are costly in terms of human life and monetary dollars is clear. What are less clear are the reasons for the significant increase in the incidence of wildlife strikes in the United States.

Figure 1: Wildlife Strikes at U.S. Airports: 1990-2007

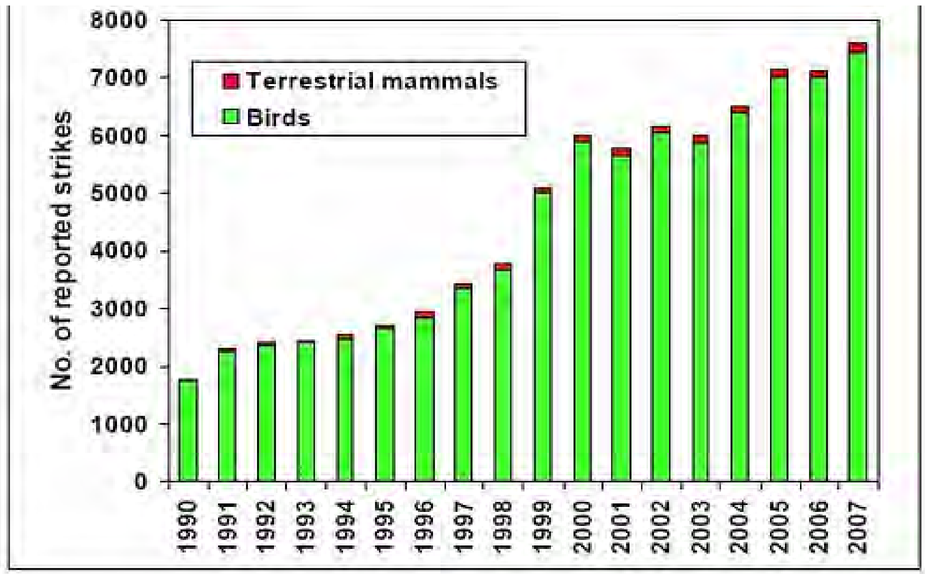


Figure 1. Number of reported bird (N = 79,972) and terrestrial mammal (N = 1,737) strikes to civil aircraft, USA, 1990–2007. Additionally, 253 and 95 strikes involving bats and reptiles, respectively, were reported for this 18-year period for a total of 82,057 strikes by all species of wildlife (see Table 1).

Dolbeer and Wright (2008)

Dolbeer and Wright (2008) argue that several factors have contributed to the increased threat of wildlife strikes at airports:

- **Due to the legacy of strict natural resource and environmental protection efforts, populations of wildlife species commonly involved in strikes have increased and adapted to living in urban settings**.
    - For example, Sauer et al. (2007) note that from 1980 to 2006, Canadian geese populations in the United States have increased by a mean of 7.3% per year.
- **Concurrent with population increases in large bird species, air traffic has substantially increased since 1980.**
    - Passenger enplanements have increased from 310 million in 1980 to 749 million in 2007 with a commensurate increase in flight operations.
- **Commercial air-carriers are replacing older three-to-four engine aircraft with more efficient and quieter two-engine aircraft.**
    - The reduction in engine redundancy increases the probability of life-threatening situations
    - Research has indicated that birds are less able to detect and avoid new faster and quieter aircraft (Kelly et al. 1999).

- **Many species of wildlife have adapted to more suburban environments, where airports tend to be located. Also, many of these species have grown drastically in size**
    - The 14 largest bird species in North America all have a body mass over 8.3 pounds, which is well above the current airframe and engine standards for wildlife strikes (Kuhn 2009; Cleary and Dolbeer 2005).

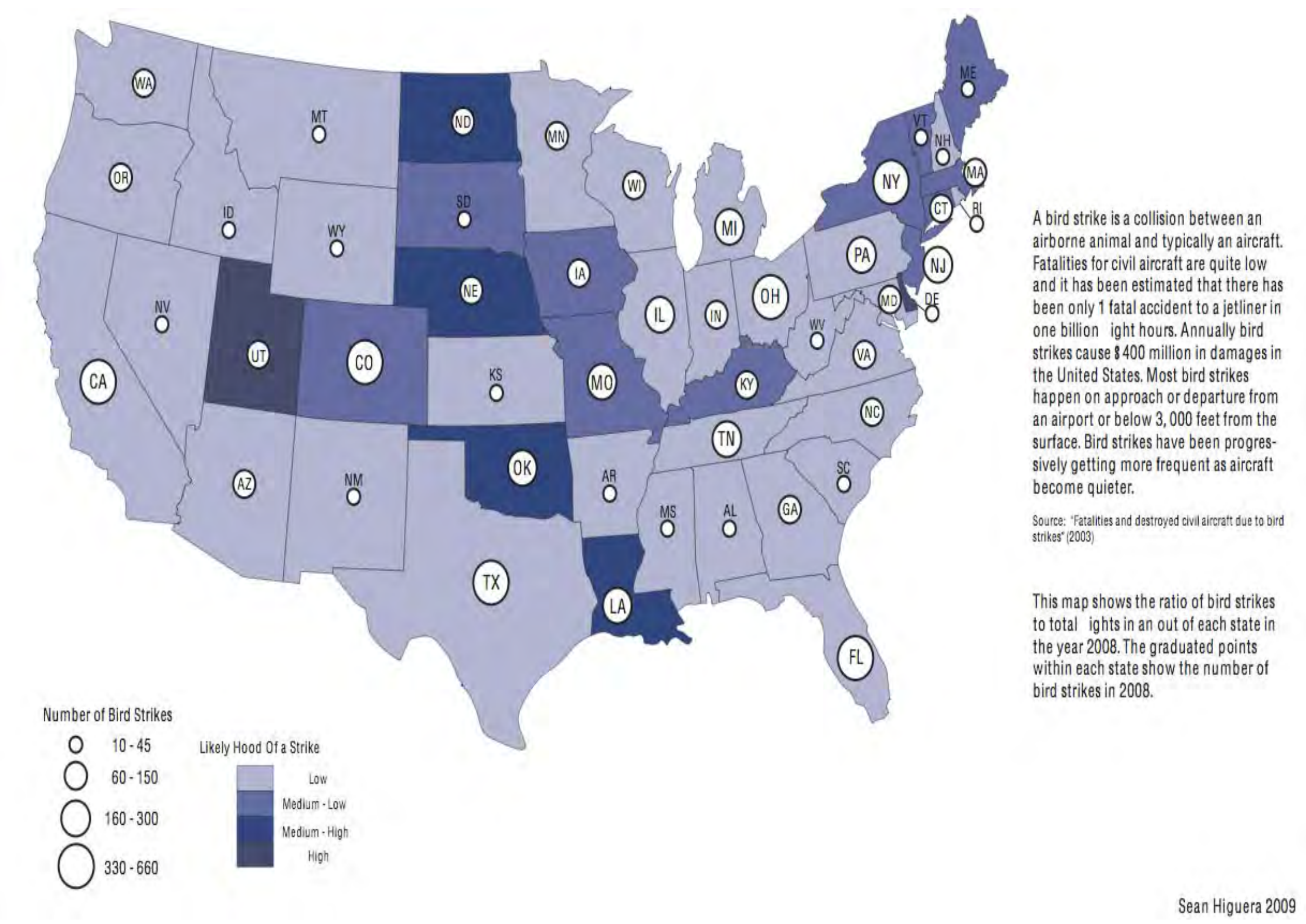
Each of the macro-level factors above has combined with local-level factors, which serve as a "risk multiplier"[1] to produce an increased threat of wildlife strikes at the nation's airports. Airports tend to be attractive areas for wildlife because desirable food, water, or habitat exists on the airfield. Additionally, wildlife may be attracted to other habitats nearby the airport such as golf courses, wetlands, or waste disposal facilities (Cleary and Dolbeer 2005). Because 74% of all strikes occur at or below 500 feet above ground level (AGL) (Cleary and Dolbeer 2005), any viable solution to wildlife strikes within the aviation system must begin with airports. The nature of the wildlife problem at an individual airport will depend on many factors including air traffic type and volume, local wildlife populations, and surrounding habitat. Figure 2 illustrates how differences in habitat even at the state level can affect the prevalence of bird strikes at airports. For example, the New England and Great Plains regions experienced a higher risk of bird strikes in 2008 than airports in the Southern or Western United States. However, when one examines airports with the most wildlife strikes in 2008, it becomes clear that these top airports span across all habitat types in the United States.

While the problem of wildlife strikes at airports is evident, a one-size fits all solution to the problem quite possibly does not exist. As one consultant put it, "There isn't a magic button in the control tower that you press and all the birds disappear" (Reinhardt 2009). However, airports can and have taken steps to mitigate the increased threat that wildlife strikes pose to aviation. For example, in 2007, Seattle-Tacoma Airport became the first airport in the world to

[1] A risk multiplier is an aggravating factor that undermines efforts to reduce risk by solving problems (The Prince of Wales; "Green Alert." Newsweek. December 14 2009. p.56)

employ an avian radar system to detect potentially hazardous bird activity on or near the airfield (Port of Seattle Website). Also, from July-September 2009, Pittsburgh International Airport conducted a trial using a bio-acoustic product from Scarecrow Bio-acoustic systems as part of their wildlife management program (Reinhardt 2009). It is clear that some airports have taken innovative steps to manage wildlife strikes. While a one step fits all solution is unlikely, many improvements to the current implementation and design of wildlife hazard management plans are possible and necessary.

Figure 2: Bird Strike Variation in the Continental United States – 2008



(Higuera 2009)

Section 1.2: The Design Challenge: Managing An Integrated System to Prevent Wildlife Strikes at Civil Airports

From the discussion in Section 1.1, the evidence is clear that wildlife strikes will continue to pose a significant challenge for airport operators. While some airports have taken innovative steps to manage wildlife strikes, airport operators still face many challenges in managing this threat to human health and safety. The landing of Flight 1549 in the Hudson River has led the FAA to consider changing regulations to require that all Part 139 airports create wildlife hazard management plans (WHMPs). Currently, Part 139.337 requires that only airports that have experienced a "triggering" event such as engine ingestion of a bird or a strike with a deer (Kuhn 2009). Only 298 of the 563 Part 139 certificated airports in the USA had FAA-approved WHMPs. As MacKinnon *et al*. (2001) and Dolbeer (2005) have noted, airport operators must exercise due diligence in managing wildlife hazards at airports in order to avoid being held liable for wildlife strike related damage and injuries. Dolbeer (2006b) argues that due diligence requires that airport operators take steps to develop WHMPs.

As the FAA decides whether to require all airports to develop WHMPs, it has become clear that there are several challenges that airport operators face in designing, implementing, managing, and monitoring these plans. *First, as Dolbeer and Wright (2009) have argued, no benchmark currently exists upon which to compare the utility of airport's WHMPs and this leaves some airport operators unsure of which mitigation strategies work best for certain species.* As airport operators begin to develop WHMPs at their airports, a measurable and quantifiable indicator of the successfulness of certain mitigation techniques versus others would be a helpful tool for designing a WHMP. Officials at Cleveland Hopkins airport (CLE) expressed that it would be helpful to develop a database of best practices and techniques currently used to mitigate specific species that would be available to share among airport operations personnel (CLE Interview 11/6/09). *Second, the development of safety management systems (SMS) by the FAA necessitates that airport operators place emphasis on designing WHMPs that identify the risk that different species pose to aircraft.* For example, Dolbeer and Wright (2009) have ranked the various risks that different wildlife pose to airports based on the number of strikes, the number of strikes causing serious damage, and the number of strikes involving multiple animals. A system that made real-time risk assessments of wildlife on the ground would be very beneficial to airport operators to determine which mitigation tactics to employ. *Third, airport operators face the challenge of staffing wildlife management efforts.* Most airports manage wildlife threats on an "as needed" basis through the use of a single employee (Cleary and Dolbeer 2005). *Finally, and most importantly, many of the current solutions to the wildlife strike problems are cost prohibitive for airports to implement.*

Many airport operators have attempted to address these challenges through the implementation of a number of technologies designed to mitigate wildlife strikes at airports. Technologies such as avian radars (Sicom, Geo-Marine, DeTect), bio-accoustics (DeTect and Scarecrow), and visual laser systems (DeTect) have been implemented by airports to manage wildlife strikes at airports. While these initiatives have demonstrated great potential in managing wildlife strikes, many agree that a system that can simultaneously provide a three dimensional image of the species, determine the species and an effective mitigation tactic, and issue warnings to pilots and wildlife-control officers based on the detected hazard will be required to fulfill the necessities of multiple-runway airports (Transport Canada 2006). Additionally, existing technologies have done little to ensure the accurate and real-time transfer of important data on the nature of wildlife threats to a central clearinghouse for further analysis.

This airport design project will outline the development of a technological innovation that could be developed to achieve an **integrated and unified reporting system** which provides real-time data on the types of wildlife present at airports, the risk posed by each of these species, the effectiveness of various dispersion tactics in mitigating different species of wildlife, and interfaces with the FAA's National Wildlife Strike Database to provide accurate real-time information to airport operators. This system would aid airport operators immensely in meeting the challenges listed above by providing them with an integrated tool that would collect and share valuable information on the types of mitigation tactics that are the most effective in managing certain species. Also, this system could be successfully integrated into the FAA's implementation plans for the NextGen system and would further the FAA's goal of implementing ICAO's SMS principals. While no "silver bullet" exists to remedy the problem of wildlife strikes at airports, an integrated system coupled with locally designed mitigation tactics could overcome many of the informational challenges faced by the FAA and airport operators in designing effective WHMPs.

Section 2: Review of the Literature and Current Wildlife Management Practices

Section 2.1: Reporting, Planning, and Training for Wildlife Management

Section 2.1.1: Developing Wildlife Hazard Assessments (WHA's) and Wildlife Hazard Management Plans (WHMP's)

One of the first steps in managing wildlife hazards at airports is through the development of Wildlife Hazard Assessments (WHAs) and Wildlife Hazard Management Plans (WHMPs). These plans are regulated under Title 14 CFR 139.337 which states that certificate holding airports must ensure that a WHA is completed when one of the following "triggering" events occur at an airport:

- An air carrier aircraft experiences multiple wildlife strikes;
- An air carrier aircraft experiences substantial damage from striking wildlife
- An air carrier aircraft experiences an engine ingestion of wildlife
- Airports have a standing Notice to Airmen warning pilots of wildlife hazards on or near the airport

Once a WHA is deemed to be necessary, airport officials must seek the assistance of a wildlife damage management biologist who meets the U.S. Office of Personal Management (OPM) standards for a wildlife biologist or has prepared an acceptable WHA or WHMP in the past. The WHA process requires a 12-month assessment of the seasonal patterns of wildlife in the surrounding area and must include:

- Analysis of the event or circumstances that prompted the study
- Identification of the wildlife species observed and their numbers, locations, and movements
- Identification and location of features on and near the airport that attract wildlife
- Description of the wildlife hazards to air carrier operations
- Recommended actions for reducing wildlife hazards to air carrier operations

When completed, the WHA is submitted to the FAA for evaluation and determination of whether a WHMP needs to be developed for each airport. Based on the quality of the WHA, the aeronautical activity at the airport, and the views of certificate holder and airport users, the FAA decides whether a WHMP is needed. If a WHMP is needed, the airport operator uses the findings of the WHA to develop the plan, which must achieve the following (Cleary and Dolbeer 2005):

- Identify personnel responsible for implementing each phase of the plan
- Identify and provide information on hazardous wildlife attractants on or near the airport
- Identify appropriate wildlife management techniques to minimize the wildlife hazard
- Prioritize appropriate management techniques
- Recommend necessary equipment and supplies
- Identify training requirements for the airport personnel who will implement the WHMP
- Identify when and how the plan will be reviewed and updated

It is important to note, that while airports that have not had a "triggering" event, many airports implement "as-needed" wildlife management practices because as experts have noted, airports may be held liable for wildlife strikes unless they use "due-diligence" in managing wildlife-related hazards (MacKinnon et al. 2001; Dolbeer 2005). However, the ditching of US Airways Flight 1549 into the Hudson River after a strike with a flock of Canadian geese has led to the FAA considering changing its regulation governing WHAs and WHMPs to require that all airports design a WHMP to manage the threat posed by wildlife strikes (Kuhn 2009). Currently, only 298 of the 563 Part 139 certified airports in the United States have FAA-approved WHMPs.

Section 2.1.2: The Need for Hazard Assessments of Risk

In November 2005, ICAO amended Annex 14, Volume 1 to ensure that all airports implement safety management systems (SMS). Stolzer, Halford, and Goglia (2008) define SMS as "a dynamic risk management system based on quality management system principles in a structure scaled appropriately to the operational risk, applied in a safety culture environment" (p. 19). Dolbeer and Wright (2009) argue that for WHMPs to be effective, they must prioritize the hazards posed by different species of wildlife. The authors argue that when the reactive ranking of species that have caused damage locally is used in conjunction with the proactive risk assessment based on the nationally determined hazard levels of wildlife observed at airports, an operator can better prioritize management activities.

Section 2.1.3: Reporting of Wildlife Strikes

Cleary and Dolbeer (2005) argue that before a problem can be solved, the problem must first be understood. One step in understanding the problem of wildlife strikes at airports is through the collection and analysis of data on strikes that have previously occurred. Advisory Circular 150/5200 032A (2004) states that all reporting of wildlife strikes is done through the completion of FAA Form 5200-7 by pilots, airport operations staff or airport maintenance personnel. Dolbeer and Wright (2005; 2008; 2009) found that only 20% of all wildlife strikes are reported at Part 139 airports while only 5% are reported at general aviation airports. Linnell, Conover, and Ohashi (1999) found that pilots only filed a report for one out of four bird strikes. There are several reasons why wildlife-strikes are under-reported:

- There are no consistent worldwide standards
- Wildlife-strike reporting is not mandatory
- Some countries are reluctant to publish wildlife strike statistics out of concern for liability and negative publicity (Transport Canada 2001)

Once a report is filed with the FAA, the National Wildlife Strike Database Manager edits the reports to ensure accurate, error-free data before entering the report into the database. The database is managed by the USDA-WS through an interagency agreement with the FAA. The staff biologist at the FAA reviews all reports before they are entered into the database. Analyses of wildlife strike data have proven invaluable in determining the magnitude, nature, and severity of the wildlife strike problem. The database provides a scientific basis for identifying risk factors; justifying, implementing, and defending corrective actions at airports; and judging the effectiveness of those corrective actions. The database is also of critical value to engine manufacturers and aeronautical engineers (Cleary and Dolbeer 2005).

Section 2.1.4: Staffing and Training of Wildlife Management Personnel

Depending on the size of an airport and the level of wildlife hazard, the WHMP may be implemented by a single airport employee undertaking wildlife control activities on an occasional "as needed" basis or by a full-time wildlife biologist with a staff of operations personnel providing continuous bird patrols (Cleary and Dolbeer 2005). It is likely that many of these wildlife management personnel (WMP) may not have formal wildlife training, which is essential to identify species at airports, develop techniques to disperse wildlife, and to implement the WHMP. Also, it is important that WMP be adequately trained in wildlife laws and regulations in order to design wildlife management systems that are within the scope of environmental regulations. Finally, it is important to train WMP on how to develop a system to document their daily activities, log information about wildlife numbers and behavior on the airport, and record all wildlife strikes with aircraft. This information is essential to document the effort being made by the airport in reducing wildlife hazards. The information is also extremely useful during periodic evaluations of the Wildlife Hazard Management Plan and when revisions to the plan are proposed (Cleary and Dolbeer 2005).

Section 2.2: Technologies used to identify and locate wildlife

Section 2.2.1: Avian Radar

As Seattle-Tacoma Airport Managing Director Mark Reis said before a House subcommittee panel investigating the ditching of Flight 1549, "To successfully manage bird populations, airports must first understand their flight patterns and behavior" (Reis 2009). One emerging technology that is increasingly being used to identify, understand, and locate birds within the airport airspace is avian radar systems. Avian radar systems allow airport officials to see further and higher than could be accomplished with the human eye. Also, avian radar systems allow for the daily monitoring of birds and recently allow for real-time tracking of birds

(Reis 2009). Avian radars, while thought of as a recent innovation, have actually been in existence since the 1940s. During World War II, military radars that were being used to track enemy movements also were able to track birds (Lack and Varley 1945). As radars became more technologically sophisticated and less expensive during the 1970s, researchers began to use radars to track birds (Nohara et al. 2007). The first modern avian radar system was installed at Seattle-Tacoma airport in August of 2007. Since then, avian radar systems have been installed at Chicago O'Hare, Dallas/Fort Worth, and John F. Kennedy International Airports (Reis 2009).

Several types of avian radar systems have been successfully implemented at airports and are currently available for use. Below is a list of avian radar systems that have been implemented at airports:

- **Avian Hazard Advisory Systems (AHAS)** were developed by the United States Air Force in the early 1980s to provide information on real-time bird concentrations and updated bird strike risk assessments. AHAS essentially assigns each square kilometer of the United States a unique bird-strike risk value.

- **Accipiter Avian Radar (AAR) by Sicom Systems** (Figure 3) was developed in 1994 to provide local, real-time and historical situational awareness of bird and aircraft movements. AAR uses a fully integrated geographical information system (GIS) that provides coordinates, speed, heading, and size perimeters of up to 1,000 targets. Also, AAR provides GIS target data for measuring the effectiveness of habitat-management and risk-mitigation strategies. Finally, AAR is the first avian radar to offer three-dimensional images of targeted birds. AAR is currently operational at Seattle-Tacoma and Toronto Pearson International Airports.

Figure 3: Accipiter Avian Radar

- **Mobile Avian Radar System (MARS) by Geo-Marine Inc.** was developed in 1994 as a sensor-based radar system designed to reduce bird strikes to aircraft and collect data for a variety of environmental applications. The MARS system runs 24/7 while continuously collecting data. Also, the MARS system provides a 360-degree sweep that can identify individual and flocks of birds.

- **MERLIN Bird Strike Avoidance Radar System by DeTect Inc. (Figures 4)** was developed in 2003 and enables Air Traffic Control, airport operations and bird-control units to monitor high-risk zones even during inclement weather. MERLIN also records bird-track data attributes including size, speed, bearing and altitude to a GIS-exportable database that can be used in long-term resource management and planning. MERLIN also can be interfaced with DeTect bird control techniques. MERLIN has been tested at Dallas Fort-Worth International Airport and Louisville International Airport.

Figure 4: MERLIN Bird Strike Avoidance Radar System

Section 2.2.2: Infrared Imaging

Infrared imaging systems are another tool at the disposal of airport operators for identifying and locating wildlife in the vicinity of the airfield. Ivey (1999) argues that thermal devices can be used to allow ground and tower personnel to pinpoint bird locations day or night, thus giving the airport operators the ability to launch countermeasures or simply warn the aircrews. Also, Ivey (1999) argues that thermal systems can be devised to detect hazards across the entire airfield:

> The system works effectively with just the thermal imager and monitor within the tower. When a Video Detection Monitor (VDM) senses both heat and movement in it's scanning area, it signals the thermal unit to stop scanning and automatically zooms in on that area. The Automatic Targeting Recognition (ATR) computer works similar to the VDM's,

> however; it incorporates a database of thermal images stored in the computer to determine what it is detecting prior to initiating the alarm. The thermal device continuously scans the airfield and the entire perimeter, feeding the information into the ATR computer. The thermal unit will automatically zoom in on the object when heat is detected. The ATR software now sets to the task of analyzing the object against known hazards to determine if that object is a human, vehicle, bird, deer, or any other hazard to aircraft. The total time from pickup to processing of an object and the correlating alarm is reportedly far less than thirty seconds.

Infrared systems currently cost anywhere from $90,000 to $175,000 (Transport Canada Website). In a comparison of three infrared devises used to observe deer, Belant and Seamans (2000) found that forward-looking infrared (FLIR) devices were able to track deer much better at night than night-vision goggles. Currently, the two major manufactures of infrared systems are Raytheon and Inframetrics.

Section 2.3: Existing wildlife control technologies and techniques

Section 2.3.1: Aircraft Flight Schedule Modification

One control technique that is rather simple and cost effective is to modify flight schedules of some aircraft to minimize the chance of a strike with a wildlife species that has a predictable pattern of movement. Air traffic controllers could temporarily close a runway with unusually high bird activity or large mammal incursion until control personnel can disperse the animals (Cleary and Dolbeer 2005). Air traffic control personnel may also not allow departures or arrivals for a 20-minute period around the peak bird traffic times of sunrise and sunset. While seemingly practical, this technique may be very disruptive to larger airports where traffic is constant and even a short-period runway closure would cause substantial delays.

Section 2.3.2: Habitat Modification and Exclusion Techniques

Cleary and Dolbeer (2005) define habitat modification as changing the airport environment to make it less attractive or inaccessible to problem wildlife. Habitat modification techniques to make the airport as unattractive as possible to wildlife must be the foundation of every airport's WHMP. Three elements must be reduced, eliminated, or excluded to ensure the success of any airport habitat modification plan: food, shelter, and water.

- **Food:** One of the most important aspects in managing wildlife habitats is to manage the supply of food on and around the airport grounds. In urban settings, food sources include handouts from people in taxi stands, grain elevators, feed mills, sewer treatment plants, and food waste around restaurants (Cleary and Dolbeer 2005). In rural areas, sources of food include sanitary landfills, agricultural crops and spilled grain along roadways. In order to control the food supply available to wildlife, airport operators can take the following steps:
    - Use chemicals and pesticides to remove food sources
    - Allow grass to grow to a length of 6-10 inches
    - Removal of seed producing trees and shrubs that are food sources to rodents, insects, and other food sources
    - Ensuring that trash receptacles are properly stored and secured
    - Ensuring that runways are kept clear of worms after rainstorms
    - Ensure that agricultural lease agreements contain provisions regulating which types of crops can be grown (Transport Canada 2001).
- **Shelter:** All wildlife require shelter for resting, reproduction, and escape. Land-use patterns surrounding the airport must also be taken into consideration when developing a shelter mitigation plan. Species such as Canadian geese will establish residence on corporate business park lawns, golf courses, and roofs. Blackbirds use marsh vegetation found in wetlands for nesting (Cleary and Dolbeer 2005). Birds are not the only concern for airport managers looking to limit the habitat of wildlife. Hygnstrom et al. (1994) suggest using both traditional and electric fencing to deter mammals from accessing the airport. Table 1 illustrates potential hazardous wildlife habitats near airports and mitigation tactics that can be used to deter wildlife.
- **Water:** Many species of wildlife, particularly waterfowl and gulls, are attracted to water not only to drink but also for shelter. Airport water habitats vary but include ditches, ponds, drainage areas, creeks, rivers, and lakes. Airport operators have a variety of mitigation techniques at their disposal including:
    - Filling or modifying to allow rapid drainage of depressions in paved areas
    - Avoid or remove retention ponds and detention ponds
    - Use physical barriers such as bird balls, nets, or wires to deter birds and other hazardous wildlife

- Increase the slope of the bank to eliminate shelter areas (Transport Canada 2001)

Table 1: Types of Hazardous Shelters and Management Techniques

Shelter/Safe Areas	Management Technique
Woodlots	Remove all undergrowth
	Thin treetops to make them less attractive as roosting sites
	Inspect trees frequently for colonies of nesting birds
Hedgerows/ Nest Trees	Cut back at least 150 m from the runway or taxiway center line
Buildings	Eliminate holes, crevices, roosting ledges and general access to buildings
	Block, cover and seal all holes, crevices and drains by using screening, concrete or brickwork
	Apply special materials to perches to keep birds away
	Slope ledges to eliminate roosting and nesting sites by using boards, plastic sheeting and concrete
	Perform routine inspections of all airside buildings and structures
	Remove old airside buildings that are no longer in use
Trees, Structures	Monitor trees around the fenced perimeter and remove if required
	Remove all large single trees as well as small clumps of trees on airside lands
Runways, Aprons & Taxiways	Carry out inspections and remove all materials that attract birds
	Put spikes on runway lights, approach lights, taxiway and apron lights to eliminate perching and nesting sites
	Spray insecticides and herbicides beside runways to eliminate seeds and insects
	Keep runways and taxiways clean

(Transport Canada 2001)

Section 2.3.3: Land-use Management Techniques

Many current airport-vicinity developments and land uses were never anticipated when most airports were first constructed—a fact that underlines the need for airport operators to have voices in land-use planning processes, partnering with municipal governments, planning authorities, business interests and agricultural interests. The management of land near airports can have a dramatic impact on the effectiveness of wildlife-management programs (Transport Canada 2001). Table 2 illustrates some of the hazardous land-uses of neighboring properties in terms of their attractiveness to wildlife. The first step in building an effective land-use management plan is to foster good relationships with neighboring stakeholders. The following steps can be taken by airport operators to manage neighboring land-use hazards:

- Conduct awareness programs with key community stakeholders to highlight potential flight-safety and liability issues
- Implement federal zoning laws under Section 503 of the Aviation Investment and Reform Act for the 21st Century pertaining to solid waste landfills
- Attempt to partner with neighboring sites to voluntarily mitigate hazards

Section 2.4: Existing wildlife repellent and harassment techniques

Repellant and harassment techniques are designed to make the area or resource desired by wildlife unattractive or to make them uncomfortable or fearful. Over the long-term, the cost-effectiveness of repelling wildlife does not compare favorable with habitat modification of exclusion techniques. It is important to note that while habitat modification and exclusion tactics may be more cost effective, they will never completely rid an airport of problem wildlife and should be used in concert with repellent and harassment techniques. Cleary and Dolbeer (2005) note several critical factors that need to be recognized in deploying repellents:

- There are no silver bullets that will solve all problems
- There is no standard protocol or set of procedures that is best for all situations
- Each wildlife species is unique and will often respond differently to various repellent techniques
- Habituation to repellent techniques can be minimized by using a variety of repellent techniques, using them sparingly, and reinforcing them with occasional lethal control

The techniques detailed in the following sections are in addition to regular wildlife patrols and runway sweeps by wildlife management personnel.

Table 2: Types of Hazardous Airport-Neighboring Land-Uses

Agriculture	**Recreational Areas**
Crops (grains, forage legumes)	Drive-in theatres
Livestock feedlots, pig farms	Golf courses
Pasture lands	Marinas
Plowing, haying, harvesting	Picnic areas
Vineyards	Outdoor restaurants
Orchards, berry farms	Beaches
	Racetracks
Food Processing	**Wildlife Concentration Areas**
Abattoirs	Wildlife refuges
Coastal fish processing plants	Bird feeding stations
Fish-waste outfall	Bird nesting colonies
Waste Facilities	Roosting sites
Garbage barges	Loafing sites (gulls on flat roofs, parking lots)
Garbage dumps	
Waste-transfer stations	**Natural Areas**
Landfills holding organic waste	Marshes/swamps
Compost facilities	Mud Flats/shorelines
	Bush or woodlots
Water Bodies	Hedgerows
Sewage lagoons	Riparian habitat
Sewage outfalls	
Oxidation ponds	
Stormwater retention ponds	
Reservoirs and lakes	

(Transport Canada 2001)

Section 2.4.1: The Use of Visual Repellants

Airport officials use several types of visual repellents to manage wildlife problems. One common technique is the use of scarecrows to repel birds. Research has shown that birds have dispersed when seeing another of its species in a "death pose" on the airfield (Cleary and Dolbeer 2005). The use of scarecrows to repel mammals from the airfield has proven to be ineffective. While scarecrows offer airport officials a low-cost repellent technique, they are inappropriate for use as a long-term solution to bird problems at airports. A more technologically sophisticated visual repellent that has shown utility in recent years is the use of hand-held laser devices (Figure 5). Blackwell et al. (2002) tested several variations of lasers on species ranging from geese to cowbirds and found that overall lasers were effective in repelling various species of birds. Werner and Clark (2006) found that a motion-activated red laser beam was successful at repelling Canadian geese. While laser devices have proven to be effective in dispersing birds, they have not been useful in repelling mammals. A final type of visual repellant that has proven to be effective is the use of aircraft landing lights to stimulate avoidance behavior in birds (Blackwell and Bernhardt 2004).

Figure 5: Avian Hand-Held Laser

<u>Section 2.4.2: The Use of Audio Repellents</u>

Propane cannons have been used at airports to disperse both mammals and birds. Generally, researchers have found that birds and deer habituate to cannons that detonate at systematic or random intervals throughout the day. Therefore, Cleary and Dolbeer (2005) note that propane cannons are more effective when used sparingly and with reinforcement by occasional killing of a few birds. Another audio repellent is the use of distress calls and pyrotechnics. These techniques have proven to be effective when combined with the non-lethal or lethal use of shotgun blasts. While these techniques have been effective in repelling birds, they have been less effective in mitigating the threat of mammals at the airport.

Section 2.4.3: The Use of Chemicals to Capture or Kill Wildlife

Some airports have used various chemicals to capture wildlife to release outside of the airfield. Alpha Chloralose (A-C) is a registered chemical with the FDA that is used as an immobilizing agent. A-C is most often incorporated into corn or bread baits; once ingested birds can be captured in 30 to 90 minutes. Some airports have used chemical tranquilizer guns to trap mammals. However, Cleary and Dolbeer (2005) argue that because most states have capture laws and deer populations are near capacity, chemical capturing of mammal is not a desirable option. Chemicals have also been used to pursue lethal management options. Starlicide is a lethal toxin for birds, which is administered through a combination of baits. Finally, chemicals and fumigants have also been used to kill rodents such as mice and rats that attract larger mammals and birds.

Section 2.4.4: The Use of Lethal Removal Tactics

Cleary and Dolbeer (2005) argue that the killing of birds and mammals at airports should be a last resort option after habitat modification, exclusion, and repellent options have been exhausted. Airport officials have used a variety of tactics including the shooting of mammals and birds. Dolbeer, Belant, and Sillings (1993) found that the implementation of a gull-shooting program at John F. Kennedy International Airport reduced gull-aircraft strikes by 70% in the first year and 89% in the second year. The killing of birds has also been accomplished through the removal and destruction of bird nests and eggs on airport property. Another tactic used by airport officials has been the hunting of deer on airport property. Finally, airport officials have used both oral and contact toxins to kill birds and small mammals at airports.

Section 2.4.5: The Use of Trained Birds and Dogs to Repel Wildlife

Since the 1940s, airports have used trained falcons and other birds of prey to disperse birds. The advantage of this approach is that birds at the airport have a natural fear response to larger birds of prey and disperse accordingly (Cleary and Dolbeer 2005). Blokpoel (1976) argue that falcons can be effective if used on a constant basis in good weather and during the daylight hours. The cost of maintaining and training these birds is a disadvantage that makes falconry programs less prevalent at airports. Other airports have used border collies to chase geese and other birds from airports. While dogs are a natural predator of birds, they will have little success in deterring birds flying above an airport.

Section 2.5: New and future technologies to prevent wildlife strikes

Many of the systems mentioned above are stand-alone bird control devices that operate independently of one another. As SMS places increased pressure on airport officials to develop risk control processes, many have looked to implement integrated wildlife management systems. Seveal technologies have been developed that offer airport officials an integrated approach to managing wildlife strikes at airports. The *MERLIN deter & detect* bird control device is an integrated system that features an advanced Radar system that monitors bird and wildlife areas and automatically activates deterrent devices that deter and harass birds. The system uses non-lethal deterrent devices such as bioacoustics, propane cannons, Long Range Acoustic Devices (LRAD) and DeTect's programmable bird laser system. *MERLIN deter & detect* can act as a stand-alone solution or can interface with existing deterrent devices.

A second technology that has recently become available to airport operators is the *Ultima* system from Scarecrow Bio-acoustic systems (Figure 6). *Ultima* is both a highly efficient bio-acoustic distress call system and a compliant data logging system. Utilizing a touch screen tablet

PC, GPS receiver and bespoke data analysis software, *Ultima* creates records of all wildlife control – both winged and four legged. The system autonomously creates an audit trail featuring date, time, location, operator, species, flock size – either by five user defined categories or individual numbers, which dispersal action was taken and what was the result. By selecting combinations of criteria (species, operator, date range, etc) it is possible to see how many actions have occurred in each grid reference. *Ultima* establishes proof of dispersal procedures completed in real time, logging operator, species, time and date; its built in GPS function logs the vehicle's airside position from which dispersal or a patrol took place (Scarecrow-Ultima brochure). Pittsburgh International Airport recently conducted a three-month trial of the Ultima system as part of their wildlife management plan (Reinhardt 2009).

Figure 6: Ultima by Scarecrow Bio-acoustics

Other technologies on the horizon have focused more on aircraft-based wildlife-strike avoidance systems than airport based systems. Although yet to be developed, there is great appeal in the concept of an airframe-mounted device that disperses birds by stimulating specific bird senses to induce avoidance behavior. Through such a device, airspace immediately ahead of an aircraft would be automatically cleared of birds. This technology could also be implemented on the ground to disperse birds from runways. Bird Avoidance Models (BAM) and Avian Hazard Advisory Systems (AHAS) may prove to be the best risk management tools for addressing bird hazards that are beyond the reach of traditional airport wildlife management programs. Also, aircraft manufactures such as Boeing have contracted with PPG Industries to redesign the next generation 737's with a new windshield that will prevent broken glass from bird strikes from entering the cockpit.

Section 2.6: Limitations of Existing Technologies

Many of the technologies and tactics used above have been proven effective at mitigating wildlife strikes at airports in the United States. However, each of the technologies used currently has a variety of limitations that make the implementation of these systems unfeasible or suboptimal for airport operators. For instance, even new technologies such as the *MERLIN detect & deter* system are cost prohibitive to many medium to smaller Part 139 airports. Another glaring limitation of many of the current wildlife hazard management systems is that they do not collect and store data on the types of species present at airports, the successfulness of specific mitigation tactics in dispersing specific species, or real-time locations of both birds and mammals. Many wildlife experts have argued that in order to improve prevention of wildlife strikes at airports, better data on not only strikes but also on near misses and successful dispersion techniques are needed (Dolbeer and Wright 2009). While new technologies that offer many of these capabilities have been tested on a limited basis at airports in the United States, an opportunity exists to develop a fully integrated wildlife strike prevention system at the nation’s airports that would enhance current and future airside technology necessary for the implementation of the NextGen air traffic control system. Integrating the latest technologies to reduce wildlife strikes at airports with the technology needed to implement the NextGen system would not only help reduce wildlife strikes at airports, but would enhance the FAA's SMS approach to reducing all safety hazards.

Section 2.7: Summary of Literature Review

The landing of US Airways Flight 1549 on the Hudson River illustrated that wildlife strikes at airports are a serious and costly problem that will continue to grow in the United States over the next decade because of an increase in air traffic and in wildlife populations that pose a significant risk to aircraft. The scope of the wildlife strike problem is underestimated because only 20% of all strikes are reported to the FAA. Most evident from the review of the literature is that the wildlife strike problem is multifaceted and that no single solution is likely to prevent all wildlife strikes at airports. Multiple agencies including the FAA and the USDA-WS are responsible for providing assistance and guidance. As the FAA decides whether to require all airports to develop WHMPs to mitigate wildlife strikes, there are several challenges that airport operators face in designing, implementing, managing, and monitoring these plans that need to be considered. First, as Dolbeer and Wright (2009) have argued, no benchmark currently exists upon which to compare the utility of airport's WHMPs and this leaves some airport operators unsure of which mitigation strategies work best for certain species. Second, the development of safety management systems (SMS) by the FAA necessitates that airport operators place emphasis on designing WHMPs that identify the risk that different species pose to aircraft. Third, airport operators face the challenge of staffing wildlife management efforts. Finally, and most importantly, many of the current solutions to the wildlife strike problems are cost prohibitive for airports to implement. While many innovative solutions to prevent wildlife strikes have been designed, the implementation and effectiveness of these solutions remains tempered due to several factors including cost prohibitiveness and a lack of information sharing on the effectiveness of various mitigation strategies. New technologies such as the *Ultima* and *MERLIN detect & deter* that integrate data collection and deterrent approaches show promise as future solutions to the wildlife strike problem.

This airport design project will outline the development of a technological innovation that could be developed to achieve a unified reporting system that provides real-time data on the types of wildlife present at airports, the risk posed by each of these species, the effectiveness of various dispersion tactics in mitigating different species of wildlife, and interfaces with the FAA's National Wildlife Strike Database to provide accurate real-time information that would be shared among airport operators. We believe that this system would aid airport operators immensely in meeting the challenges listed above by providing them with an integrated system, which will serve as a tool that would collect and share valuable information on the types of mitigation tactics used at airports that are the most effective in managing certain species. Also, this system could be successfully integrated into the FAA's implementation plans for the NextGen system and would further the FAA's goal of implementing ICAO's SMS principles.

Section 3: Developing an Integrated System to Manage Wildlife Strikes at Part 139 Airports

Section 3.1: Methodology

The overarching methodology used in this proposal is one that is interdisciplinary in nature. Specifically, in addressing the multi-faceted problem of wildlife strikes at airports, this proposal has drawn on techniques from the fields of systems engineering, public policy analysis, and aviation management to develop an integrated approach to assist airport officials in finding solutions to this problem. The development of the integrated technology using the *Merlin detect and deter system, Ultima* data collection software and ASDE-X sensor systems draws on techniques from systems engineering. The cost benefit analysis, risk assessment, and implementation plan draw on techniques from the field of public policy analysis. Finally, the presentation of existing systems and techniques along with the reaction of airport and industry officials illustrates key concepts from aviation management. These three interdisciplinary approaches were used to develop the integrated system to manage wildlife strikes at airports.

Section 3.2: An Integrated System to Prevent Wildlife Strikes

The limitations of current wildlife management techniques coupled with the development of the NextGen system have presented a unique opportunity to integrate existing technologies that allow airports officials and the FAA to more effectively manage the threat posed by wildlife strikes. The design of the integrated system for managing wildlife strikes was guided by three principles: Integration of NextGen technologies with wildlife management technologies to give air traffic and airport operations officials increased information to make dispersal decisions, integration of individual airport mitigation tactics with an FAA mandated base level of technology, and utilization of real-time data collection, management, and sharing system to build a risk based system consistent with Safety Management System principles. The integrated system to prevent wildlife strikes at airports is outlined through further elaboration of these three principles and illustrated in Figure 10.

Principle #1: Integration of NextGen technologies with wildlife management technologies to give air traffic and airport operations officials increased information to make dispersal decisions

The major innovation of this proposal is to merge three existing wildlife mitigation technologies (*Merlin avian radar and detect and deter*, *Ultima* data logging system by Scarecrow Bio-acoustics and ASDE-X by Sensis) that will provide airport operations and air traffic control with real-time information to make mitigation decisions. *Merlin* aviation radar and *Merlin detect and deter* is an integrated system that utilizes a fully functional avian radar system that provides real-time data on the presence of wildlife above the airfield. *Merlin* avian radar also houses a fully functional data collection and storage system. The *Merlin detect and deter* system interfaces the radar system with existing mitigation technologies (bio-acoustics, lasers, etc.) and automatically engages deterrent systems to prevent wildlife from entering the airfield. One limitation of the *Merlin* system is that it is not able to identify specific species and it does not make dispersal decisions based on risk and the type of species present. The *Ultima* system utilizes GPS technology to identify, locate, and catalogue various wildlife species at a particular moment in time. Additionally, the *Ultima* system also provides airport operations personnel with information on the effectiveness of various mitigation techniques such as the use of lasers and bio-acoustic sounds, which can be interfaced with the system. The system contains self-learning software that records the effectiveness of mitigation techniques on specific species and alters its recommended mitigation strategy. One limitation of *Ultima* is that it cannot interface with an avian radar system such as the *Merlin* system to make species determinations.

The Sensis ASDE-X technology would be used to supplement *Ultima's* GPS function to provide even greater coverage of the airfield. ASDE-X is a key technology that will be used as the FAA begins to implement the NextGen system to provide greater coverage of ground movements on the airfield. Specifically, ASDE-X sensors would be placed on the airfield to detect wildlife and provide coverage of up to 5,000 feet AGL. ASDE-X also comes equipped with a data-recording feature that would interface with the *Ultima* system's species recognition software to provide airport operations and air traffic control personnel with real-time information to make dispersal decisions. Therefore, as wildlife entered the airspace, the ASDE-X sensors along with the *Ultima* GPS system and the *Merlin* avian radar would locate and identify the species prevalent. The integration of these three wildlife identifying systems would represent a massive upgrade over current observation techniques, which are usually conducted by the human eye. A determination of the species would be made by the *Ultima's* species recognition software and the identifying information will be sent to the *Ultima* tablets housed in airport operations, air traffic control and the airport's wildlife data hub. Based on previous dispersal effectiveness data (contained in the *Ultima's* self-learning software), airport operations, airport wildlife, and air traffic control personnel could make an informed, risk-based dispersal decision and use the *Merlin detect and deter system* to engage their existing dispersal technologies. The result of this dispersal action will then be recorded into the *Ultima* system's database.

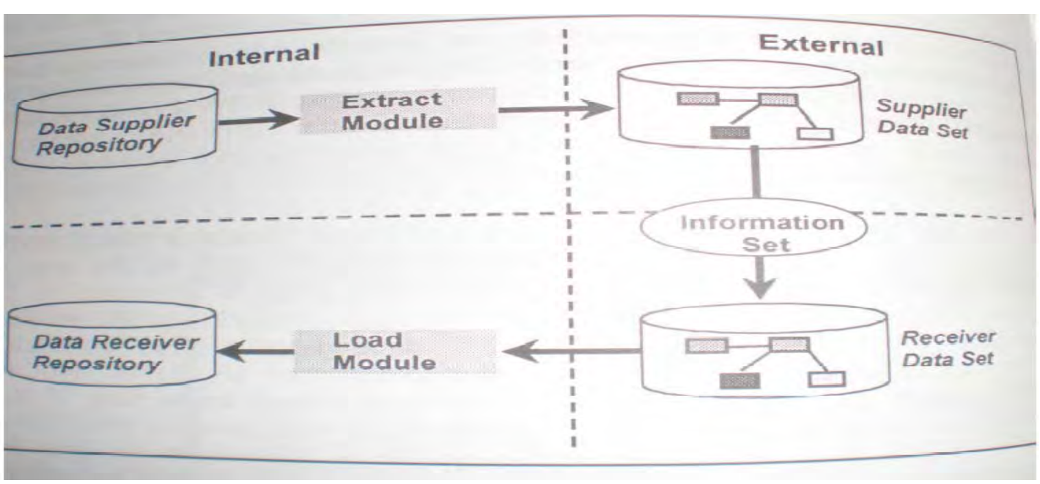
Principle #2: Integration of individual airport mitigation tactics with a FAA mandated base level of technology

A major benefit of the system described in this proposal is that it allows individual airports to retain their existing mitigation techniques used under their current WHMP while also providing a system that gives airport operators more resources with which to make dispersal decisions. The *Merlin deter and detect* system allows airport operations personnel to interface their existing dispersal technologies with the system. This gives operators the ability to use incoming information from both the avian radar and *Ultima* species recognition software to make a decision on which dispersal technologies are most appropriate given the species present and the past success of the technology in dispersing the species. The proposed system, if fully implemented, would provide a base level of technology that the FAA and airport operators could use to satisfy many requirements of the implementation of safety management systems at airports. As the FAA continues to build and implement its NextGen system, consideration should be made to integrate wildlife strike avoidance technologies such as the one outlined here to ensure a system based safety approach.

Principle #3: Utilization of real-time data collection, management, and sharing system to build a risk-based system consistent with Safety Management System principles

In conversations with wildlife biologists and airport operations officials, one common theme that emerged was that airport officials currently share information on wildlife management techniques through informal means including “email blasts through informal networks” (CLE Interview 11/6/09). Seamster and Kanki (2002) note that one of the most pressing challenges facing aviation is the management of data and information. A critical element of the implementation of Safety Management Systems (SMS) for airport operators outlined in FAA Advisory Circular 150/5200-37 is to develop a reporting system at airports that would be part of a larger database containing information on the successfulness of various mitigation techniques. Specifically, our proposal would use the *Ultima* system to provide real-time data to airport operations and air traffic control personnel to make mitigation decisions. Also, this information would be collected and distributed at each individual airport through the ASDE-X Data Distribution software currently being used at six airports. This information would then be sent to the FAA’s Aviation Safety Information Analysis and Sharing System (ASIAS) where other airports could access data on the success of various mitigation techniques. This is consistent with other aviation information sharing programs operated by the FAA including the Aviation Safety Reporting Program (ASRP), which is a voluntary safety program that allows individuals within the aviation system to voluntarily report safety violations without fear of enforcement action (Advisory Circular 00-46D). Specifically, ASRP reports are submitted to a national clearinghouse operated by NASA that allows officials from air carriers, airports, etc., to search and create reports of safety incidents that have occurred within the United States in a given period of time. A similar system called the National Wildlife Management Database (NWMD) would be created under this proposal and would serve as a clearinghouse for data collected through the *Ultima* system on the types of species prevalent at airports, patterns of wildlife activity (i.e. time of day, part of airport, etc.), and the effectiveness of mitigation techniques in dispersing wildlife. NWMD (as a proactive source of data) could also be used in concert with the FAA National Wildlife Strike Database (a reactive source of data) to develop a risk-based assessment tool to proactively seek solutions to airport specific as well as system-wide wildlife threats. Figure 7 illustrates how the information sharing system would be structured.

Figure 7: Wildlife Information Clearinghouse Management System (Seamster and Kanki 2002)



Section 3.3: Congruence with FAA's Goals

The system outlined in this proposal is consistent with several of the stated goals of the FAA and Wildlife Services Division of USDA. First, mandating a plan to develop a base level of technology as outlined here would necessitate that all Part 139 airports in the United States develop a WHMP (currently only 298 of 598 Part 139 airports have a WHMP), which is a critical component of the FAA's movement to bring Part 139 airports into compliance with having safety management systems. As Certalert No. 09-10, issued on June 11, 2009 noted, many airports that experience triggering events are not adequately compiling with Part 139.337, which states that airports that experience a triggering event must develop a risk-based WHMP. Second, a window of opportunity exists for the FAA to couple two very important issues, wildlife strike management and air traffic management, by integrating the former into the NextGen implementation program. Given the public attention to bird strikes in the wake of the ditching of U.S. Airways Flight 1549 and the relative difficulty the FAA has had in convincing Congress of the urgent need for improved air traffic control, the ability to merge the two issues may result in a more expedient implementation and funding process for NextGen. Finally, the NWMD would also strengthen the FAA's safety culture by providing another tool through which risk-based safety assessments could be made. The NWMD also would provide solutions to several of the most commonly identified problems of WHMPs by providing a clearinghouse where airport operators could identify best practices, case studies, and trends that could guide dispersal techniques at other airports.

Section 4: Interaction with wildlife services division USDA, airport operators, and industry officials

Throughout the design of the integrated system to prevent wildlife strikes at civil airports, the research team engaged several airport officials, biologists, and industry officials. Specifically, the group met with several officials at Cleveland Hopkins International Airport and Cleveland Burke Lakefront Airport on November 6, 2009 including Commissioner Fred Szabo, Deputy Commissioner of Operations and Safety Erik Williams, Properties Officer Alexander Peric, Wildlife Biologist Rebecca Mihalco, Wildlife Biologist Randy Outward, and Superintendent of Operations Robert Fischietto.

During this meeting, the research team made a 30-minute presentation to the airport officials outlining key components of the proposed integrated system to prevent wildlife strikes at airports. After the presentation, the members assembled gave the group feedback on the proposed system. Specifically, several officials noted that while they informally communicated with other airport officials on wildlife threats and dispersal technique effectiveness, an integrated data collection clearinghouse was something that they would find helpful in doing their work. Additionally, several officials expressed the desire to retain current dispersal and mitigation techniques such as the periodic shooting of birds and habitat-modification tactics.

Finally, several officials at CLE noted that they were familiar with the FAA's ASDE-X program and saw potential benefit in merging wildlife management tools with the NextGen component. After critiquing the proposal, officials presented the WHMP currently used by the airport. Contained in the WHMP was valuable information on the frequency, timing, and observation of species of wildlife at CLE that could be sent to a national database of wildlife activity at airports.

Terry Parris, Air Traffic Control Supervisor at Akron-Canton Airport (CAK) was interviewed for an ATC perspective on the proposed system. Mr. Parris noted that the reporting process used by CAK was very similar to that used at CLE. Mr. Parris noted that while providing air traffic controllers with real-time information on wildlife movements would be beneficial to controllers, he was resistant to having this information sent directly to pilots on approach. Finally, several e-mail communications took place between the research team and industry officials whose technologies are described throughout this proposal. Specifically, the group received information and technical specifics from Gary Andrews, General Manager of DeTect, Inc., Josey Melick, Marketing and Communications Accipiter Radar, and Anthony Walker, Chief Executive Scarecrow Bio-Acoustic Systems, Ltd.

Section 5: Safety/risk assessment

In 2005, ICAO mandated that its 190 member states develop and implement safety management systems (SMS) programs to achieve an acceptable level of safety in aviation. ICAO defines SMS programs as "an organized approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures" (ICAO 2009). The ICAO requirement applies to three main areas including operation of aircraft, air traffic services, and airports (ICAO 2009). In order to assist airport officials in meeting the ICAO's mandate, the FAA released AC 150/5200-37 *Introduction to Safety Management Systems for Airport Operators* in 2007 to introduce the concept of SMS to airport operators to provide guidance for SMS development by these organizations. One key component to the development of SMS principles at airports is the implementation of programs that utilize a Safety Risk Management (SRM) approach for identifying hazards and risks prevalent at airports. This research team feels that the main contribution of the proposed integrated system to manage wildlife strikes is that it would help airports move towards a more risk-based approach to managing wildlife strikes at airports. Stolzer, Halford, and Goglia (2008) argue that at its core, SRM is a three-step process that involves identifying hazards, assessing risk, and controlling risk. AC 150/5200-37 identifies five phases of SRM: describe the system, identify the hazards, determine the risk, assess and analyze the risk, and treat the risk.

Describe the system

The FAA SMS Manual states that in describing the system, airport operators should provide a description of the system and its operational environment. The proposed integrated system to prevent wildlife strikes would assist airport operators in describing the environment in which their airport operates by providing aggregate data on the number of sightings of particular species and their movement on the airfield.

Identify the hazards

AC 150/5200-37 notes that the process for identifying hazards at airports must be done in a systematic, disciplined way. Stolzer, Halford, and Goglia (2008) argue that observational hazard identification after a safety event (a wildlife strike) is only the first step to developing an effective hazard system, “the observations at the event level must relate to and interface with the system of observations that has been developed to capture all of the hazard information” (p.120). The proposed system’s information collection and distribution capabilities will supplement existing hazard assessment tools such as the Department of Defense’s Bird Avoidance Model (BAM) and the Avian Hazard Advisory System (AHAS). Also, by identifying the species at airports, the integrated system will allow airport operators to better identify the types of hazards at airports.

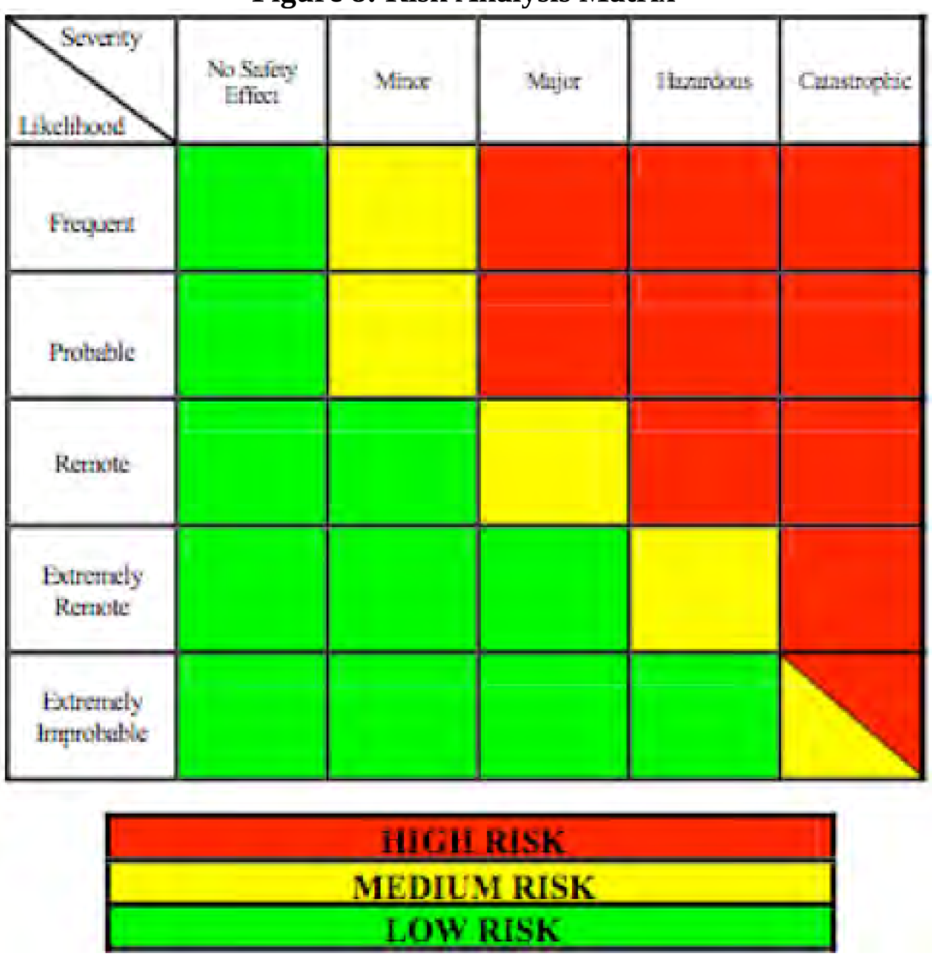
Determine the Risk

In this phase, each hazard in its system context is identified to determine what risks exist, if any, that may be related to the hazard. In this phase, there is no determination of the severity or potential of the risk occurring (AC 150/5200-37). The integrated system’s species identification system will allow airport operators to prioritize the risk associated with the hazard posed by each species.

Assess and Analyze the Risk

Risk is the composite of the predicted severity and likelihood of the outcome or effect of the hazard in the worst credible system state. In order to assess the risk of an accident or incident occurring, severity and likelihood are first determined. Severity is determined by the worst credible potential outcome. Less severe effects may be considered in addition to this, but at a minimum, the most severe effects are considered. Determination of severity is independent of likelihood, and likelihood should not be considered when determining severity. The FAA recommends the use of a risk matrix (Figure 8). The green shaded area in Figure 9 represents a low area of risk where the identified hazards do not require to be actively managed. The yellow area represents medium risk where tracking and management of hazards are required. Finally, the red shaded area in Figure 8 represents an area where there is an unacceptably high level of risk caused by common-cause events. The integrated system proposed here will actually improve airport's risk position by allowing operators to have more complete information on the wildlife hazard posed at airports. Additionally, the NWMD will enable airport operators to gain a broader understanding of the potential risk that various species may pose to the aviation system through the use of aggregate data and also case studies showing how to best manage and mitigate wildlife strike related risk.

Figure 8: Risk Analysis Matrix



Treat the Risk

AC 150/5200-37 notes that there are four strategies that can be used to lessen the effect of the hazard on the system: avoidance, assumption, control, and transfer. By providing airport operators and air traffic control personnel with real-time data and also accurate trend data, the integrated system allows these operators to make risk-based dispersal and mitigation decisions. For example, an operations official may decide from looking at the decreasing trend in sparrow populations at his/her airport, that the airport should shift its focus from sparrow prevention techniques such as propane cannons to techniques that focus on species that have growing populations such as raptors and that pose greater threats to aircraft. The operator may decide to shift his/her dispersal technique from the use of bioacoustics to other techniques such as lasers.

Section 6: Impact of the Integrated System and Financial Analysis

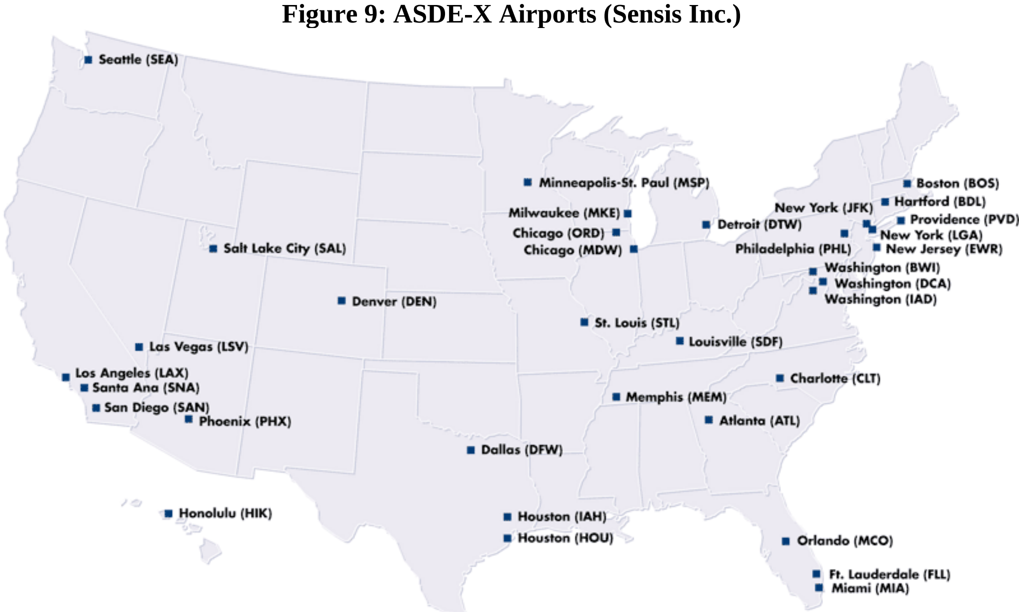
The integrated system to manage wildlife strikes at Part 139 airports outlined in this proposal will attempt to overcome critical limitations of existing wildlife management techniques used by the nation's large airports. First, by developing a system that utilizes real-time data and allows airports to interface their exiting wildlife dispersal techniques, this system gives airport operators and ATC personnel increased flexibility and options in managing wildlife at airports. Second, the *Ultima* system's self-leaning species recognition software coupled with the development of a national level database (NWMD) on the effectiveness of various dispersal techniques on different species of wildlife will allow both FAA officials and individual operators to develop risk based approaches to manage wildlife at the nation's large airports that focus on the likelihood and potential severity of accidents caused by various species. Third, this integrated system will provide a baseline level of technology and management, which will allow airport operators to compare their WHMPs and mitigation techniques to those used by other airport operators. Finally, this integrated system will help reduce the long-term costs of managing wildlife at airports by allowing airport operators to use risk-based safety information to target their mitigation techniques.

Section 6.1: Commercial Potential and Development of Technology

A substantial advantage of this integrated system is that several of the technologies included in this proposal are currently operational at airports in the United States, which reduces the overall cost of development and the lag time between development and implementation. For example, the *MERLIN avian radar* and *Deter and Detect* systems are currently being tested at Logan International Airport (BOS) in Boston, MA. Pittsburgh International Airport (PIT) recently concluded a trial operation of the *Ultima* data collection and bio-acoustic system.

Additionally, eight airports in the United States have fully implemented the ASDE-X system with another nine in the process. The FAA has approved funding for another 18 ASDE-X projects to be implemented in the next several years (Figure 9). Finally, the FAA and Wildlife-services USDA could manage the development of the NWMD jointly. NWMD could then be run by an outside agency or company (NASA and Mitre Corporation manage several existing FAA databases including ASRS) and integrated into the FAA's Aviation Safety Information Analysis and Sharing system.

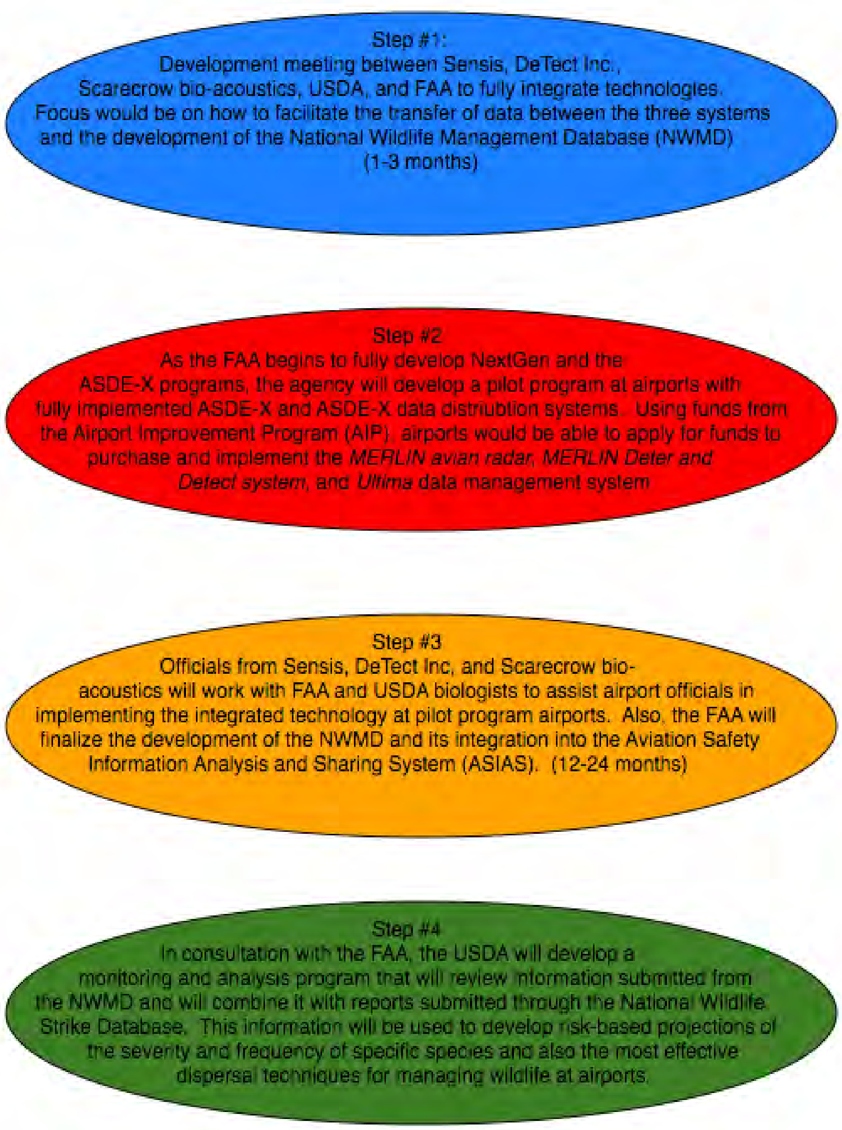
Figure 9: ASDE-X Airports (Sensis Inc.)



<u>Section 6.2: Implementation Plan and Timeline</u>

The implementation of the integrated system proposed here will largely follow the FAA's proposed plan for fully implementing NextGen and the ASDE-X program. However, before the technologies could be implemented, a meeting between Sensis, DeTect Inc., Scarecrow bio-acoustics Ltd, USDA, as well as other vendors designated by the FAA or a representative group of an airport trade association such as AAAE, and the FAA would be conducted to discuss the future development and integration of the *MERLIN, Ultima, and* ASDE-X technologies to fully facilitate an integrated approach to managing bird strikes at the nation's airports. Specifically, as the FAA further develops the ASDE-X and ASDE-X data distribution programs, a pilot program using funds from the Airport Improvement Project would allow airports with fully implemented ASDE-X and data distribution programs to apply for grants to implement the *MERLIN avian radar, Deter and Detect, and Ultima* systems or other systems designated by the FAA. Figure 10 outlines the full implementation plan for the proposed integrated wildlife management system below.

Figure 10: Integrated Wildlife Management System Implementation Plan



Section 6.3: Projected Cost-Benefit Analysis

Munger (2000) argues that for cost benefits analysis to work, it has to be possible to measure the costs and benefits of an action by reducing the effects of those actions to the amount of consumer surplus gained or lost. Developing accurate cost and benefit projections is inherently difficult because figures used in cost-benefit analyses are estimates based on trends using current data. However, cost-benefit analysis is commonly used to justify public policies in accordance with the Kaldor-Hicks principle (i.e. benefits are greater than costs). In his seminal article, Allan (2002) developed a model for estimating the cost of wildlife strikes to the aviation system in the United States. Allan (2002) found that the major cost to airports and air carriers when a wildlife strike occurs is the cost of delay. Specifically, Allan found that the cost of a primary delay was $75,000, a primary cancellation was $75,000, a secondary delay was $35,000 and a secondary cancellation was $75,000. These figures are inherently conservative because they to not include repairs to aircraft, increased insurance premiums, and other costs in the calculations. The following cost-benefit analysis uses the figures estimated by Allan (2002) as the primary source of cost savings (benefit) and cost estimates from Sensis, DeTect Inc, and Scarecrow bioacoustics. Additionally, the following assumptions and projections will be inherent in the cost benefit analysis:

- An airport with a total of 500,000 movements per year (Average for large hub airport)
- A bird strike rate of 2 per 10,000 movements (the current U.S. average)
- Use of the integrated system will reduce strikes by 20% (DeTect has found that MERLIN system reduces strikes by 40-60%)
- $75,000 reduction in primary delay per wildlife strike incident (Allan 2002)
- $90,000 average repair cost for damaged transport category aircraft per wildlife strike (Transport Canada 2001)

Table 3: Estimated Costs for Integrated Wildlife Management System

Cost Drivers	Estimated Dollar Value
MERLIN Avian Radar and Detect and Deter Systems	$1,500,000 (Average cost for large airport)
Ultima Data Management System	$30,000
ASDE-X System and Data Distribution	$4,760,000 (Estimated using initial $100 million appropriation for 21 airports)
National Wildlife Management Database Start-up Cost	$2,500,000 (Estimated from development of similar databases)
Total Costs	**$8,790,000**

Table 4: Estimated Benefits for Integrated Wildlife Management System

Projected Cost Savings (Benefits)	Estimated Dollar Value
500,000 movements with a rate of 2 strikes per 10,000 movements ($75,000 per strike) and 20% reduction ($75,000 x 100 strikes x 20%)	$1,500,000
100 strikes resulting in $90,000 per strike with 20% reduction ($90,000 x 100 strikes x 20%)	$1,800,000
Total Annual Benefits	**$3,300,000**

Equation #1: Reconciliation of Costs and Benefits with Discount Rate

Present Value= Present Costs –Discounted Benefits

PV= \$8,790,000- (\$3,300,000/(1.05 discount rate) $^{5\ \text{years}}$

PV= $8,790,000- $2,585,636

PV= -$6,204,363

Estimated Break Even Period is 4 years

Table 3 uses cost estimates from Sensis, DeTect Inc, and Scarecrow bioacoustics to develop a total cost for the technologies needed to develop the proposed system. Additionally, the development cost of the NWMD was estimated using the cost of the development of the National Wildlife Strike Database and the Aviation Safety Reporting System as references. The total start-up costs for the development of the integrated system are approximately $8.8 million. Table 4 estimates the potential cost savings from the implementation of the integrated wildlife management system using estimates derived from Allan's (2002) delay cost figures and Transport Canada's (2001) analysis of the cost of aircraft repairs due to wildlife strikes. Using 500,000 aircraft movements as a representative statistic for an average large hub airport, a strike rate was calculated (2 strikes per 10,000 movements). Additionally, the 20% reduction rate was obtained from DeTect Inc. based in its tests of the *MERLIN detect and deter system* (DeTect Inc. 2009). This figure is actually very conservative given that DeTect found a 40-60% reduction in wildlife strikes at airports with the *MERLIN avian radar and detect and deter system.* Based on these calculations, the projected annual cost savings is approximately $3.3 million. Equation 1 illustrates the reconciliation of costs and benefits given the presence of a discounting procedure. Munger (2000) notes that a dollar today is worth more than a dollar in the future. Given this assumption, the present benefit was discounted using a 5% discount rate (standard discount rate) over a 5-year period resulting in a discounted annual benefit of $2.6 million. Using these figures it can be estimated that the integrated wildlife system will pay for itself after a period of about four years.

Section 7: Conclusion

The problem of wildlife strikes at the nation's airports will continue to grow in the coming years as bird populations increase while more passengers take to the skies. The ditching of US Airways Flight 1549 in the Hudson River in New York has resulted in a window of opportunity for the FAA to develop an integrated wildlife management system is congruent with ICAO's SMS mandate by providing risk-based assessments on the threat of specific wildlife species, allows airports to tailor their dispersal techniques to local environmental conditions, gives greater flexibility to airport operators and air traffic control personnel in making dispersal decisions, and centralizes the collection and distribution of data on the effectiveness of various dispersal techniques by creating a new National Wildlife Management Database.

The major innovation of this proposal is to merge three existing wildlife mitigation technologies (*Merlin avian radar detect and deter, Ultima* data logging system by Scarecrow Bio-acoustics and ASDE-X by Sensis) that will provide airport operations and air traffic control with real-time information to make wildlife strike mitigation decisions. Based on the implementation plan and cost-benefit analysis presented in this proposal, the proposed system could be fully implemented at 35 airports in the next two years and would pay for its $8.7 million dollar average cost per airport in a period of about four years while reducing wildlife strikes by 20%.

Appendix A: Contact Information for Research Team Members

Faculty Advisor:

Dr. I. Richmond Nettey
Associate Dean, College of Technology
and Course Professor, Airport Management
Kent State University, 117 Van Deusen Hall
375 Terrace Drive, Kent, OH 44242
inettey@kent.edu or inettey@hotmail.com
330.672.9476 or 330.524.9693

Research Team Leader:
Russell W. Mills
Rmills2@kent.edu

Research Team Members:
Bryan Beck
bbeck6@kent.edu

Timothy Becker
Tbecker1@kent.edu

Galym Gabbas
ggabbas@kent.edu

Skyler Edenhart-Pepe
sedenhar@kent.edu

Michael Sciolino
msciolin@kent.edu

Appendix B: Description of the University

Established in 1910 as Kent Normal School by a statutory act of the State of Ohio, Kent State University has evolved into the second largest state university system in Ohio, the "birthplace of aviation," as well as the oldest and largest state university in Northeast Ohio with over 35,000 graduate and undergraduate students at Kent campus, the home of the Aeronautics Program, and seven regional campuses around Northeast Ohio.

The internationally known events of May 4, 1970, which involved the tragic loss of four students during a period of national unrest, have also influenced institutional purpose and contributed towards the evolution of Kent State University into a well known leading university in the United States and the entire world. In transcending these events, Kent State University has become renowned for the broad range and distinction of its academic programs, innovative research, collaborative partnerships, and broad-based policies on faculty work.

Kent State University ranks among the top 90 public universities in the United States, according to the Carnegie Foundation for the Advancement of Teaching. This Carnegie ranking places Kent State University in an elite group among the 3,900-odd colleges and universities in the United States. Kent State University's institutional purpose is fulfilled, in part, through providing numerous associate degree programs in various technical and business fields at the seven regional campuses, some 271 academic programs of undergraduate study, 214 academic programs at the master's level, and 59 areas of doctoral study in the Colleges of Architecture and Environmental Design; the Arts, Arts and Sciences; Business Administration; Communication and Information; Education; Nursing; and Technology, which is the academic home of the Aeronautics Program.

In addition to the preceding colleges, which are administered and headed by academic deans who report to the University Provost, Kent State University has the College of Research and Graduate Studies, College of Continuing Studies, the Honors College, as well as diverse centers, institutes, and research bureaus in specific areas, such as the world-renowned Glenn H. Brown Liquid Crystal Institute.

With Kent State Airport dating back to 1917, aviation education at Kent State University has evolved into a nationally renowned and accredited degree program with areas of specialization in Aeronautical Studies, Aeronautical Systems Engineering Technology, Aircraft Maintenance Technology, Air Traffic Control, Aviation Management, and Flight Technology. Flight training is provided with Kent State University's fleet of 25 single- and twin-engine airplanes under 14 CFR Part 141.

Under the leadership of Dr. I. Richmond Nettey, then Senior Academic Program Director of Aeronautics and now associate dean of the College of Technology, the Aeronautics Program became the first and only aviation program in Ohio to become accredited by the Aviation Accreditation Board International (AABI) on 16th February 2006. After a thorough review during a highly competitive process, the FAA authorized Kent State University as the first and only Air Traffic–Collegiate Training Initiative (AT-CTI) program in Ohio in fall 2007. At present, the Aeronautics Program in the College of Technology at Kent State University remains the first and only accredited aviation program in Ohio and the first and only FAA approved AT-CTI program in Ohio – birthplace of aviation.

Appendix C: Description of Non-University Partners

There were no non-university partners associated with the production of this submission.

Appendix E: Evaluation of Educational Experience

Student Team

1. Did the FAA Design Competition provide a meaningful learning experience for you? Why or why not?

The FAA Design Competition provided the research team with a forum to develop specialized in a particular area of aviation research. The problem of wildlife strikes at airports is an important and salient topic has real and substantial consequences for the aviation industry. Throughout the research process, members of the research team utilized rigorous investigative techniques and learned academic skills including writing a literature review, using a multi-method approach to answering a research question, and writing and analyzing a systematic proposal. More importantly, members of the research team presented their ideas to members of the aviation community including airport commissioners, air traffic control personnel, and industry. These interactions provided the research team with invaluable experience in communicating with and listening to aviation officials.

2. What challenges did you and/or your team encounter in undertaking the Competition? How did you overcome them?

The research team faced several challenges in completing the FAA's Design Competition project. As with most collaborative projects, the team faced communication difficulties such not responding in a timely manner to email requests for information, difficulty with coordinating schedules for group meetings, and a difficulty in using a uniformed language in describing the integrated system (i.e. MERLIN vs. Deter and detect). To overcome these communication related problems, the group scheduled meetings during times that worked well for everyone such as immediately following class or on holidays such as Veterans Day. Additionally, during these meetings, specific tasks and deadlines were issued to reduce the need for email communications and allow for a more efficient division of labor.

A second challenge that faced the research team is one that is almost too obvious: no member of the research team possesses significant experience in the aviation industry. Members of the research team were able to overcome this limitation through extensive background research on existing wildlife management and mitigation techniques and technologies currently used by airports. Also, through interactions with airport officials and site visits, the research team was able to gain valuable insight into how the technologies mentioned in the proposal operate in practice. A final challenge faced by the research team was one of designing a system that would not be cost restrictive to airports. Through the development of the implementation plan, the group focused on how to structure the program using existing FAA funding streams to make the system available to many large Part 139 airports in the United States.

3. Describe the process you or your team used for developing your hypothesis.

The development of the research team's hypothesis was largely driven through what social scientists call a grounded or inductive approach. Once the group identified the scope of the wildlife strike problem in the United States, a very thorough literature review was conducted that resulted in the identification of several existing technologies used by airports to manage wildlife. These technologies were then analyzed for strengths and weaknesses, which resulted in the development of a recommended integrated system. Once this system was developed, the group then met with officials at Cleveland Hopkins International Airport to solicit feedback on the proposal and to allow for revisions based on the comments received during the meeting. The finalized proposal featuring the integrated system to manage wildlife at airports was developed through a series of revisions integrating feedback from airport officials and continued research of other systems used at the nation's airports.

4. **Was participation by industry in the project appropriate, meaningful and useful? Why or why not?**

Participation by industry officials was crucial to the success of the project, and research team members were often in close contact with these officials. As mentioned before, team members met with a variety of industry officials including airport operations officials, wildlife biologists, dispersal industry officials, and air traffic control personnel. These officials often went above and beyond the call of duty to assist the research team by providing valuable feedback, informational materials, and in some cases unscheduled meetings. The feedback received through the formal presentation and informal communication with industry officials helped the research team with information collection for the literature review, formulating the final integrated wildlife management system, providing cost estimates for the implementation of the system, and also providing guidance on the limitations and drawbacks of integrating several stand alone technologies. The table below lists the contact information for the industry officials contacted by the research team.

Contact	Title	Organization	Email	Phone
Fred Szabo	Commissioner	Cleveland Hopkins Int'l Apt	FSzabo@clevelandairport.com	216-265-6000
Erik Williams	Dep. Commissnr. Ops and Safety	Cleveland Hopkins Int'l Apt	EWilliams@clevelandairport.com	216-265-6000
Alexander Peric	Properties Officer	Cleveland Hopkins Int'l Apt	aperic@clevelandairport.com	216-265-6000
Rebecca Mihalco	Wildlife Biologist	Wildlife Services-UDSA	rebecca.l.mihalco@aphis.usda.gov	216-538-0202
Randy Outward	Wildlife biologist	Wildlife Services-USDA	Randy.j.outward@aphis.usda.gov	216-664-6897
Robert Fischietto	Superintendent, Operations	Cleveland Hopkins Int'l Apt	RFischietto@clevelandairport.com	216-295-6090
Gary Andrews	General Manager	DeTect Inc.	gary.andrews@detect-inc.com	850-763-7200
Anthony Walker	Chief Executive Officer	Scarecrow Bio-Acoustics Ltd	anthony.walker@scarecrow.eu	01825 766363
Josey Melick	Marketing and Communications	Accipiter Radar	jmelick@accipiterradar.com	905-228-6888
Terry Parris	ATC Supervisor	FAA - CAK		330-434-8989

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

Throughout the research process, members of the team developed and refined several technical, professional, and experience-based skills that are often not part of the traditional classroom experience. A particular skill that the team developed throughout the research process was the ability to professionally communicate a technical proposal to a group of industry and airport officials. Specifically, the group's presentation to officials at Cleveland Hopkins International Airport helped members of the group develop professional speaking skills, the ability to quickly, accurately, and thoughtfully answer questions posed by officials, and also helped the members of the group to better use visual presentation tools such as PowerPoint. These skills will be beneficial to several members of the group, particularly because students in technology-focused fields are rarely are exposed to situations that allow them the opportunity to make professional presentations. Finally, members of the research team have gained valuable knowledge in a salient and important topic (wildlife strikes) that crosses the fields of engineering, aviation, and biology. As this topic continues to be on the front page of newspapers across the United States, members of the research team hope that their knowledge and ideas will be used to solve this important public problem.

Faculty Advisor

l. Describe the value of the educational experience for your student(s) participating in this Competition submission.

The educational experience was priceless for the six students (five undergrads, one grad) who participated in this competition submission. The experience augmented learning from the Airport Management class in multiple ways for the six students.

Among other benefits, it compelled exposure to practitioners from industry as well as emerging and innovative technologies in wildlife hazard management practices at large airports. Perhaps the most important benefit involved a realization that their proposal can improve aviation safety.

2. Was the learning experience appropriate to the course level or context in which the competition was undertaken?

Even though the practical aspects of the learning experience exceeded the norm for the course, the overall learning experience was appropriate to both the course level and content.

3. What challenges did the students face and overcome?

Time management is a perennial challenge for students who juggle academic responsibilities with work related responsibilities, as well as social issues while working towards a university degree. However, this student team overcame that challenge successfully to produce this very important work, which offers potential benefits to operational safety at airports in both commercial and general aviation.

The core idea of the proposal and honing it into an integrated system as the most effective approach got established in early meetings with the group. Arranging interviews with practitioners and experts, deciding who does what on the team, making time for travel to airports, etc., for interviews, while juggling other course requirements and work related responsibilities were among the challenges the students faced and managed to overcome successfully.

4. Would you use this Competition as an educational vehicle in the future? Why or why not?

Affirmative, they add considerably to the learning experience.

5. Are there changes to the Competition that you would suggest for future years?

None. Since the proposals have become group efforts comprising several individuals among whom the monetary prize is shared, perhaps the prizes could be augmented to $5,000 for first place, $3,000 for second place and $1,500 for third place.

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