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Bird Deterrence at Low Level Windshear Alert System (LLWAS) Poles

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Figure 1. Taxidermist's Black Vulture Effigy – A species-specific bird deterrent method tested at the Fort Myers LLWAS Remote Station #5.

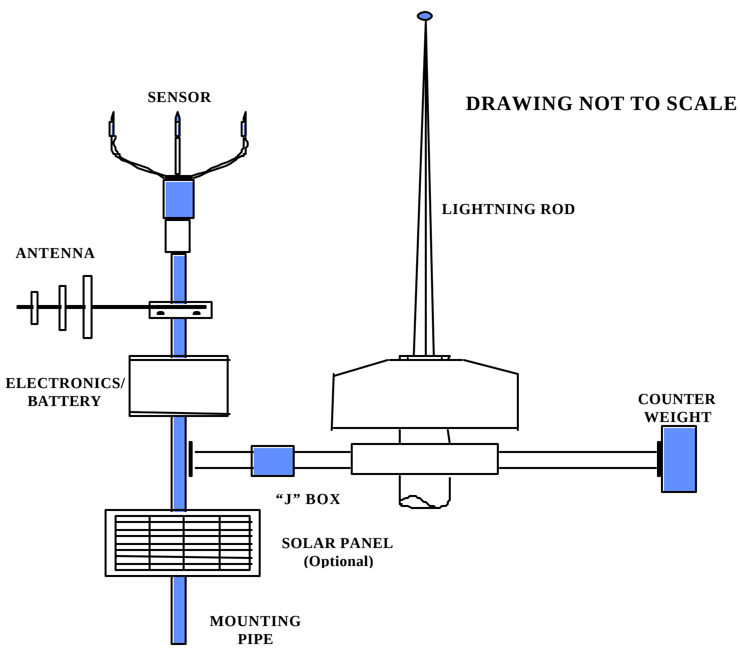
ABSTRACT

■ Perching birds cause interference with data flow from the sensors used in a new version of Low Level Windshear Alert System (LLWAS). LLWAS is a US Federal Aviation Administration (FAA) airport, weather safety program consisting of a network of anemometers on top of tall poles used for detecting wind shear. Deadly wind shear has caused aircraft accidents with fatalities by creating a sudden loss of airspeed at low altitude upon take-off or landing. During installation of the LLWAS's initial site at Fort Myers, FL, Turkey Vultures and Black Vultures were observed to perch on the arms of the sonic wind sensor at the top of a pole, blocking the data signal. This could lead to erroneous readings and can eventually cause hard failure of the equipment. Bird spikes have proven unsuccessful in preventing perching. As a temporary deterrent the FAA used a vulture effigy. With the assistance of the U.S, Department of Agriculture (USDA), the vulture effigy has been successful as a short-term solution. However, in consultation with the USDA and commercial interests, the FAA concluded that non-lethal electrical shock is the best long-term solution and is in the process of designing this for use on the LLWAS. This solution would permanently deter multiple species in an environmentally responsible manner for nationwide installation at all LLWAS sites.

1. Windshear and Microbursts

"Windshear" denotes locally divergent winds. As a gust front passes by, it can create windshear, with a sharp change in wind speed and direction across the front as measured at two nearby geographical locations or altitudes. "Microbursts" are caused by the decay of violent, convective thunderstorms where great volumes of cooled, dense air, rain and ice fall back to Earth from high in the anvil thunderheads. As this heavy downdraft hits the Earth, violent winds spread out along the ground surface in a compact wave of out rushing air. Aircraft that fly through a microburst experience a sudden head wind with increased lift, then a downdraft causing loss of climb, and finally a tail wind with a devastating decrease in lift which causes the aircraft to lose airspeed on the backside. On flying through a strong microburst, airspeed losses of 35 to 95 knots can happen within a mile or two. Sudden loss of airspeed may stall traversing aircraft and stalled aircraft must dive to recover airspeed. Microbursts that hit on or near airports and surprise pilots who are on final approach or initial climb may find themselves unprepared, or at too low an altitude to recover. Strong windshear and microbursts have caused or contributed to numerous air disasters, most recently the loss of a McDonnell-Douglas DC-9 at Charlotte, North Carolina on July 2, 1994. (Evans & Weber, 2000)

Figure 2. LLWAS Remote Station



2. Low Level Windshear Alert System

The Federal Aviation Administration employs Low Level Windshear Alert Systems (LLWAS) [pronounced ***él·wôss***] at over one hundred, medium to large air traffic density airports in the United States. The anemometer-based LLWAS warns of the presence of low altitude, windshear and microburst hazards at the airport terminal. Each LLWAS uses multiple Remote Stations mounted on top of tall poles to measure current wind speed and direction at several sites along runways and approach and departure corridors. A typical LLWAS uses six Remote Stations per runway and may have up to thirty-two Remote Stations per airport. LLWAS Remote Stations radio their wind observations to a Master Station located at the Air Traffic Control Tower. The LLWAS Master Station calculates whether strongly divergent winds are present across the airport operating area. If strongly divergent winds are present, the LLWAS alerts Air Traffic Controllers that hazardous windshear or microburst conditions exist along the endangered runway corridor. The Air Traffic Controllers advise pilots by voice radio of the LLWAS alerts.

3. New Sonic Anemometer with No Moving Parts

For the past twenty years, LLWAS bivane anemometers have measured wind speed and direction using old, spinning "cup and vane" technology with little bird interference. New LLWAS systems will employ an upgraded ultrasonic anemometer, with no moving parts, to reduce wear and tear and to extend the Remote Station's service life. The new ultrasonic anemometer (a.k.a. "sonic sensor") has three transducers, exactingly mounted in a trident fashion. (See Figure 2) The transducers both emit ultrasonic sound waves (a chirp), and in turn, listen to the chirps of the other transducers, measuring the Doppler time delay in each direction. Moving wind either speeds up or retards the transit time of sound between transducers, depending on the direction of the wind with respect to the transducer arms. The transducers collect this data each second and a processor in the base of the sonic sensor calculates wind speed and direction. Should any obstruction mask the transducers line-of-sight, the result might lead to missing or erroneous wind speed and direction data. The FAA cannot tolerate false data that could lead to false alarms being passed to air traffic controllers. In fact, wind flow along the horizontal plane of the three transducers cannot be obstructed at all (no wind shadowing) within three meters. Any modification that disrupts wind flow along the plane of the transducers will invoke an extensive round of re-certification testing. If the transducer signals are disrupted for longer than 30 seconds, the entire Remote Station declares a hard failure and the LLWAS system reconfigures in a degraded mode, to exclude the failed Remote Station. Each transducer comes equipped with a small heater to prevent icing. The sonic sensor also comes with four, 8 centimeter long, fiber, bird spikes that mount on the end of each transducer arm and also in the center of the sonic sensor body. These bird spikes may prevent small birds from nesting but may not prevent large birds from perching.

Figure 3. Installing the Sonic Sensor

Figure 4. Raising the LLWAS Remote Station

LLWAS sonic anemometers are mounted at the top of unattended, 50-meter poles, both on and off airport property, thus becoming the highest perch around. (See Figure 3) The entire Remote Station attaches to a floating ring that rises and lowers by a cable and winch system operated from the base of the pole. (See Figure 4) The first airport to use the new sonic sensor is Fort Myers, Florida that became operational in December 2000.

4. Specific Bird Problem at Fort Myers

The Fort Myers LLWAS Remote Station #5 is located near a grove of dead pine trees that houses a rookery of both turkey vultures and black vultures. The birds were immediately attracted to the new 50-meter tall LLWAS pole and the unobstructed views from the sensor. (See Figure 5)

Figure 5. Fort Myers, Florida LLWAS Remote Station #5 with a Vulture Problem – Vulture blocking the sensor is seen at left.

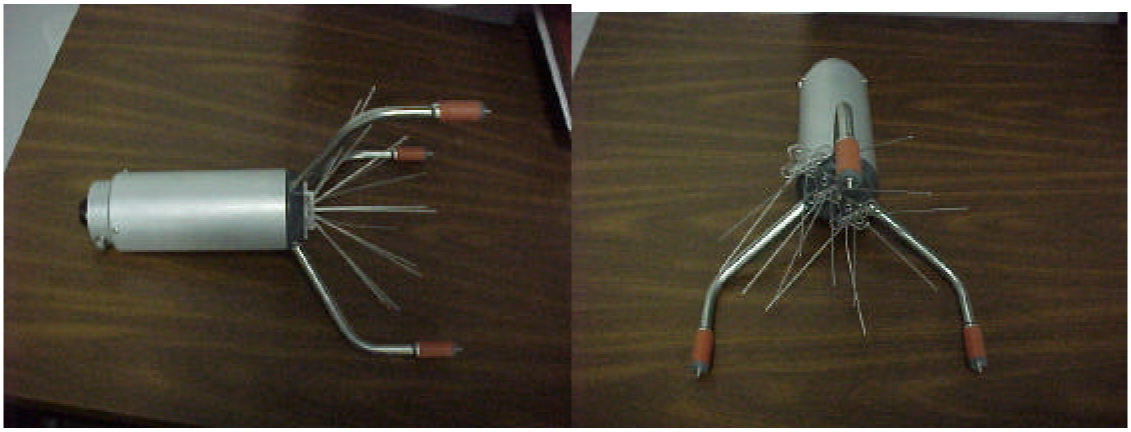
Bird spikes on the present design have been ineffectual to the perching of vultures, since they appear to find a natural hold by clutching one foot to each of two of the sensor arms, like branches on a pine tree. They sit over free space, facing the central body of the sonic sensor. Vultures are tall enough to loom over the third arm that rises to slightly below beak level. Because there are so many birds in these colonies they swarm over and loiter on the LLWAS pole frequently and in large numbers for the excellent vantage. In addition to vultures, other users of the sonic sensor report owls and raptors perch on the sonic sensor at other sites. It is possible that small birds after the spring migration may attempt to build nests on the LLWAS towers. Pigeons in urban areas and osprey at shore sites may well attempt to nest on the sensors too. Eagles may learn to drop sticks on the sensor arms to make an unshakable nest. The perching and nesting behavior of many avian species must be accounted for in seeking a viable national solution, since LLWAS are deployed across the United States from Connecticut to Florida and from Baltimore to San Francisco.

5. Potential Bird Deterrence Solutions Considered by the FAA

When the FAA first considered upgrading the LLWAS to sonic sensors the LLWAS engineers consulted a wildlife biologist in the Airport Safety Office about the planned operation and constraints associated with the new sonic sensor. LLWAS remote stations sit atop tall poles making an inviting and commanding perch for raptors. Even though the sonic sensor makes noise, birds quickly become accustomed to noise-making devices. The FAA determined that the only effective method of long-term bird control would be by exclusion. Frightening, repellents, toxicants, fumigants, trapping, shooting, electric shock, habitat modification and other control methods were discounted due to the constraints of unattended operation and difficult access presented by the tall poles. A non-lethal exclusion method should work with most birds including raptors. Three types of exclusion control were suggested for use in combination: 1) Bird spikes on all horizontal surfaces to discourage small nesting birds, 2) Porcupine wires such as (Cat Claw™, Nixalite™, ECOPIC™, or Bird Barrier™) to prevent perching by large birds, and if necessary, 3) a grid wire line system. (Cleary, 1997) The sonic sensor already has bird spikes installed, but the support arms, solar panel, and equipment enclosure, are ideal for perching by raptors.

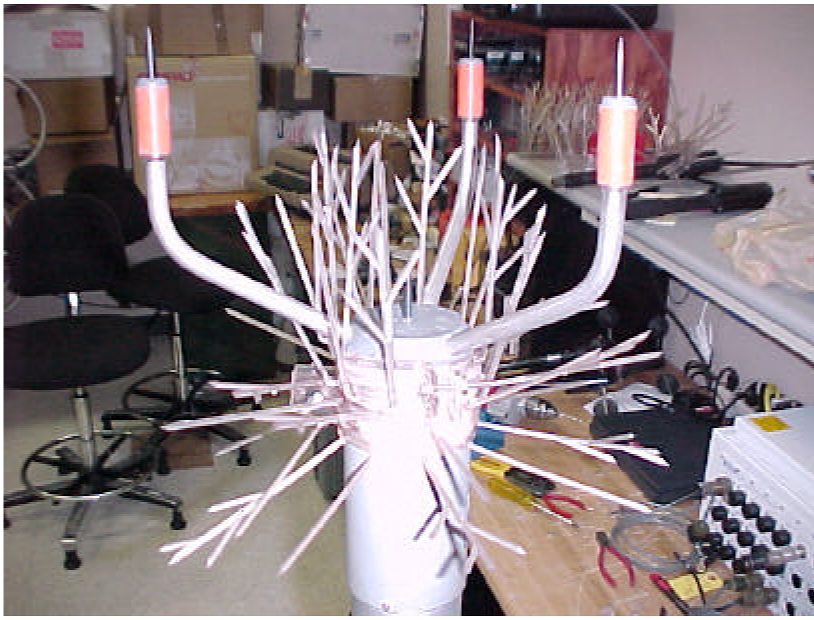
After the Fort Myers installation, the LLWAS Program Office held an LLWAS “Bird Summit” meeting to reconsider possible bird deterrents. At the “Bird Summit” the following methods were further explored.

Figure 6. Potential Porcupine Wire Solution Using Bird*B*Gone Spike 2000 8” Spikes



A. PORCUPINE WIRE – Porcupine wire might be used on the three sonic sensor support arms from the central base out to the point at which the arms become vertical. The porcupine wire spikes would be installed to lie below and not to interfere with the sensor line of sight. Wind flow with porcupine wire would have to be checked. Porcupine wire comes in stainless steel, and nonmetallic durable materials. A quick modification using Bird-B-Gone, Bird Spike 2000, 8” spikes should be trimmed, not extend beyond the plane of the transducers to prevent undesirable wind effects. (See figure 6.)

Figure 7. Eagle Proof Sonic Sensor for Use in Alaska



The manufacturer of the sonic sensor developed a similar approach to prevent eagles from perching on the sonic sensors used in Alaska. (See Figure 7.)

Even the best-laid, single method exclusion systems can, and have been, defeated by birds. Birds, such as osprey, eagles and even pigeons have learned to drop sticks into porcupine wire until they established the foundation for an unshakable nest.

B. GRID WIRE - A grid wire system uses tightly stretched parallel strands of 16 to 18 gauge steel wire or 80 pound+ test monofilament line to prevent perching on conduit and narrow ledges. Grid wire might be used over top of porcupine wire on the top edge of the LLWAS-RS solar panel, for instance, to prevent roosting.

C. VENDOR APPROACH – The manufacturer of the sonic sensor plans to engineer a perch, (accommodation) to raise the highest point above the plane of the transducers. (See Figure 8.)

Figure 8. Proposed Vendor Engineering Modification adds a Perch to the Sonic Sensor

This might be available as a commercial-off-the-shelf modification kit for the sonic sensor. Its mirror-image design on the face of it appears to prevent disruption of the horizontal airflow, but this would need verification in a calibrated wind tunnel. It does not prevent roosting colonies of birds as seen at Fort Myers from perching on the lower arms in addition to the perch above. Birds encouraged to perch above the transducers may cause long term problems through “deposits” left on the sensor arms that run down over the transducers. Anything that is added to the sensor must be of a similar material to help assure that the modified sensor continues to meet the existing operating requirements.

The transducers have heaters to prevent icing that would also keep the perch ice free in winter. If the design is such that it may jeopardize the performance of the sensor, additional operational exposure requirements (e.g. blowing snow, icing, etc.), may need to be specifically tested. The vendor's perch might be adjusted from accommodation to exclusion by replacing the flat horizontal surface in the center of the upper perch with a cone shape to reduce a bird's ability to perch on it and by using stainless steel wire (about 12 – 14 gauge for example), connecting the center of the sensor, with the center of the perch.

D. VULTURE EFFIGIES - The United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) maintains a *Wildlife Services* Branch in Gainesville Florida to address wildlife damage management issues. The FAA and the USDA *Wildlife Services* Branch have a cooperative relationship to investigate wildlife hazards on or near airports. Accordingly the FAA contacted Dr. Michael L. Avery, Project Leader, USDA/APHIS/WS/NWRC, Florida Field Station (Avery, 2000) to assess the vulture problem at Fort Myers. After performing a first-hand field survey Dr Avery reported that of the six LLWAS units deployed around the periphery of the airport, that only LLWAS Site #5, has experienced repeated interruptions. Site #5 is located off the southwest corner of the airport in a low-lying wooded area. It is secluded, and the many pine trees adjacent to the site provide ideal roost habitat. There were 20 to 30 turkey vultures and black vultures in the trees within 15-20 m of the LLWAS pole when first surveyed. Dr. Avery has had success with species specific effigies of vultures in reducing the number of perches. Effigies present a bird-in-distress to scare away others. *Wildlife Services* subsequently recovered a black vulture carcass that had been recently killed. Vultures are protected by the Migratory Bird Treaty Act such that their use requires proper licensing and consultation with the USDA. In late October when Dr Avery went back to site #5, and installed this black vulture carcass in effigy. By then, there were 50 to 75 vultures in the trees surrounding the site, and they were only mildly disturbed by his activity. The carcass was attached with twine and a swivel to the horizontal arm of the unit opposite the anemometer. The carcass hung head down about 1 m below the unit. (See Figure 9)

Figure 9. Black Vulture Effigy in Place on Fort Myers LLWAS Remote Station #5

After the unit returned to the top of the pole, a turkey vulture flew around the top of the pole and made several passes close to the carcass. It touched down momentarily on the unit several times, and then landed approximately 3 m from the carcass. Vultures began returning to the roost area in the evening and a turkey vulture landed on the arm from which the carcass was suspended. Then two more turkey vultures landed nearby on the apparatus and finally a fourth turkey vulture landed on the anemometer arms. Had the system been operating, the first three birds would not have interrupted the signal, but the fourth bird would have caused an interruption. All four birds stayed for well over an hour. There were no birds on the pole the next morning.

Figure 10. Taxidermists Effigy at 3 Months

The FAA agreed to leave the carcass in place for a week and to monitor and record interruptions of the sonic anemometers. The number and duration of interruptions with the effigy would be compared with those recorded prior to carcass installation. The use of the LLWAS structure by vultures following installation of the carcass was initially disappointing but not totally surprising. Dr Avery had seen this pattern by vultures at a communication tower site where he installed a carcass. Birds did not immediately vacate the area, but did so after several days, and remained away from the tower thereafter. If the black vulture effigy appeared to be ineffective, Dr Avery further proposed to install a turkey vulture effigy to determine if the same species makes a difference. After a week with the effigy there had been just one brief interruption of the system that could have been caused by any bird perching on the sensor, not necessarily a vulture. The effigy finally fell apart after about 40 days with only the legs remaining aloft. It was replaced with a taxidermic version that lasted about three months. It was mounted with one wing out in order to spin in the breeze from a swivel mount that eventually broke and had to be replaced with stronger ropes. (See Figure 10)

If the effigies continue to work well, then a long lasting rubber model might be produced to last a year. Effigies are not recommended for LLWAS poles readily visible to the general public, since the airport operating authority might expect to receive frequent calls about a bird in distress. Fort Myers site #5 is well secluded. In comparison site #1 is in a rental car parking lot, well exposed to public view and therefore unsuitable for an effigy.

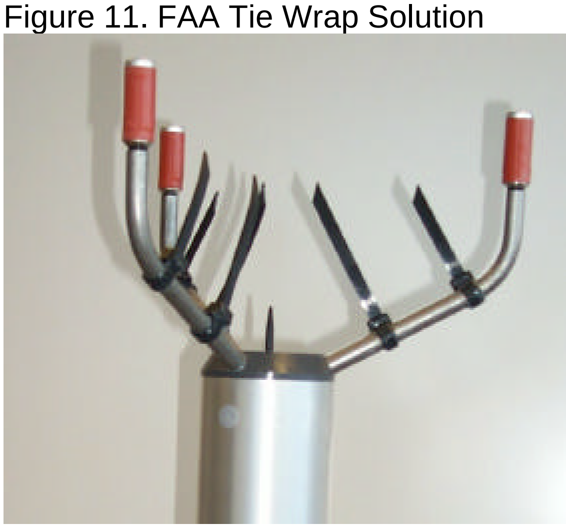
E. HABITAT MODIFICATION – For Ft Myers, Dr. Avery also recommended a long-term solution to the vulture problem would include habitat modification around LLWAS site #5. The wooded area immediately surrounding LLWAS site #5 is ideal vulture roost habitat. Removing some of the pine trees would reduce the attractiveness of the roosting habitat and might greatly reduce the chance that a vulture will perch on the pole and cause problems for the system. The FAA Environmental Team coordinated with appropriate agencies to pursue this part of the solution. Rather than clear-cutting back by about 200', the fish and wildlife agencies preferred "opening up the habitat" by selectively cutting only the trees favored by the vultures. A survey would be needed to mark the favorite trees and they could be removed by local labor. Only a few trees would be taken. LLWAS-RS Pole #5 is situated near a major vulture roost on the west-side of the airport such that cutting down the favored trees may well move the colony nearer rather than farther from airport operational areas. A "Vulture Management Plan" for the west side of the Airport that looks at the bigger picture of where the vultures would relocate to, would need to be developed prior to cutting trees. The FAA determined that this would have minimal environmental impact and could commence within a few weeks of the go-ahead. The Fort Myers airport authority subsequently requested the FAA not plan efforts for habitat modification as this could move the roost to even more operationally sensitive areas. The airport authority prefers to coexist using the other bird proofing methods. (Dryden, McCormick, Nickels, Beever, Personal Communication)

F. ELECTRIC SHOCK – Dr. Avery advised that the FAA consider electric shock as a permanent solution. A mild electric shock would effectively deter any bird that tried to perch on the unit. Commercial bird shocking strips are readily available and could be easily installed on the arms and the flat top of the apparatus. Strands of electrified wire could also be strung among the sonic sensor arms to discourage birds from perching on that critical area. A market survey revealed that devices that produce electrical shocks are commercially available but would take significant redesign for LLWAS use. A light-weight, low-power, non-Earth Ground, solar/battery powered shocking device capable of unattended operation and long-term exposure to the elements would be needed.

G. INVERTED OPERATION – An FAA field technician and "bird watching hobbyist" in the Southern Regional Office suggested turning the anemometer upside down, so that the birds can't perch between the sensors. Drawbacks with this approach he saw, would be a loss of about 6 feet in elevation, and the wind shielding effect of the pole. But the birds could roost on the other parts of the pole and arms with probably little affect on the operation of the sensor. Upon further study, the sonic sensor could be mounted upside down to prevent birds from blocking the path of the transducers. The sensor has built-in software for inverted operation. But further drawbacks include excessive rainwater runoff and icing when inverted and difficulty in aligning the sensor to magnetic north. The base of the sensor would need special waterproofing beyond what the vendor has used. An outdoor rated, nondrying silicone-type sealant to cover the cable exit and probably a cannon-type connector bonded to the sensor would be required. The shielding effect of the pole is especially worrisome as the sensor needs to be more than 3 meters from the pole's wind shadow. Extensive head-to-toe testing of two sensors right-side up and upside down to disprove the effects of wind shadowing would also be needed. This may be hard to do in a wind tunnel.

H. EXISTING BIRD SPIKES/DO NOTHING SOLUTION – It has been suggested that no special bird-proofing is needed overall aside from the four existing bird spikes, since the LLWAS system is advisory in nature and that it is unlikely birds would perch on the LLWAS during thunderstorms when it is most needed. Yet LLWAS-RS does provides Airport Winds (formerly termed "centerfield winds") from the most centrally-located primary and then two back-up Remote Stations. Airport Winds from specific remote stations have a higher priority to Air Traffic Operations than data from outlying poles and so may be accorded more protection from bird disruptions even during calm conditions. Multiple methods of exclusion for various levels of assurance may be needed.

Figure 11. FAA Tie Wrap Solution



I. TIE-WRAP - This solution has been successfully used for about a month in side by side comparisons with a mechanical anemometer with no noticeable effect on wind speed or direction. (See Figure 11) Prior to these modifications, a second LLWAS test site, at Tampa Florida, was visited by large birds daily. Since these modifications only 2-3 very brief (10 second) visits were observed in the one month of evaluation. The birds were seen to perch on the LLWAS antenna and other ring structures instead. The tie wraps will be UV protected and cut at a 60 degree diagonal right under the sensor plane. RTV compound is used to keep the tie wraps in place.

6. Second Bird Summit Meeting

In a follow-up Bird Summit meeting, most interested parties who assisted the FAA in determining the best bird proofing solution concluded that for protecting the sensor, electric shock is favored as a foolproof solution to absolutely exclude birds. It is a technically complex and expensive solution that will take months to procure and prepare for FAA unattended use. We decided to pursue electric shock but would only deploy it where and when needed on a pole-by-pole basis. (See figure 12)

Figure 12. Notional Electric Fence Mock-up

The current commercial products seemed limited because they only advertise a 600-hour rechargeable battery life under a solar power option, until an Internet market survey revealed a once-a-year maintenance system offered Sureguard™ Fencing and sold by Power Innovations, 110 Borton Road, Lismore 2480, NSW Australia. This method works by educating the birds with non-lethal electric shocks. The unit delivers a static electric "ping" and then recharges for about a minute before the next shock, allowing the animal to lose its grip and flee. Non-Earth ground systems employ two or three live wires, and would be attached with identical wire looms along the sensor arms for uniformity of design.

We expect to mount the wires 1 centimeter (cm) apart for large birds and 0.5 cm apart for small birds, as matched to the size of their feet. Perhaps only a few pingger/charger/solar panel units would be needed to float between LLWAS poles with non-powered electric fence wires remaining in between, as a deterrent to "educated" birds. Repeat offenders would be surprised every now and again when live power is applied to random poles during routine maintenance visits. We must not use the sensor arms as a ground for the zapper, since the sonic sensor vendor didn't think this was a good idea. If deployed nationally, electric fences can also protect the LLWAS solar panel with a set of closely parallel wires run along the top edge. Different strength electric fences are available. We purchased both a 0.05 Joule output, Sureguard™ "Pingg String" Electronic Animal Fence designed (in Australia) for confining cats and wombats and a 0.5 joule output, Sureguard™ Model S-1 electric fence, good for kangaroos and larger animals. Uncertainties in the estimated electrical resistance of a birds foot in wet and dry conditions impels us to start with the low power version first, but to have a higher power fence available, if no behavioral impact occurs at first. Sureguard™ salesmen have reported their electric fences have been used in Australia with some success by a firm called "Cockiestopper" to discourage birds from roosting on roof mounted, solar power units used for heating swimming pools. (Suregard, 2000)

We determined the second best method for protecting the sensor was the simple Tie Wrap method of exclusion. Tie wraps have been field tested for a month with good results. In studying the long-term suitability of materials we found steel tie wraps in addition to the plastic that may last longer. One concern with tie wraps is being able to exactly duplicate a configuration to go through wind tunnel validation. The vendor suggested tie wrap guides could be inscribed along the arms and prefabricated lengths cut to make a fairly standard kit. We will need to test the sensitivity of configuration in the wind tunnel. So long as the tie wraps remain below the plane of the transducers, this solution should be effective. Tie wraps present a more open configuration that may not hold dropped sticks as well as porcupine wire. In addition, we need at least one bird spike on the center of the sensor. Perhaps a cone shape could be used for the central bird spike without detrimental wind effects that would really discourage nest building. Rather than drill holes in the solar panel, porcupine wire (8") stainless steel could be used on the solar panels in conjunction with sensor tie wraps. Sensor Tie Wrap/Center Bird

Spike with Solar Panel Porcupine Wire would be implemented nationally on all poles at least until electric shock can be perfected.

The third best method for the specific problem of the vulture roost at Fort Myers Pole #5 is the effigy method. For this deterrent, the FAA is taking advantage of certain behaviors attributed to vultures. Vultures avoid perching in the vicinity of others of their kind exhibiting morbidity or mortality. Observations support the finding that individual birds that encounter the effigy, even once, will avoid a future encounter. This appears to be specific to the species, yet may not deter other species from perching. We agreed to continue hanging an effigy as it produced good results for this specific problem.

7. DRAFT LLWAS BIRD CONTROL METHOD EVALUATION CHECKLIST

The various bird control methods mentioned in this paper are all compared in an evaluation checklist, attached at the back. (See Table 1 below) Methods include the following: A) Porcupine Wire, B) Bird Wire, C) Perch, D) Effigies, E) Habitant Modification by Tree cutting), F) Electric Shock, G) Inverted Operation, H) Bird Spikes/Do nothing, and I) Tie Wraps.

8. FINDINGS AND CONCLUSION

Effigy - Thus far, the taxidermic vulture effigy appears to remain an effective deterrent for that species. However, the FAA recognizes that this deterrent is high maintenance and expensive in the long-term. The effigy has fallen down in high winds or from tousling by birds. This necessitates periodic monitoring by FAA technicians and re-harnessing the effigy to the remote station when it falls off. The FAA purchases effigies through a special program of the United States Department of Agriculture for $250.00 (US) each. As a species protected by United States law, it is illegal to possess a carcass except through special arrangements. The useful life of an effigy is three to six months. This is due to weathering and abuse by birds.

Habitat Modification – Habitat modification is a notable long-term solution, especially for airports located within an area of roosts. This solution requires coordinated planning and collaboration with Federal, state and local fish and wildlife agencies. Observation to identify, and planning to remove, only the favored trees, will minimize the environmental impact. It is important to conduct a survey of regional roosts and land uses to ensure that the bird nuisance does not relocate from the facility to augment nuisances at other facilities or land uses.

Porcupine Wire and Tie-Wraps - Porcupine Wire and Tie Wraps are effective relative to the toughness of the bird hide. Periodic maintenance to remove dropped sticks and other components of nesting will be essential to maintain the viability of the deterrent.

Presently the FAA has concluded that:

1. Use of vulture effigies is the best short-term solution for deterring vultures.
2. Use of electric shock is the best long-term solution for excluding all birds. It is worth developing a nationwide solution.
3. Tie-wrap is the second best long-term solution. However, it would work best with at least one bird spike in the center of the sensor array. Additionally, porcupine wire would be used to preclude birds from other sensitive parts of the remote station.

Data drops" due to bird perching are an unacceptable risk for the nationwide LLWAS system. As airports intrude on sensitive avian habitat, we must remain aware that avian behavior can interfere with the vital operation of facilities and equipment. Thoughtful designs can minimize equipment outages and the morbidity or mortality of species. Bird deterrence applications described in this paper may apply to not only LLWAS poles, but to other facilities and equipment. The LLWAS bird proof design and engineering discussed here are under consideration for use at FAA radar installations.

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Epilogue

Figure 13. Longer, Sharper Central Bird Spike Installed at Fort Myers

The National Weather Service (NWS) is procuring a similar wind sensor and has certified a long, metal center bird spike for use in wind tunnel testing. Two of the NWS long metal bird spikes were installed, one at Fort Myers remote station #1 and one at remote station #4. This time of year is the rainy season for Fort Myers. In the dry season, during the early evening hours there is more bird activity than this time of year because of the weather. The FAA will do a broader test at Fort Myers with certified NWS bird spikes. After we installed the center spike, we did have what we believe to be some birds land and stay a short period of time at night. The bird did cause some short-term data loss. FAA is considering setting up a night vision camera to monitor this problem.

. **Table 1. COMPARISON OF LLWAS SONIC SENSOR BIRD CONTROL METHODS**

Bird Control Method Sensor	A Porcupine Wire	B Bird Wire	C Perch - COTS	D Vulture Effigies	E Habitat Modifi-cation	F Electric Shock	G Inverted Operation	H Bird Spikes / Do Nothing	I Tie Wraps
Scare				✓					
Accommodate			✓						
Exclude	✓	✓				✓	✓	✓	✓
Relocate					✓				
Local Fix at Fort Myers only				*X*	*X*				
National Fix at all sites	*X*	*X*	*X*			*X*	*X*	*X*	*X*
Single/Multiple bird species	*Multiple*	*Multiple*	*Multiple*	*Single*	*Single*	*Multiple*	*Multiple*	*Multiple*	*Multiple*
Effectiveness on a single bird	High	*Medium*	High	Species Specific High	Medium	High	High	Low	High
Effectiveness on Perching Large Birds	High	*Medium*	Low	Species Specific High	High	High	High	Low	High
Effectiveness on Perching Small Birds	High	*Medium*	Low	Low	Medium	High	High	Low	Medium
Effectiveness on Nesting Large Birds	Low	Medium	Low	Species Specific High	Medium	High	High	Low	Medium
Effectiveness on Nesting Small Birds	Low	Low	Low	Low	High	High	High	High	Low
Expected Maintenance	2/year Clear nesting starts	1/year	4/year Clean Depo-sits	6/year	Once/ 10 Years	Often	2/year	None	1/Year
Non-recurring Cost	Small	Small	Small	Small	Large to Medium	Large	Small	None	Small
Recurring Cost	Medium	Small	Small	Large	Low to Medium	Large	Medium	None	Small
Wind Tunnel Test Required	✓	✓	✓	N/A	N/A	✓	“Head to Toe” Test	N/A	✓
*Icing/Snow Build up Testing Required ***	✓	✓	✓	*N/A*	*N/A*	✓	*“Head to Toe” Test*	*N/A*	✓
Long Term Suitability of Materials	✓	✓	✓	✓	*N/A*	✓	✓	*N/A*	✓
Other Associated Steps	Buy and Build	Buy and Build	Buy COTS	Ensure supply per species	Regula-tory Comp-liance & Contract Locally	Buy, Design, Build, Main-tain	Water proof sensor, change settings	None	Easy to build – comes in stainless steel?
Remarks	Icing and snow build-up are a worry as is nest building by stick dropping	Potential for crosstalk and need for acoustic isolation makes this more difficult	Perch is heated, prevents icing but draws 25 watts up to 75 watts – hard on solar power	Specific for one pole/one site only, concern if used at more “public” sites	Concern about where we move the vultures to – one pole/one site fix only	High dollar, complex and long schedule to build but it seems most effective	Concerns about icing running down the center - its not heated, needs new alignment procedure	Some sonic sensors are provided without post mounts for spikes on arms	Hard to duplicate exactly to ensure no wind effects – some measure & guides are needed

*** Icing/Snow Buildup Testing includes icing, blowing snow, snow build-up. This test should verify that only limited snow/ice buildup occurs and that any buildup does not adversely effect sensor operation.*