ISU Webinar: Reducing Barriers for Deployment of Offshore Wind Energy

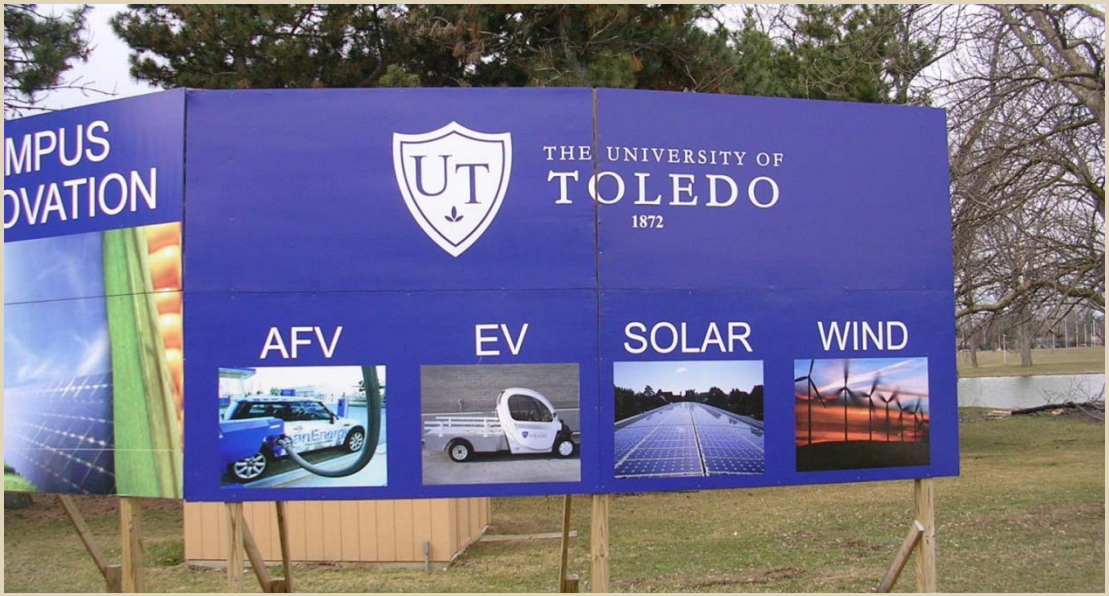
Coastal Ohio Wind Project

February 18, 2015

Dr. Peter Gorsevski, Associate Professor Geospatial Sciences
BOWLING GREEN STATE UNIVERSITY

Coastal Ohio Wind Project

The COWP intended to address problems that ***impeded deployment of wind turbines*** in the coastal and offshore regions of Northern Ohio. The project evaluated the potential impact of offshore turbines on migratory and resident birds by developing ***multidisciplinary research*** which involved wildlife biology, electrical and mechanical engineering, regional economic development, and geospatial science.



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Coastal Ohio Wind Project

The particular tasks of the project were:

- To develop different methods for optimizing ***avian surveillance*** and ***monitoring strategies*** needed for offshore turbine sites;

- To understand advantages and disadvantages from ***different Wind Turbine Generators (WTG)*** for addressing local conditions associated with the Great Lakes region;

- To develop ***economic scenarios*** for determining economic feasibility and potential cost savings for offshore WTG deployment; and

- To develop an ***environmental Geospatial database*** that integrates datasets and products developed by the project.

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Avian Surveillance and Monitoring

This research component develops a monitoring system for ***nocturnal flight of birds/bats activity*** using three different monitoring sensor devices that are tested in a near-shore environment along Lake Erie.

The devices used in the project include:

- Thermal infrared (IR) cameras
- Radar Surveillance
- Acoustic Recorders

Thermal IR

FLIR SR-19 thermal camera

The IR camera system has standard resolution Focal Plane Array (FPA) of 320 (H) x 240(V) pixels.

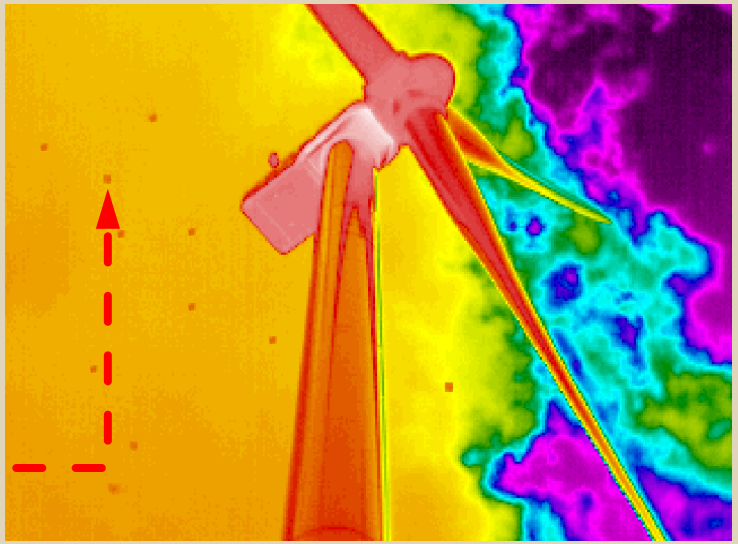
The detector frame rate is *thirty frames/second*.

The IR camera was installed pointing up vertically; the top of the field of view was rotated 19.75º from north.

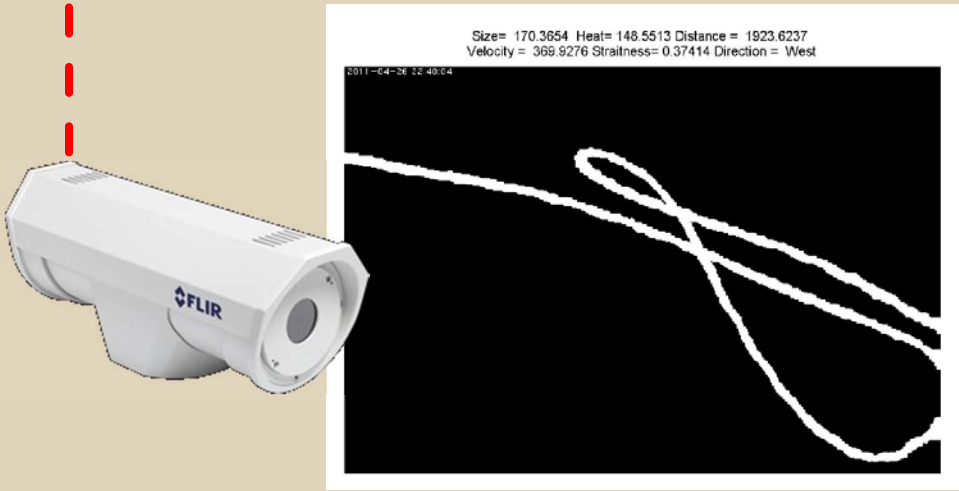
Thermal IR

To *remove barriers slowing offshore development* in the Great Lakes by examining:

- Avian issues, including methods for ***remote sensing to detect bird/bat strikes over water***, in order to measure/mitigate environmental damage, and to develop operating protocols to address environmental risk reduction



Thermal Infrared



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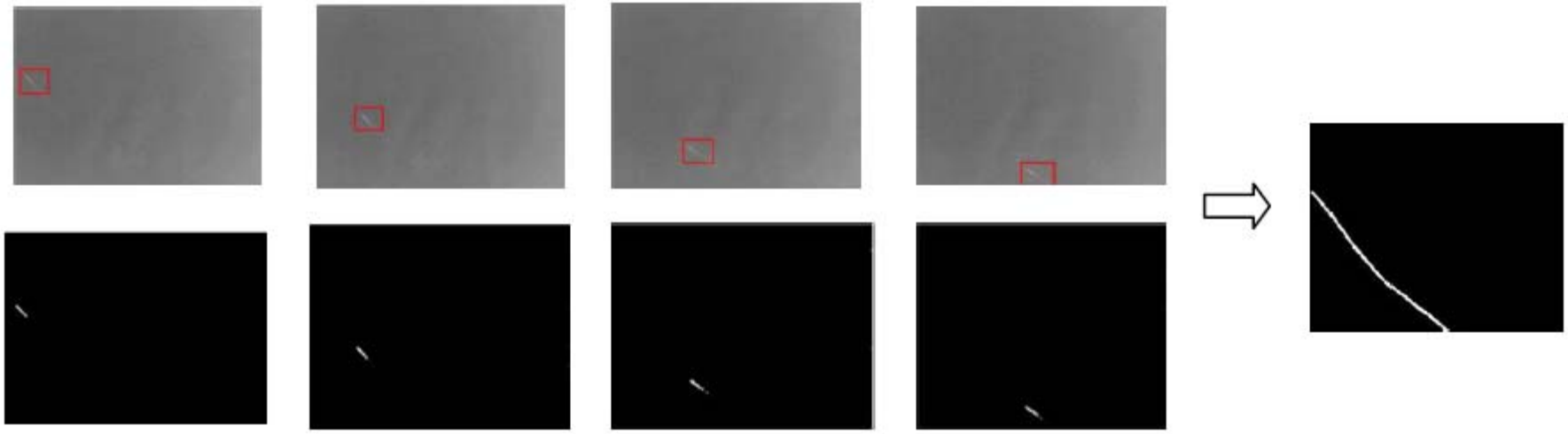
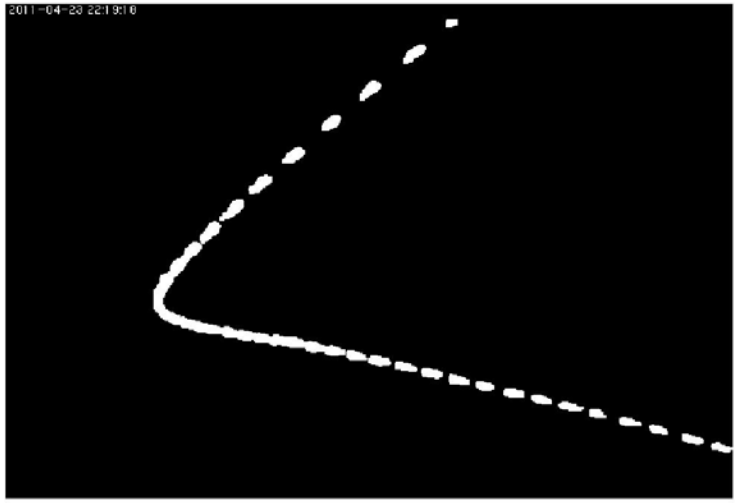
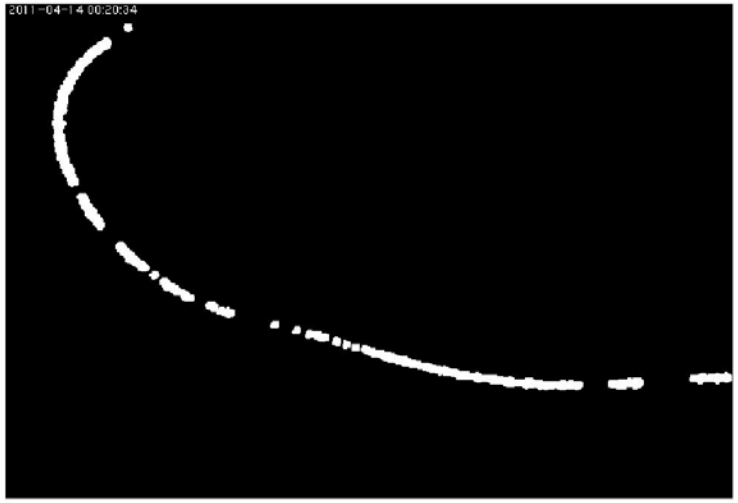
Thermal IR



Size= 168.825 Heat= 147.375 Distance = 963.8703
Velocity = 722.9027 Straitness= 0.50605 Direction = Northeast



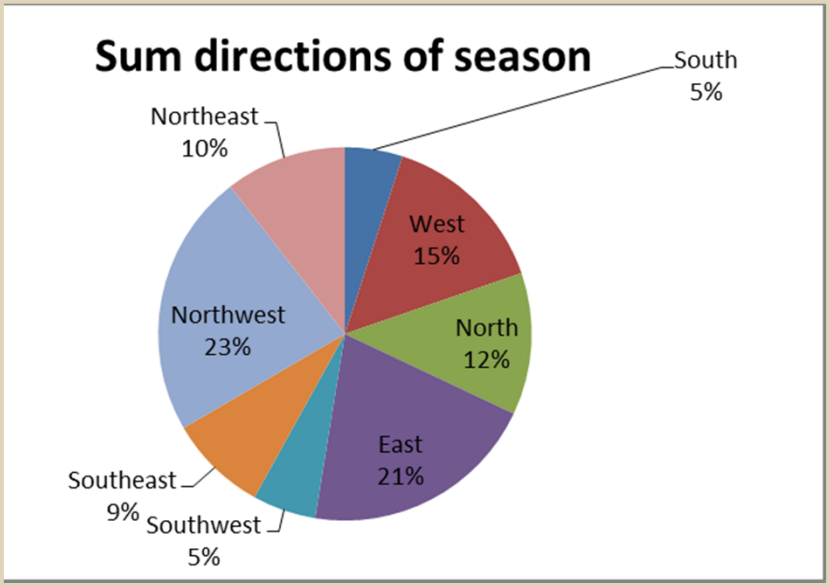
Size= 75.4444 Heat= 146.5794 Distance = 878.6112
Velocity = 209.1931 Straitness= 0.76405 Direction = West

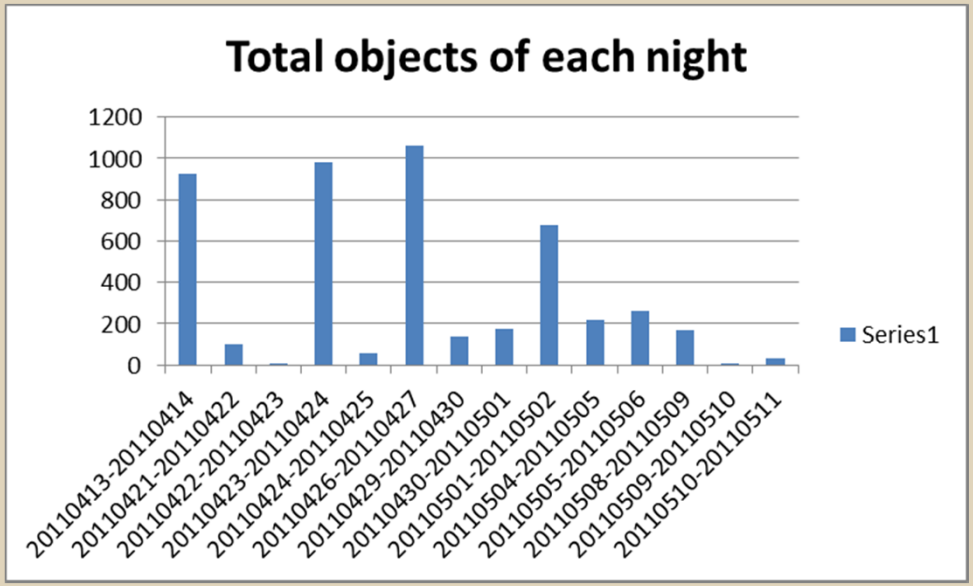


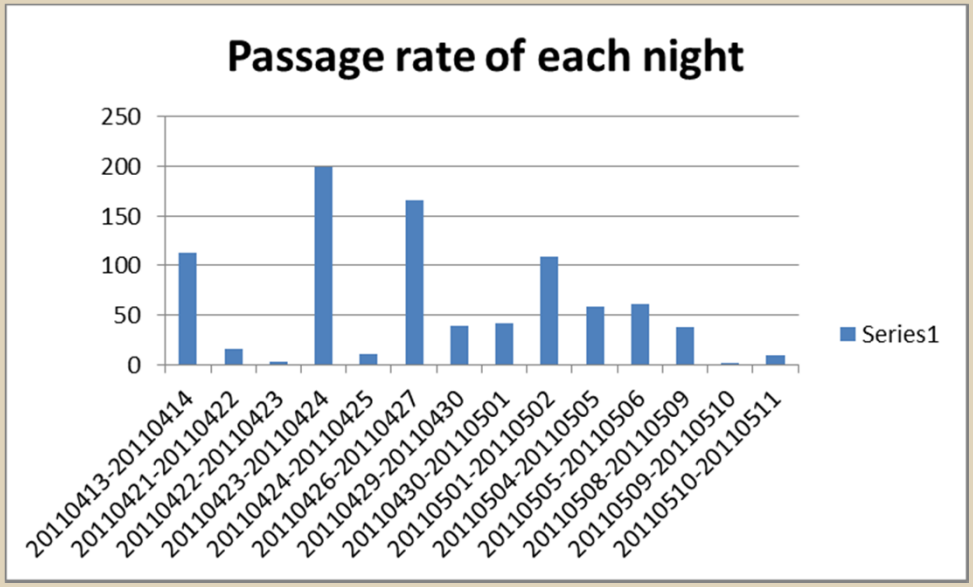
Thermal IR Data

A	B	C	D	E	F	G	H
ImageName	size(pix)	Heat	Distance(pix)	Velocity(pix/sec)	Straitness	Direction	Angle
20110413_20-25-32(1)1.jpg	269.3158	154.6316	516.859	816.0931	0.99484	East	104.4144
20110413_20-25-32(1)2.jpg	82.8	121	499.4649	2996.7896	0.99967	West	288.5116
20110413_20-25-32(1)3.jpg	69.5	118	131.9666	989.7496	0.99989	West	253.4731
20110413_20-25-32(1)4.jpg	150.5	117.5	239.6248	1797.1861	1	Northwes	337.2644
20110413_20-25-32(1)5.jpg	142.4	127.2	326.9619	1961.7715	0.99999	Northwes	335.7217
20110413_20-25-32(1)6.jpg	99	139.1875	476.5204	446.7379	0.99589	North	342.1483
20110413_20-25-32(1)7.jpg	194.4706	133.5882	677.5395	1195.658	0.99872	Northwes	333.7790
20110413_20-25-32(1)8.jpg	160.5556	128.6667	610.7419	2035.8065	0.99879	Northwes	335.2524
20110413_20-25-32(1)9.jpg	112.8889	122.2222	556.5542	1855.1808	0.99993	West	290.8382
20110413_20-25-32(1)10.jpg	59.5	127.5	26.0417	390.6254	1	Northwes	337.5472
20110413_20-25-32(1)11.jpg	70	132.3333	386.5233	1932.6165	0.99989	Northwes	333.1153
20110413_20-25-32(1)12.jpg	73.7826	126.913	691.9969	902.6046	0.99456	Northwes	337.5786
20110413_20-25-32(1)13.jpg	293.2	146.8	576.9553	1153.9106	0.99969	Southeast	155.8229
20110413_20-25-32(1)14.jpg	84.9211	138.6842	718.2438	567.0345	0.97921	Southeast	134.5971
20110413_20-25-32(1)15.jpg	70.4545	134.2727	621.1533	847.0272	0.99986	Northwes	336.6435
20110413_20-25-32(1)16.jpg	286.5455	135.7273	613.4829	1673.1352	0.99997	West	254.1435
20110413_20-25-32(1)17.jpg	510.5	153.2	313.6743	941.023	0.99911	Southeast	131.7350
20110413_20-25-32(1)18.jpg	187.6522	141.6957	678.2137	884.6266	0.99891	Southeast	153.9589
20110413_20-25-32(1)19.jpg	621	147	48.3034	724.5517	1	West	283.4014
20110413_20-25-32(1)20.jpg	77	156	9.7545	146.3178	1	East	110.9276
20110413_20-25-32(1)21.jpg	117.6667	133.1905	576.5909	823.7012	0.99623	Northeast	52.2618
20110413_20-25-32(1)22.jpg	88.1081	135.3514	688.2255	558.0207	0.99895	East	69.3667
20110413_20-25-32(1)23.jpg	61	122.3333	543.1344	2715.6722	0.99972	West	285.9623

Thermal IR Data







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Thermal IR

Some of the IR detection work that has been conducted at UT/BGSU involved the following areas:

- **Data fusion** of radar, IR and acoustic data
- Development of **faster IR video processing algorithms**
- Fast computation of IR Video via **parallel processing**.
- Quantification of **uncertainties**.

A Parallel Implementation of IR Vid
on a GPU

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***Abstract*—A bird and bat monitoring system has been developed that uses marine radar, IR camera and acoustic recorders for wind farm applications. IR video recording is used to monitor birds and bats activity which will be useful for wildlife biologists in developing mitigation techniques to minimize impact of wind turbines on birds and bats. In order to process nocturnal migration data that is recorded from one hour after sun set to one hour before the sun rise requires high speed computations. IR video processing is computationally intensive. A parallel processing approach and use of GPU is proposed to process IR video data that will meet real time requirements. This paper examines the parallel implementation of the IR video processing on GPU. We achieved the real time requirements and the necessary performance for analyzing IR with size 704x480.**

I. INTRODUCTION

Wind energy provides green energy and is growing at a rapid pace. Wind turbines are often in the path of migratory birds and bats. Nocturnally migrating birds and bats are at a higher risk of colliding with turbines. It has become necessary to monitor birds and bats activity in the vicinity of wind turbines. A monitoring system has been developed which uses marine radar, Infrared thermal camera (IR) and acoustic recorders for the study of their behavior in the vicinity of wind turbines. This work aims to assist wildlife biologists in the observation of birds'/bats' behaviors.

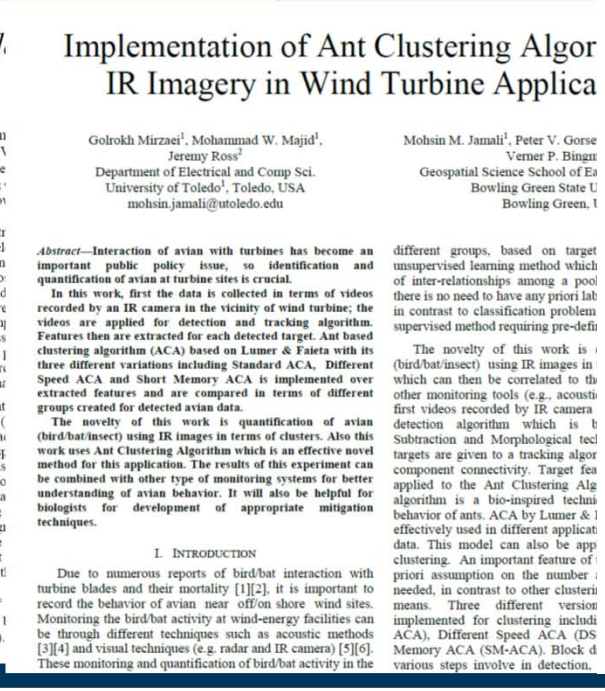
The IR camera provides excellent night visibility and situational awareness, even in absolute darkness. The IR data processing is different from the normal video processing

researchers with the tr
information such as vel
size. IR video processin
needs to be as fast as po
30 fps (frames per second
time requirements. There
provide higher throughp
purpose Graphic Process
cost parallel computing
very beneficial in researc
[3, 4] and for medical ima

There are three essent
background subtraction (
component labeling. Ba
image pixels that corres
background model [6] is
previous n-frames as sho
the current frame. The ba
frames. At the beginning
takes the constant backgr
from the 6th frame to the
number of targets is not
assembled by observing t

$$B(x,y,t) =$$

Where $B(x,y,t)$ is the
the image for pixel (x, y).



Implementation of Ant Clustering Algor
IR Imagery in Wind Turbine Applica

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Geospatial Science School of Ea
Bowling Green State U
Bowling Green,

***Abstract*—Interaction of avian with turbines has become an important public policy issue, so identification and quantification of avian at turbine sites is crucial.**

In this work, first the data is collected in terms of videos recorded by an IR camera in the vicinity of wind turbine; the videos are applied for detection and tracking algorithm. Features then are extracted for each detected target. Ant based clustering algorithm (ACA) based on Lumer & Faieta with its three different variations including Standard ACA, Different Speed ACA and Short Memory ACA is implemented over extracted features and are compared in terms of different groups created for detected avian data.

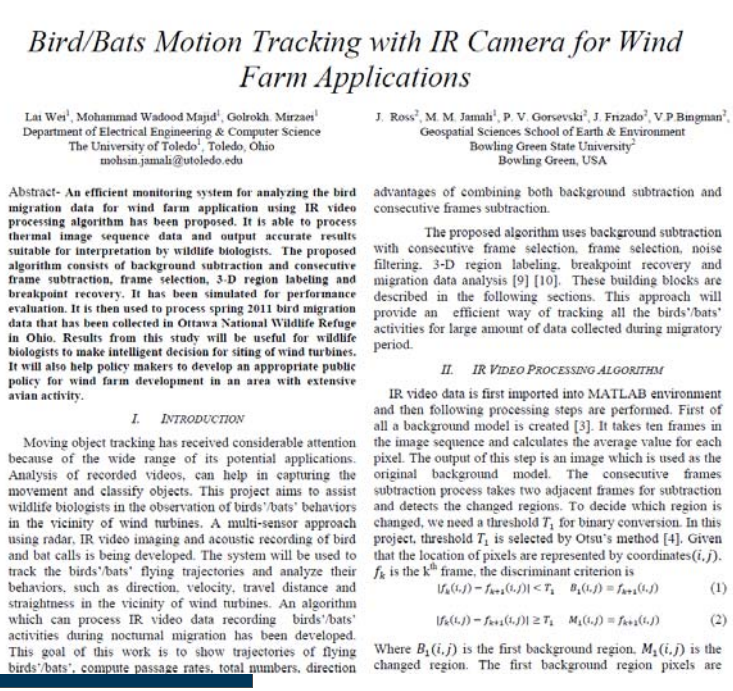
The novelty of this work is quantification of avian (bird/bat/insect) using IR images in terms of clusters. Also this work uses Ant Clustering Algorithm which is an effective novel method for this application. The results of this experiment can be combined with other type of monitoring systems for better understanding of avian behavior. It will also be helpful for biologists for development of appropriate mitigation techniques.

I. INTRODUCTION

Due to numerous reports of bird/bat interaction with turbine blades and their mortality [1][2], it is important to record the behavior of avian near off/on shore wind sites. Monitoring the bird/bat activity at wind-energy facilities can be through different techniques such as acoustic methods [3][4] and visual techniques (e.g. radar and IR camera) [5][6]. These monitoring and quantification of bird/bat activity in the

different groups, based on target
unsupervised learning method which
of inter-relationships among a pool
there is no need to have any priori lab
in contrast to classification problem
supervised method requiring pre-defi

The novelty of this work is
(bird/bat/insect) using IR images in
which can then be correlated to th
other monitoring tools (e.g., acousti
first videos recorded by IR camera
detection algorithm which is b
Subtraction and Morphological tec
targets are given to a tracking algor
component connectivity. Target fea
applied to the Ant Clustering Alg
algorithm is a bio-inspired techni
behavior of ants. ACA by Lumer &
effectively used in different applicat
data. This model can also be app
clustering. An important feature of
priori assumption on the number
needed, in contrast to other clusteri
means. Three different version
implemented for clustering includi
ACA), Different Speed ACA (DS
Memory ACA (SM-ACA). Block d
various steps involve in detection,



Bird/Bats Motion Tracking with IR Camera for Wind Farm Applications

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J. Ross[2], M. M. Jamali[1], P. V. Gorsevski[2], J. Frizado[2], V.P Bingman[2],
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Abstract- **An efficient monitoring system for analyzing the bird migration data for wind farm application using IR video processing algorithm has been proposed. It is able to process thermal image sequence data and output accurate results suitable for interpretation by wildlife biologists. The proposed algorithm consists of background subtraction and consecutive frame subtraction, frame selection, 3-D region labeling and breakpoint recovery. It has been simulated for performance evaluation. It is then used to process spring 2011 bird migration data that has been collected in Ottawa National Wildlife Refuge in Ohio. Results from this study will be useful for wildlife biologists to make intelligent decision for siting of wind turbines. It will also help policy makers to develop an appropriate public policy for wind farm development in an area with extensive avian activity.**

I. INTRODUCTION

Moving object tracking has received considerable attention because of the wide range of its potential applications. Analysis of recorded videos, can help in capturing the movement and classify objects. This project aims to assist wildlife biologists in the observation of birds'/bats' behaviors in the vicinity of wind turbines. A multi-sensor approach using radar, IR video imaging and acoustic recording of bird and bat calls is being developed. The system will be used to track the birds'/bats' flying trajectories and analyze their behaviors, such as direction, velocity, travel distance and straightness in the vicinity of wind turbines. An algorithm which can process IR video data recording birds'/bats' activities during nocturnal migration has been developed. This goal of this work is to show trajectories of flying birds'/bats', compute passage rates, total numbers, direction

advantages of combining both background subtraction and consecutive frames subtraction.

The proposed algorithm uses background subtraction with consecutive frame selection, frame selection, noise filtering, 3-D region labeling, breakpoint recovery and migration data analysis [9] [10]. These building blocks are described in the following sections. This approach will provide an efficient way of tracking all the birds'/bats' activities for large amount of data collected during migratory period.

II. IR VIDEO PROCESSING ALGORITHM

IR video data is first imported into MATLAB environment and then following processing steps are performed. First of all a background model is created [3]. It takes ten frames in the image sequence and calculates the average value for each pixel. The output of this step is an image which is used as the original background model. The consecutive frames subtraction process takes two adjacent frames for subtraction and detects the changed regions. To decide which region is changed, we need a threshold T_1 for binary conversion. In this project, threshold T_1 is selected by Otsu's method [4]. Given that the location of pixels are represented by coordinates(i,j). f_k is the k^{th} frame, the discriminant criterion is

$$|f_k(i,j) - f_{k+1}(i,j)| < T_1 \quad B_1(i,j) = f_{k+1}(i,j) \qquad (1)$$

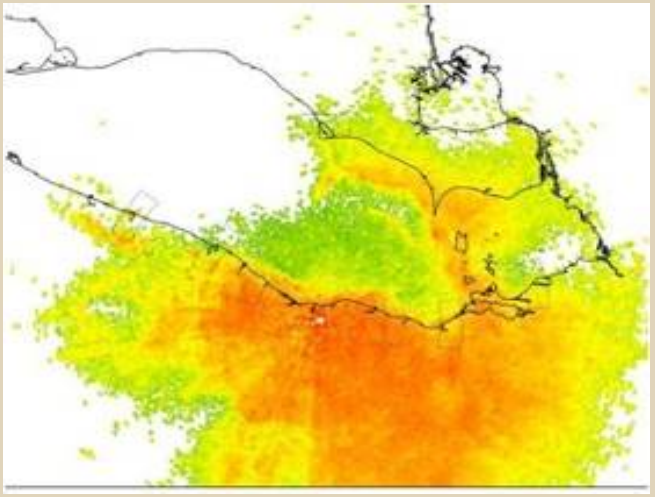
$$|f_k(i,j) - f_{k+1}(i,j)| \geq T_1 \quad M_1(i,j) = f_{k+1}(i,j) \qquad (2)$$

Where $B_1(i,j)$ is the first background region, $M_1(i,j)$ is the changed region. The first background region pixels are

Radar Surveillance

Marine Radar -- Furuno 1525 MK3 - 25 kW radar unit (range scales 1/8-96 n.mi.) with a 6.5 ft. horizontal array antenna and a digitizing card XIR3000 by Russell Technologies Inc

Doppler Radar Imaging



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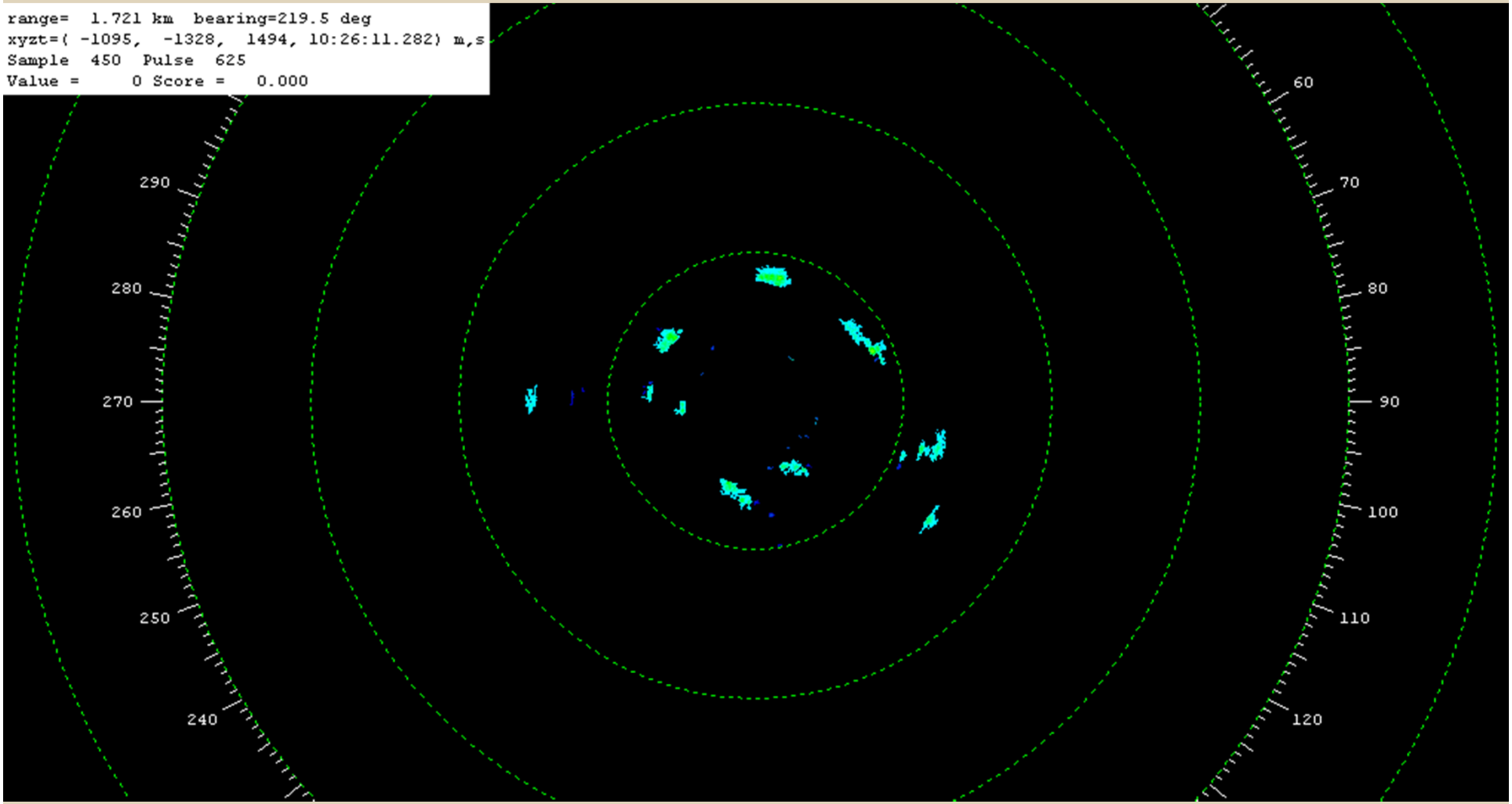
Marine Radar Data Processing (radR)



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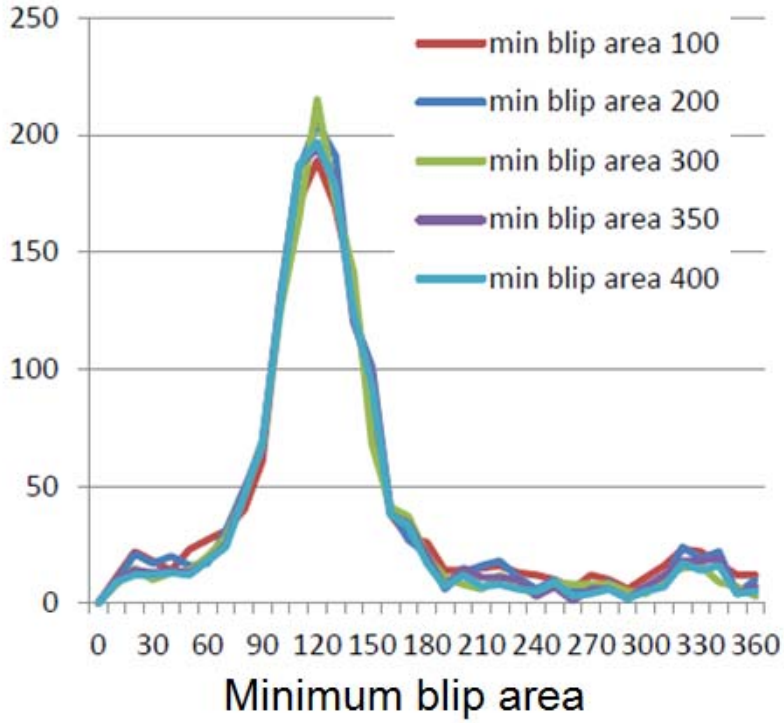
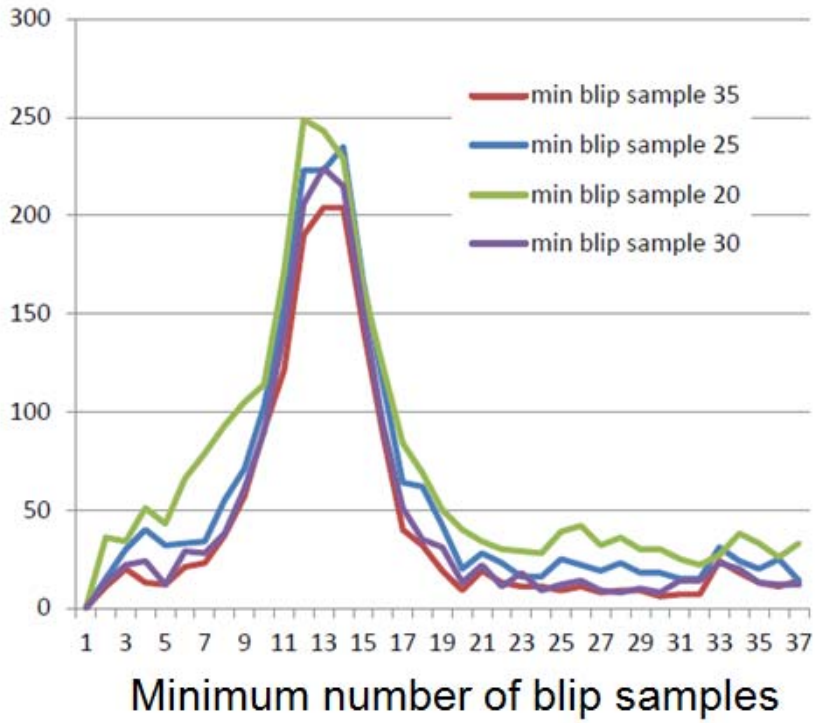
Marine Radar Sensitivity Analysis





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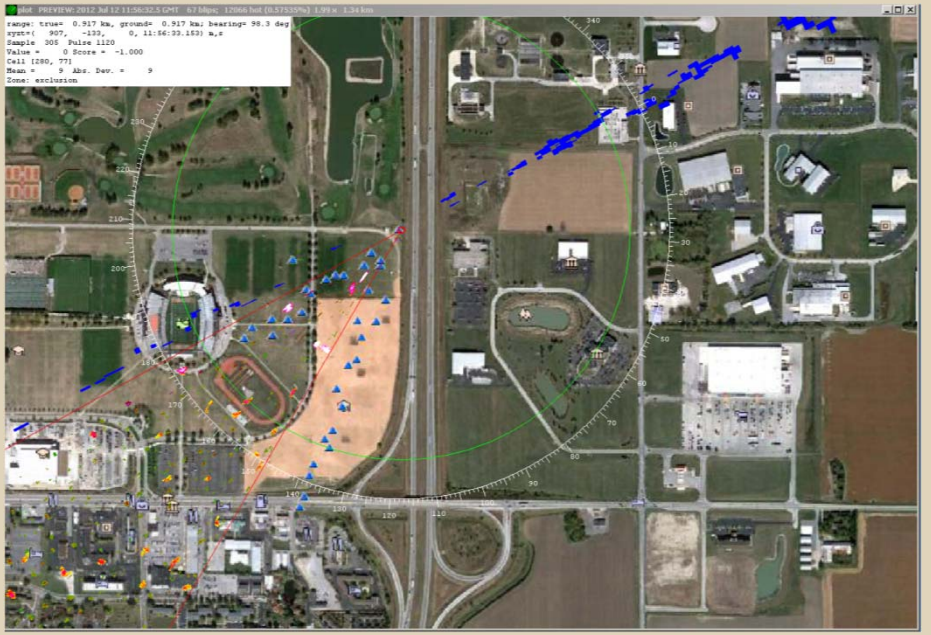
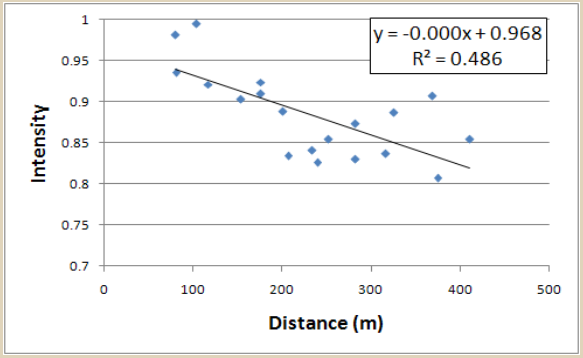
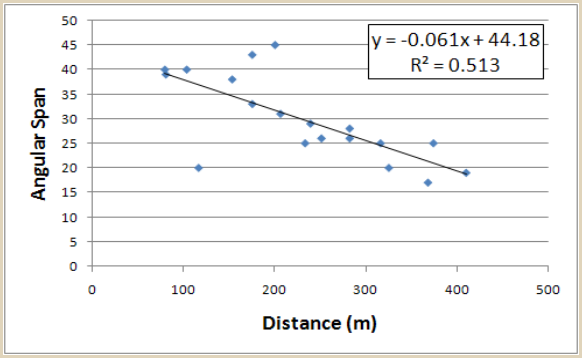
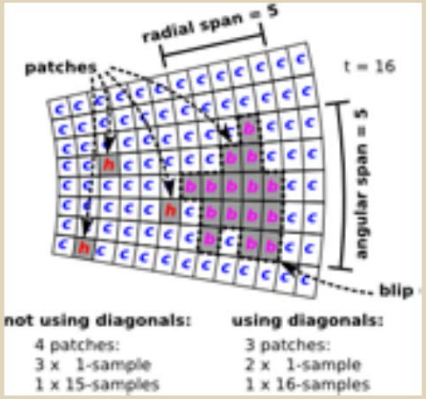
Marine Radar Calibration









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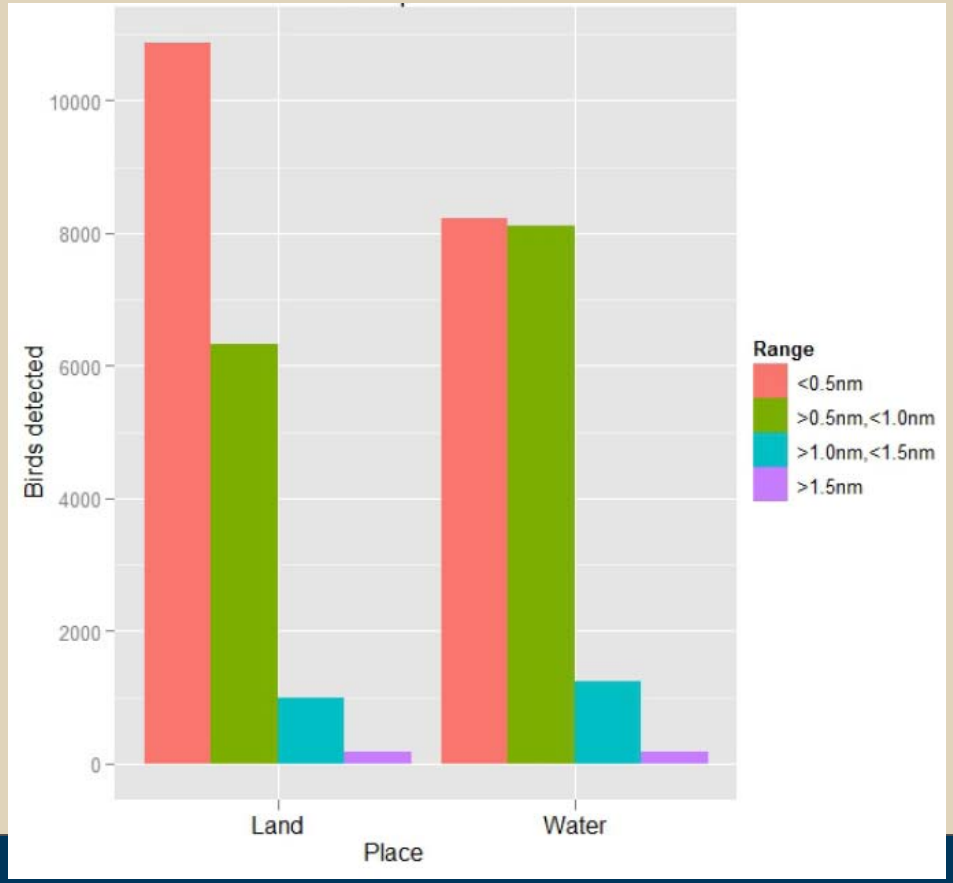
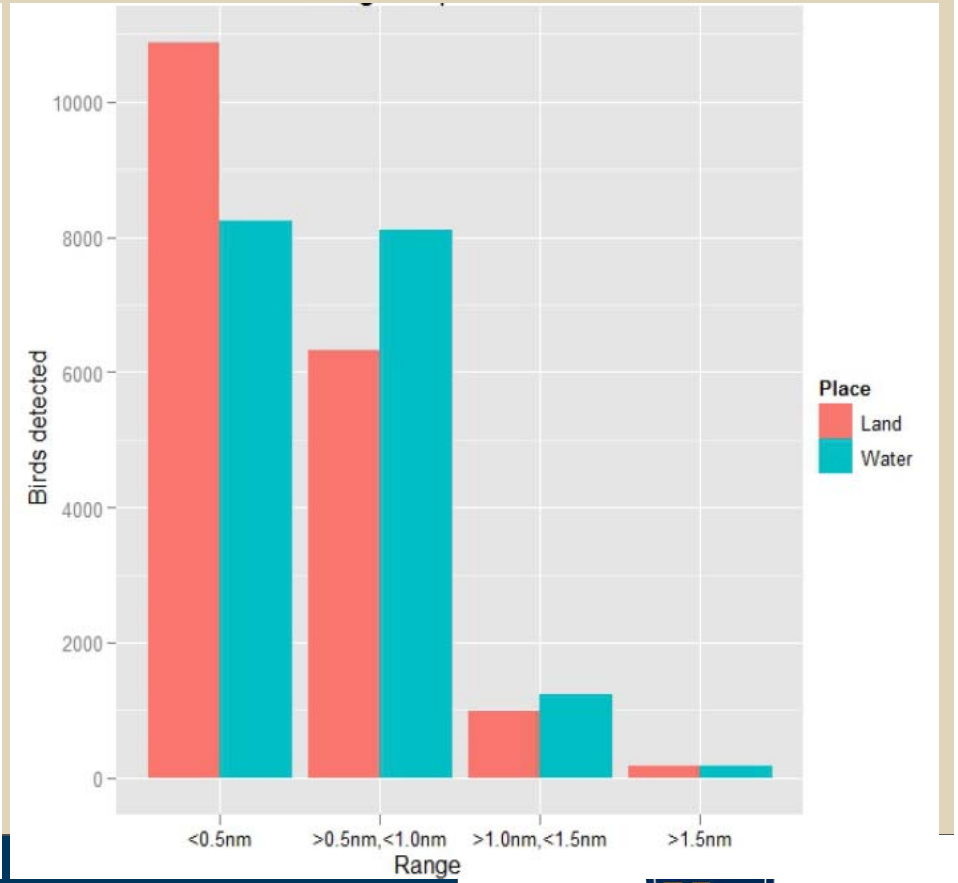
Marine Radar Data

Some of the data that collected with the marine radar and parabolic antenna included:

Total # of birds detected with respect to land & water



Total # of birds detected with respect to range division



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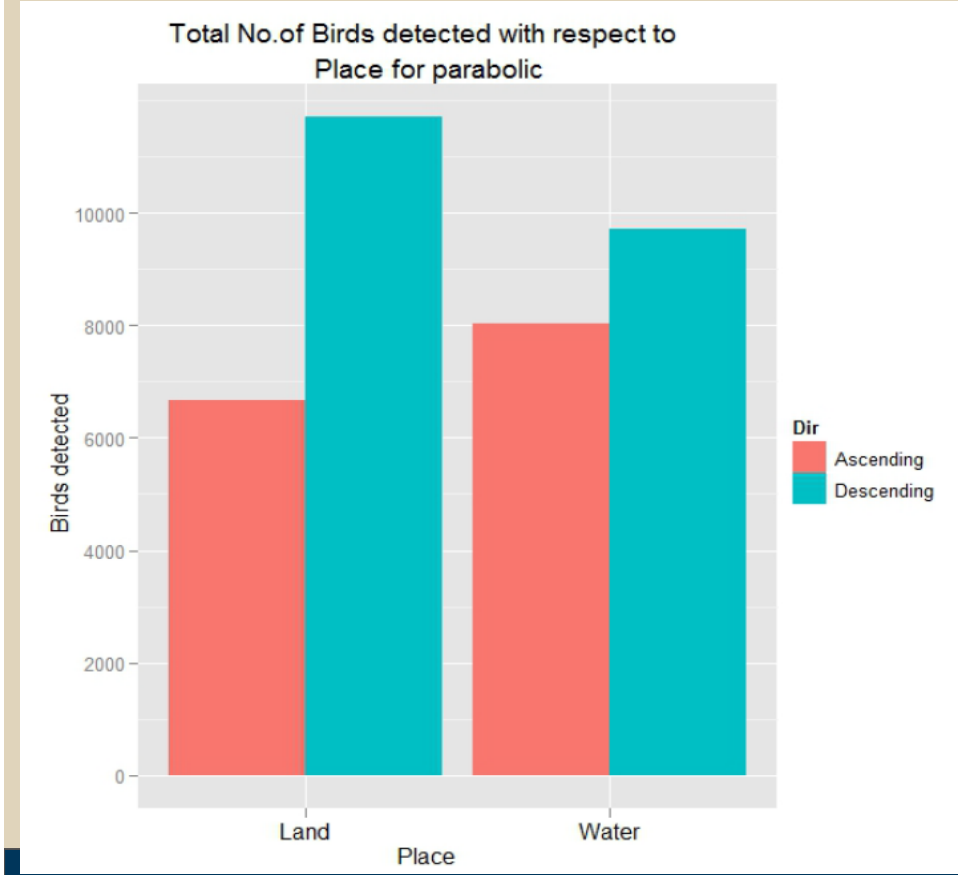
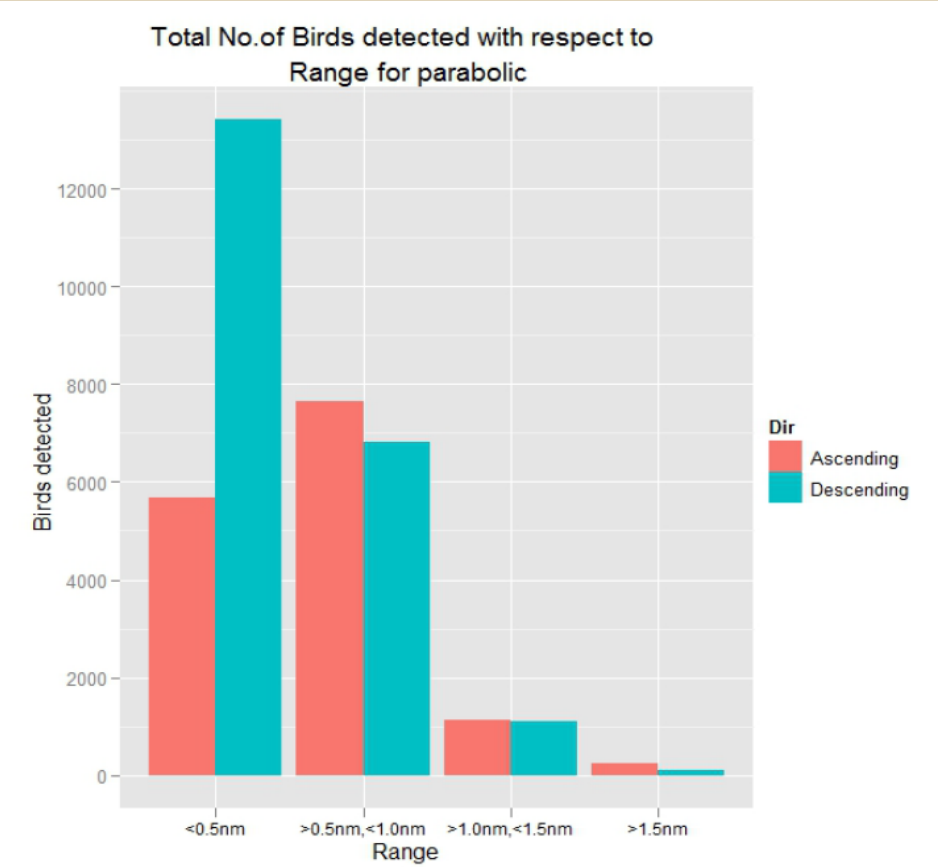
Marine Radar Data

Some of the data that collected with the marine radar and parabolic antenna included:

Total # of birds detected with respect to land & water



Total # of birds detected with respect to range division



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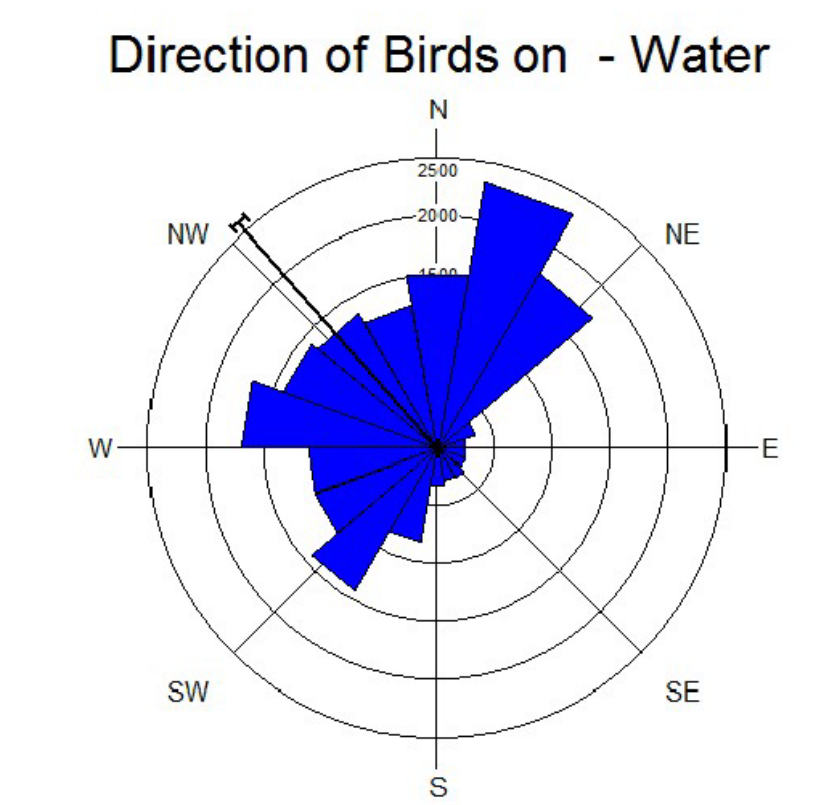
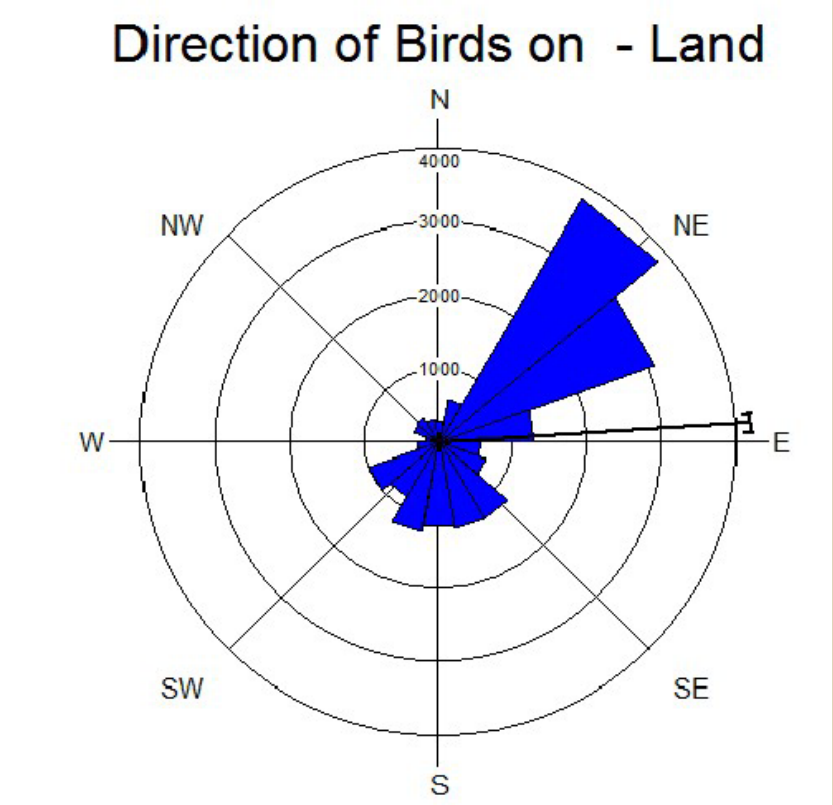
Marine Radar Data

Some of the data that collected with the marine radar and parabolic antenna included:

Direction of birds detected on water



Direction of birds detected on land



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Remote Avian Monitoring System for Wind Turbines

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***Abstract*— A radar and IR based avian monitoring system for an offshore wind turbine application has been designed. The avian monitoring system is capable of capturing radar and IR data. The data is synchronized and sent to a remote computer via 3G system. The IR camera needs to be synchronized with the radar view from a remote location. The system was constructed and successfully tested for remote synchronization of radar and IR camera and transfer of data over the internet. The system is designed to monitor avian activity around offshore wind turbines.**

I. INTRODUCTION

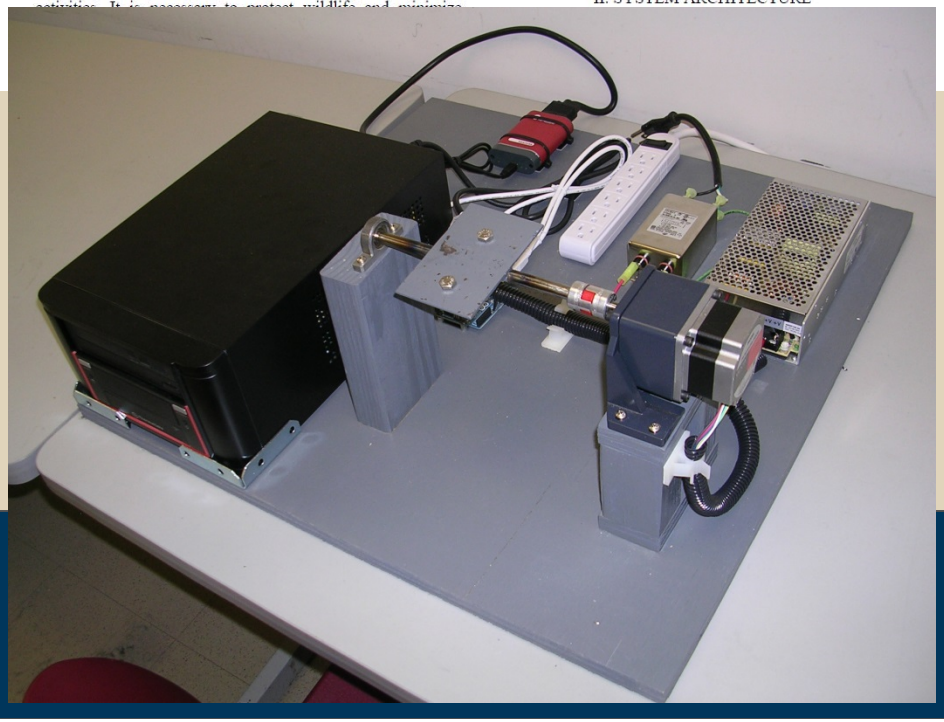
Wind energy provides green energy and is being developed in great numbers both as on-shore and offshore wind farms. Wind energy can affect wildlife especially nocturnally active birds and bats. Fatalities to birds and bats have been widely reported near wind turbines. According to the American Bird Conservancy, each wind turbine in the United States can kill up to eight birds per year, culminating in the death of 10,000-40,000 birds each year across America [1]. These turbines extend about 120 meters high in the sky and impede the flight behaviors of bird/bat and other wildlife especially during foraging, mating, descending and ascending activities. It is necessary to protect wildlife and minimize

can be used to quantify spatial and temporal patterns in migration.

Some, researchers have combined radar with infrared cameras and bio-acoustics microphones to enhance the monitoring and classification on nocturnal bird and bat flights/migration. Infrared (IR) camera can be used to distinguish among birds, bats and insects. Likewise, acoustic monitoring technique have designed to recognize different bird and bat species vocalizations. This approach builds off existing and expanding birdcall database and uses acoustic recognition software for bird and bat identification.

A system is being developed which will combine data from multiple radars, IR camera and bird and bat call recorders, as well as Doppler weather radar(NEXRAD) data from nearby stations. Efforts are being directed to concurrently processing data from multiple sources. Various radar, IR, bird/bat calls recognition algorithms are being investigated and they will be incorporated into comprehensive monitoring system. A system has been designed to move the IR camera in sync with the radar so radar and IR camera will have the same viewing area. Two proposed part of the system namely the detectors at the turbine site (offshore or on-shore) and the laboratory interface are connected with a wireless network. A block diagram of this system is shown in Fig. 1.

II. SYSTEM ARCHITECTURE



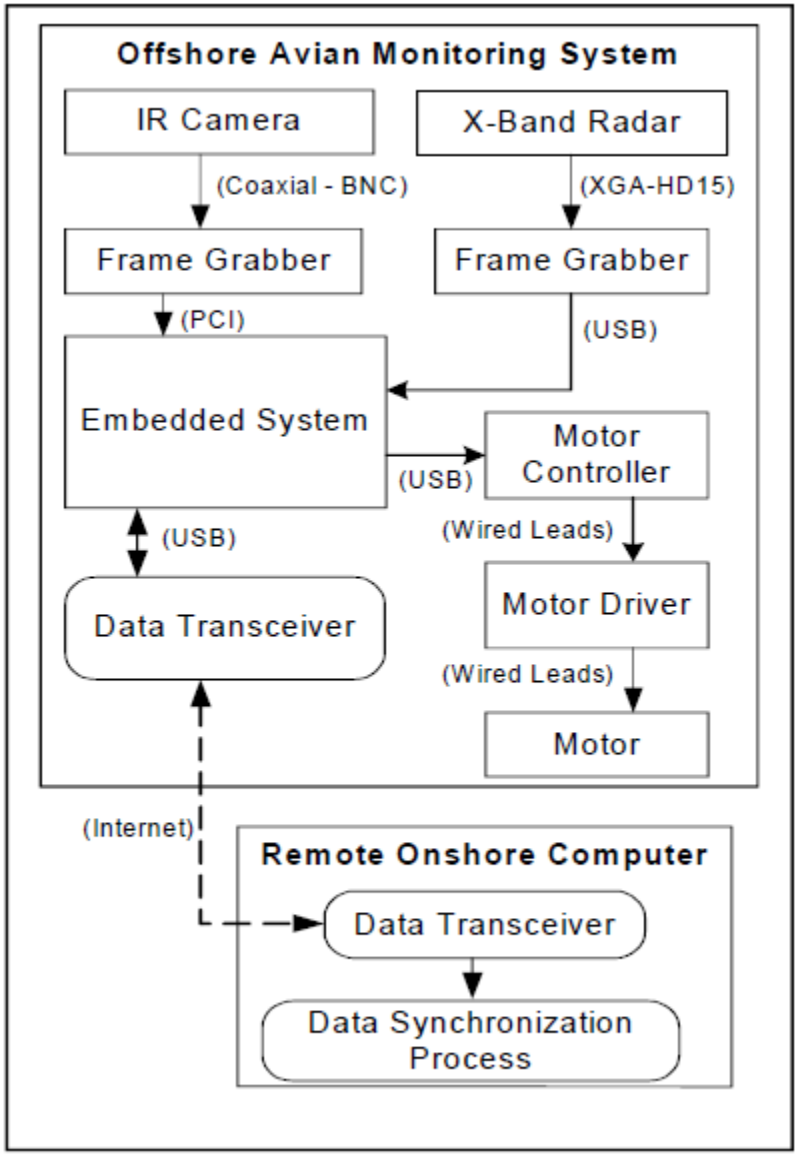


Fig. 2: Overall System Design

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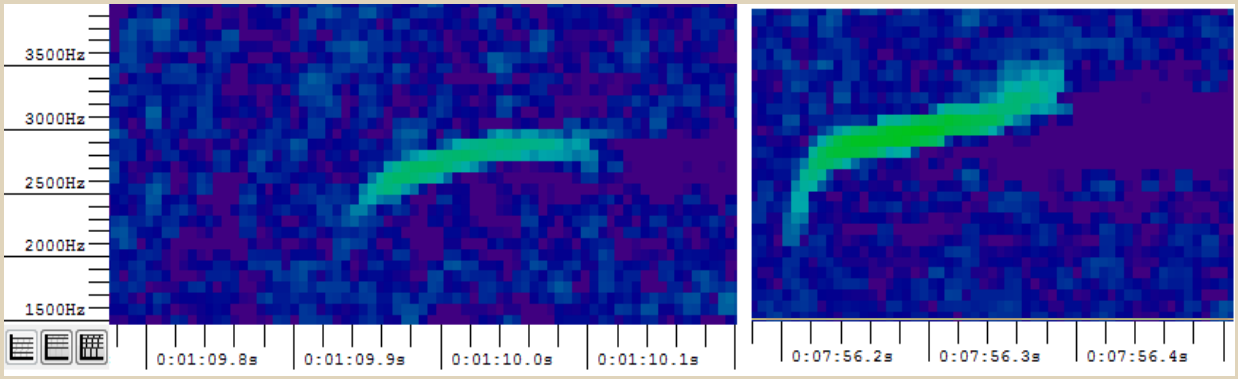
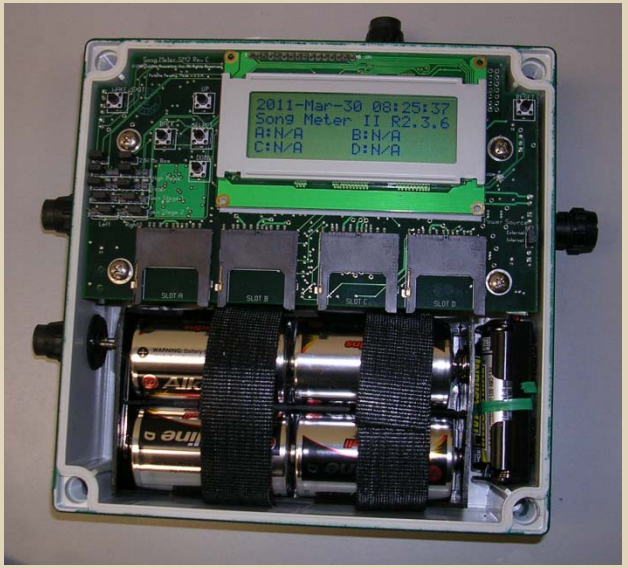
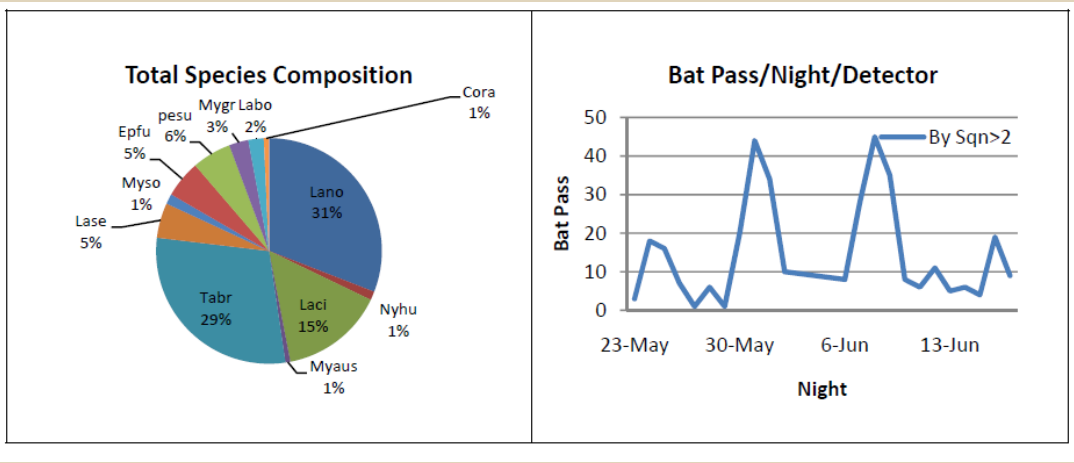
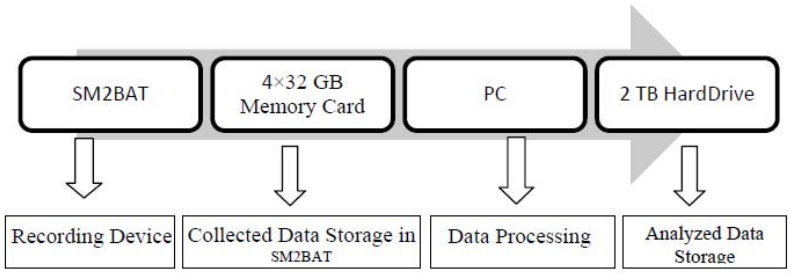
Acoustic Recorders









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Findings from Marine Radar, Acoustics, IR

- Bird and bat passage ***rates per hour comparable during heavy migrations*** in both spring and fall

- Passage rates were significantly correlated to ***wind direction*** and ***wind speed***

- ***Altitude of migration*** was higher during heavy migrations and ***higher over water*** relative to over land

- Notable portions of migration on some ***spring nights occurred parallel the shoreline***, often moving perpendicular to southern winds

- ***High stopover density*** was more strongly associated with migration volume the following night rather than the preceding night (with exceptions)

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Wind Turbine Generators (WTG)

This component evaluates the ***feasibility of different WTG*** designs including two- and three-bladed, down-wind, and up-wind turbines for offshore deployment.

The ***water tunnel studies*** tested scale model studies that could be used to adequately produce accurate models of motions from a wind turbine platform subject to large waves.

Another key development for this task is focused on evaluation of passive methods (i.e., application of different materials and paint coats) for ***mitigation of ice accretion*** on the wind turbine blades during icing conditions.

Wind Turbine Generators (WTG)

To *perform an engineering analysis* comparing the benefits of ***two*** and ***three bladed WTG's*** for offshore use. ***Two bladed machines*** are of significant interest for reducing installation and maintenance costs due to their

- Lighter head and tower weights
- Lower center of gravity
- Lower drive train torque stemming from higher operating speeds
- ***Reducing the complexity*** of offshore construction
- ***Foundation*** and ***issues related to ice*** damage in fresh water lakes in order to assure high reliability, long-term installations.

MOD-5B Wind Turbine
(Two-bladed, teetered hub, 3.2 MW)

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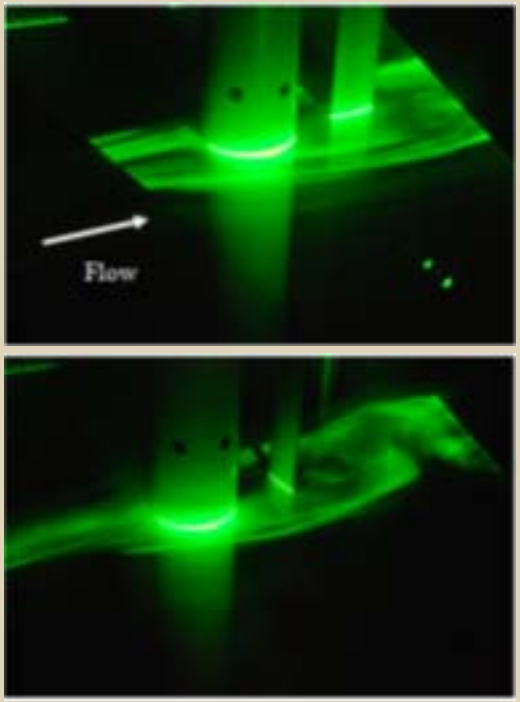
Wind Turbine Generators (WTG)

Flow visualizations were conducted to qualitatively study the ***rotor blade-tower interactions*** for upwind and downwind turbine rotor configurations with the rotor blade situated directly upstream or downstream of the tower.

UT 3x3 Low Speed Wind Tunnel and Wave Tank



Smoke flow visualizations of the tower-blade interaction with the blade at different angles of attack

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WTG's Engineering Analysis

The University of Toledo's ***water channel*** was used for testing the hydrodynamic behavior of a floating platform in flowing water. Important consideration included wave loading on submerged or surface piercing structures.

UT ***Water channel*** consists of a 16-ft long channel with an 18-in. by 12-in. cross-section, motorized head and tail gates for water depth and flow rate adjustments, two pumps, a tile motor for the channel, and various barriers for inside the channel to create desired flows.

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Acquisition of turbine operation data in near shore environment

Wind Turbine and Zephir LIDAR System

The system was acquired and installed at Woodlands School in Huron, Ohio, which is located near Lake Erie. A total of ten measurement heights were chosen for data collection, which are 200m, 150m, 100m, 80m, 60m, 40m, 38m, 30m, 20m, and 10m.

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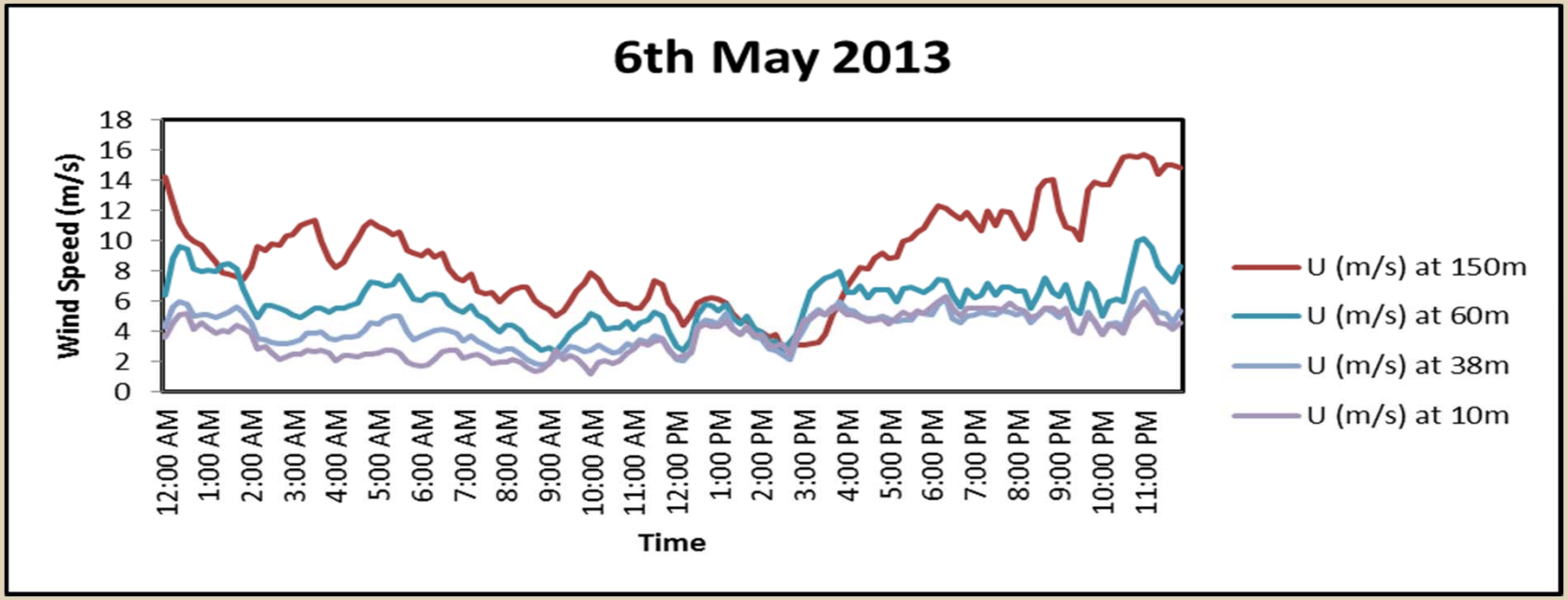
Wind Resources Management

Data on wind speed, direction, and shear were collected. The wind speed was measured by the LIDAR at 10 different heights. As an example, the data for May 6, 2013 are presented below. In the figure, data for only 4 heights, 10m, 38m, 60m, and 150m.



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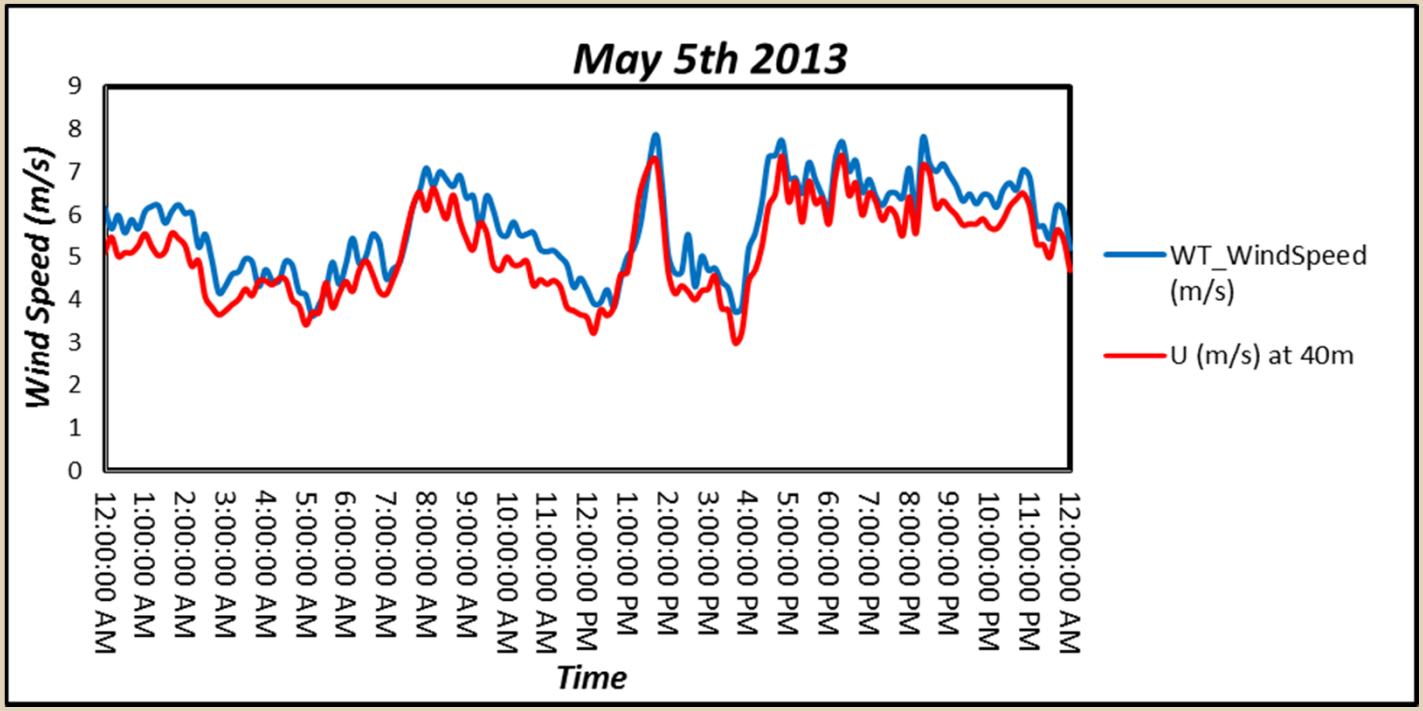
Wind Resources Management

To assess the accuracy of the use of wind turbine hub wind measurement as a means of representing **wind speed** for characterizing turbine power, the wind speed recorded by the Woodlands School wind turbine ***anemometer*** were accessed and compared with the LIDAR data. An example is shown below.



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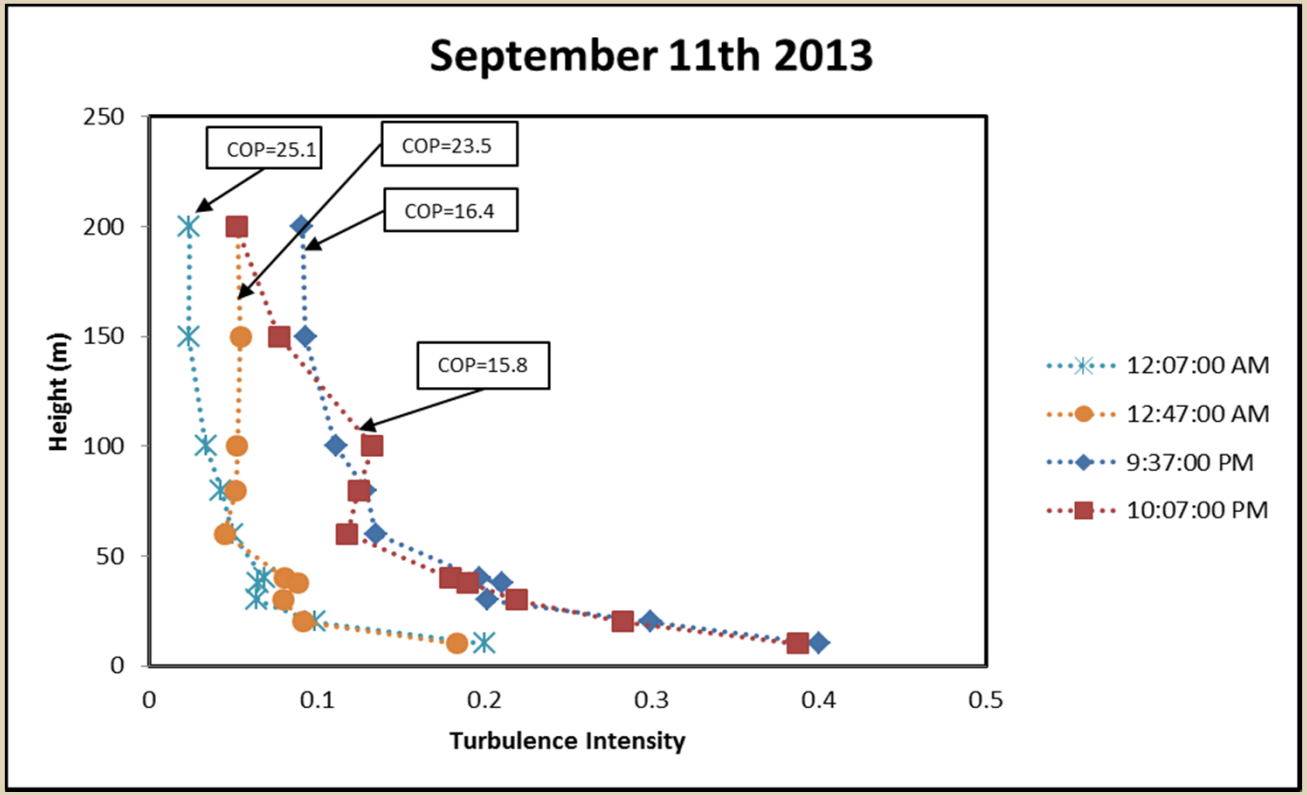
Wind Resources Management

Turbulence intensity was also measured at the site It is observed that ***turbulence intensity decrease with increasing height substantially***. The measurements over time document a quantitative estimate of this reduction.



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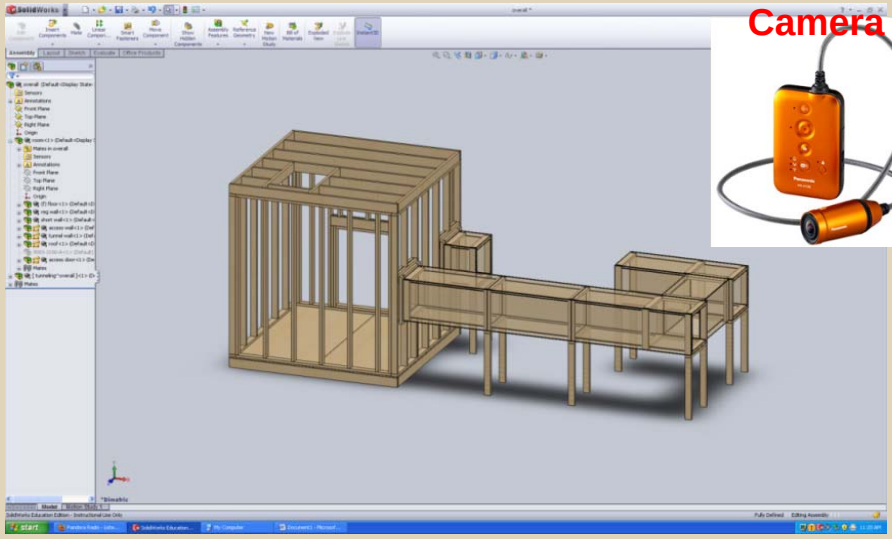
Icing and its Mitigation on WTG Systems

Icing Closed-Loop Research Tunnel Development

An icing research tunnel (IRT) was **designed** and **constructed** that enabled **consistent and repeatable ice accretion** conditions with ***variable wind speeds***, ***water droplet sizes***, and ***temperatures between*** approximately 0°C and -20°C.

The IRT's **cooling system** from **Parameter Generation and Control** (PGC) has the capacity to maintain -20 ±0.2°C using a 7500 BTU rated cooler that is powered by 230 volt, 3 phase 20 amp electric service.



Panasonic HX-A100D Camera

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Study of Passive Ice Mitigation Method

- Icing tests were conducted using an **airfoil section** and a cylindrical cylinder. Tests were conducted at ***several wind speeds up to 40 miles per hour*** in the tunnel's test section.
- Lift and drag forces on the test articles were measured as the ice accumulated on the airfoil. Also, photographs of the icing progression were taken to study how ice accreted on the test articles treated with various ice coatings.
- Coatings used in the tests were Boyd Coatings Research Company CRC6040R3, MicroPhase Coatings Inc. PhaseBreak TP, ESL and Flex coatings.

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Findings of Passive Ice

An ***icing research tunnel*** was developed and used to evaluate several commercially available coatings for potential application wind turbines to mitigate ice formation on these structures. The tests were conducted ***at different wind speeds up to 40 miles per hour***.

It was observed that ice formed on the wind turbine and tower structures **regardless of the coatings** used within minutes. Ice began to form on the leading edge of the airfoil section and accumulated with time. Liquid droplets continued to shed from the middle section of the airfoil during the tests.

Findings of Passive Ice

When comparing ***ice accumulation and adhesion characteristics*** for the four coatings tested, ***for ice thickness*** during accumulation, the ***airfoil treated with CRC6040R3 had the least***, followed by the ESL, Flex, and TP, respectively. However, when comparing the ***coatings by ability to reduce ice adhesion***, the ***Flex showed the highest reduction***, followed by the ESL, TP and CRC 6040R3 coatings.

The ***ice accumulated on the Flex coated surface shed under gravity*** when rotated 90 degrees following the tests while the other coatings required application of varying degrees of force to remove the ice. Therefore, ice coatings were not sufficient in preventing ice accumulation. However, Flex coating shows promise. For rotating blades, there exist centrifugal forces that may help shed the ice. Additional tests should be conducted on rotating blades in the icing tunnel to substantiate whether this coating will be an effective passive means of ice mitigation on wind turbine blades.

WTG's Engineering Findings

1.The **two blade rotor configuration potentially costs 20% less** than a three blade configuration that produces the same power at the same site.

1.The *foundation design for a wind turbine* in Lake Erie ***will be driven by ice loads*** based on the currently available ice data and ice mechanics models. Hence, for Lake Eire, the cost savings will be somewhat smaller than the other lakes in the Great Lakes.

1.Considering the size of cranes and vessels currently available in the Great Lakes, the cost ***optimal wind turbine size will be 3 MW***, not larger.

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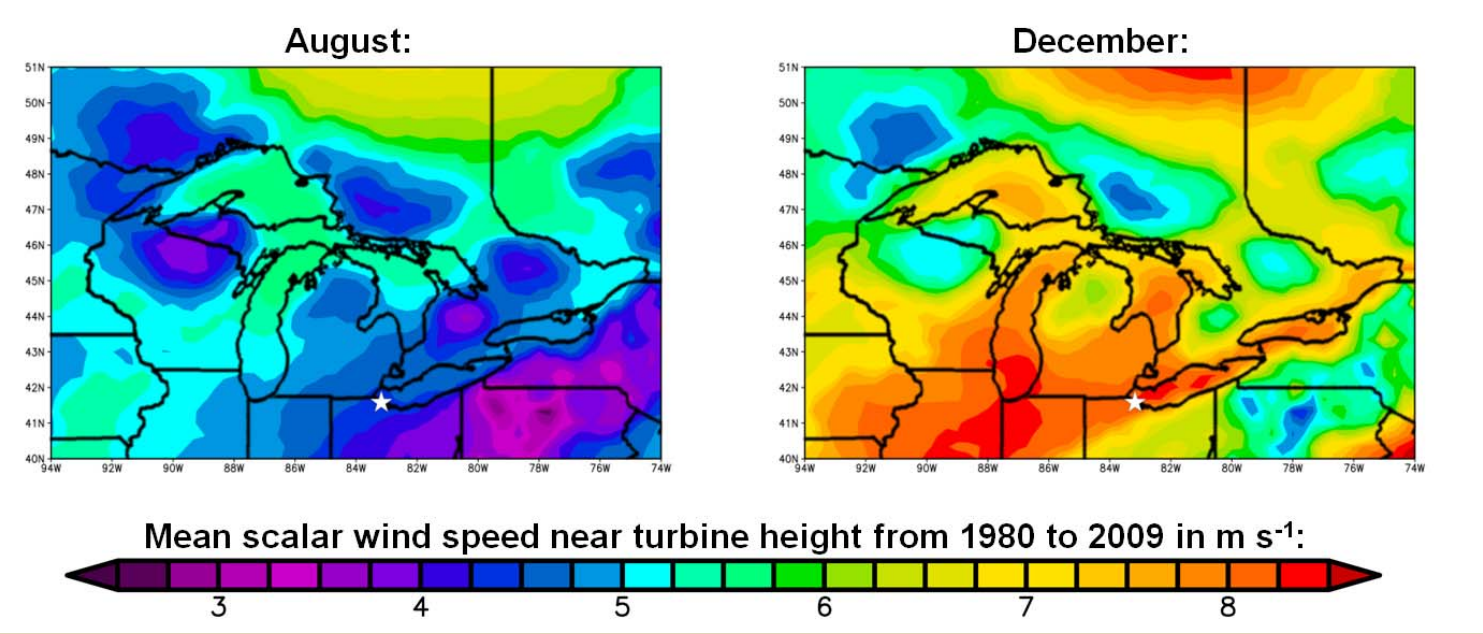
Geospatial Data

Design and implement a ***geodatabase*** structure in support of offshore wind turbine development by identifying, collecting, and rectifying existing pertinent data (lake bottom conditions, lake bottom engineering parameters, extent of ice, ice flow motion/directions, lake condition sensors, navigation pathways)

Geospatial Data

We processed several sources of wind data for the area with ***temporal resolutions as fine as 10-minute intervals***. The figure below shows one of these sources, the National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis, for the month which typically has the weakest winds at our study site (August), and the month which typically has the strongest winds at our study site (December).



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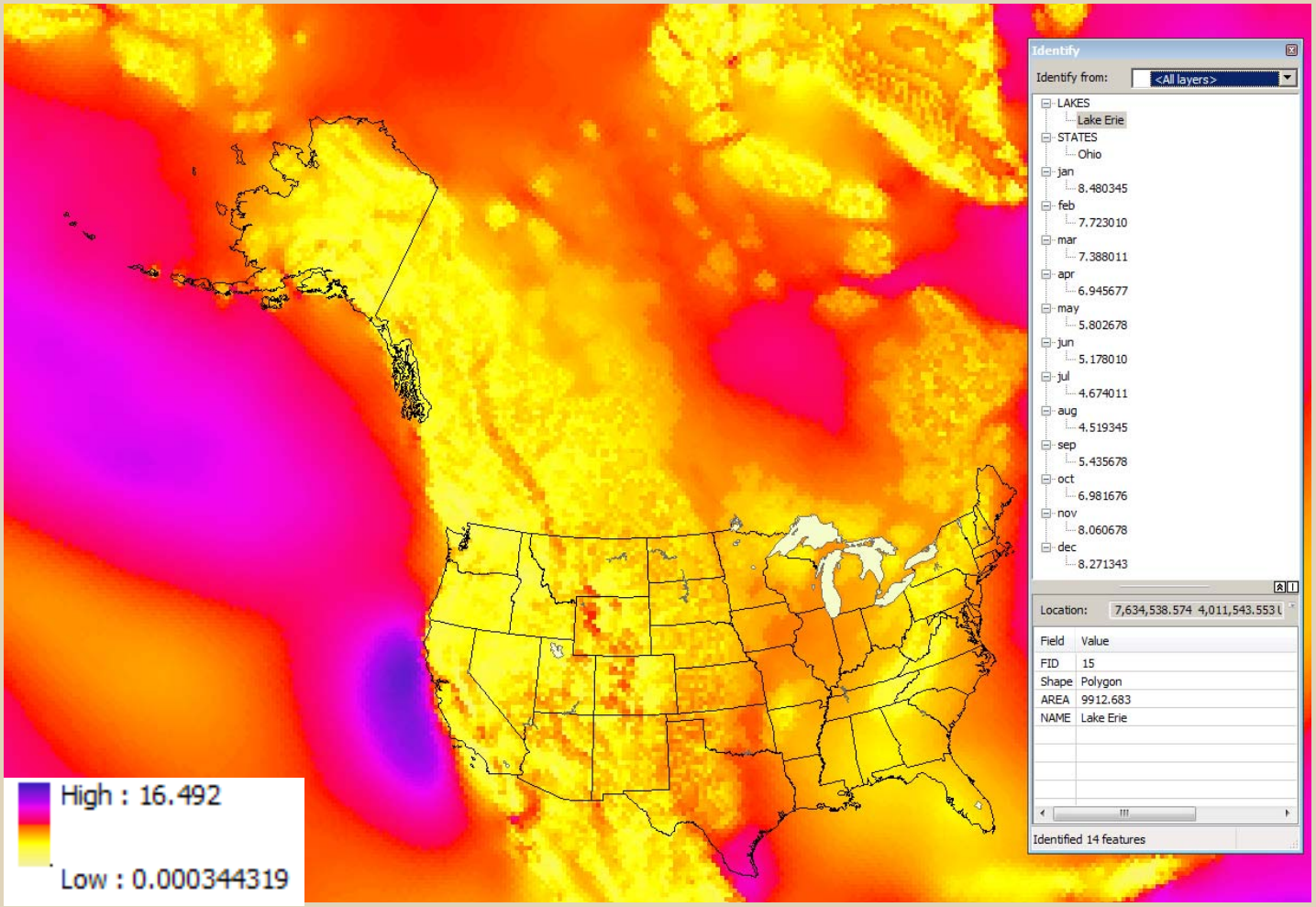
Geospatial Data



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Group-Based Spatial Decision Support System

Energy Policy 55 (2013) 374–385

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

A group-based spatial decision support system for wind farm site selection in Northwest Ohio

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Enrique Gomezdelcampo [e]

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[b] Department of Geology, Bowling Green State U
[c] Electrical Engineering & Computer Science, Uni
[d] Center for Regional Development & School of
[e] Department of Geology & Department of the E

HIGHLIGHTS

- We present a prototype tool that we d
- Multiple participants rank the factors
- The factors are aggregated by WLC tec
- Group-based solution uses Borda meth
- Sensitivity analysis is performed on th

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Wind farm siting
Borda method

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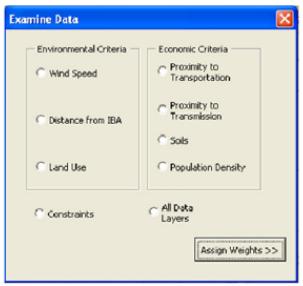

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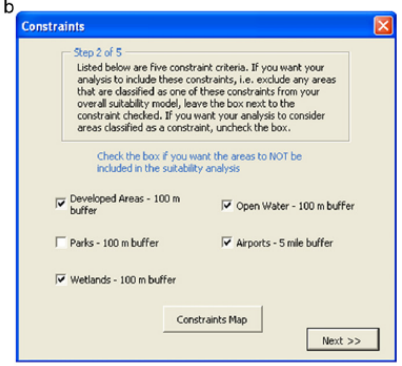

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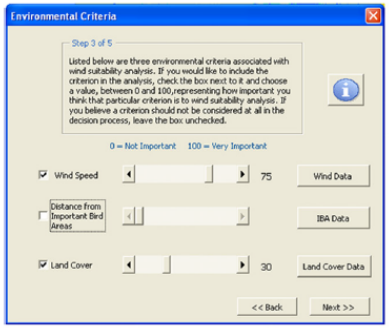

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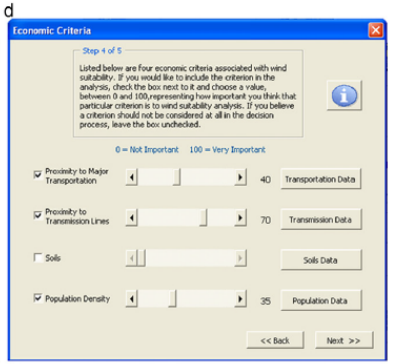

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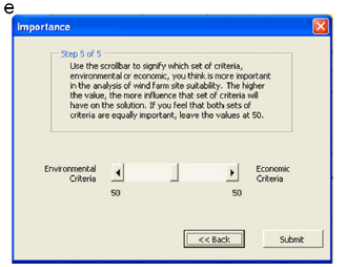

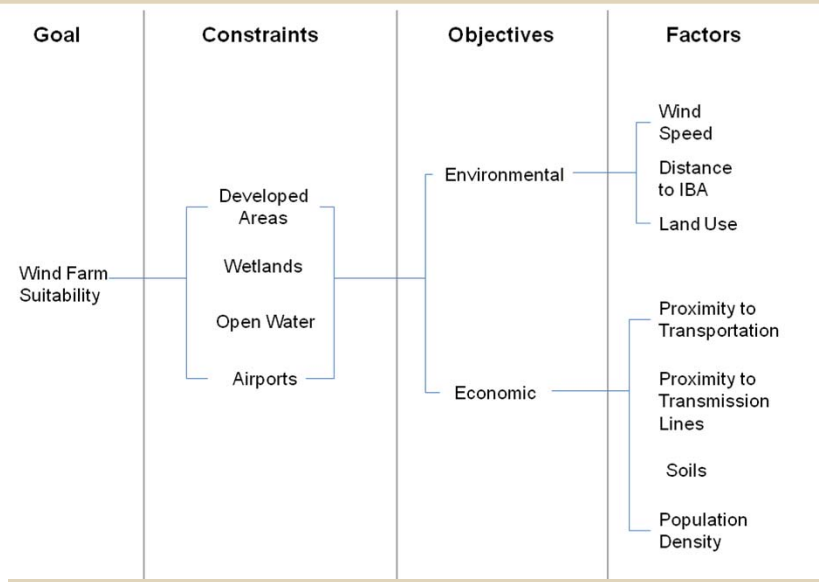

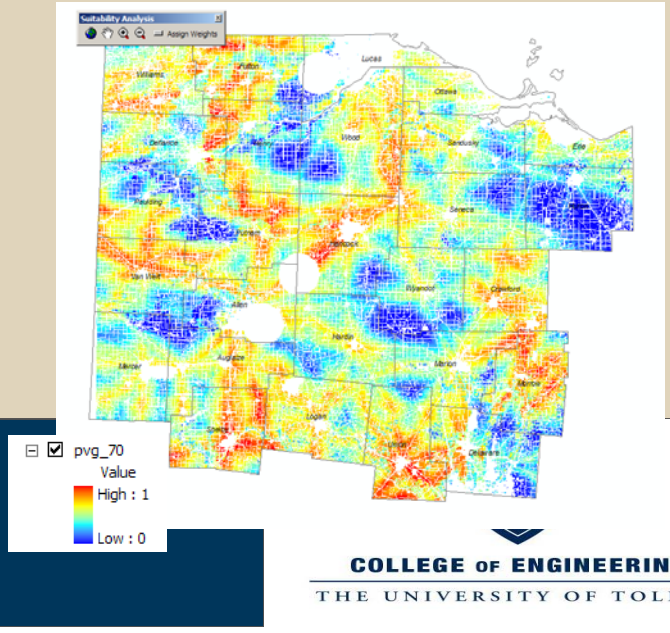

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Web-Based Participatory GIS

Renewable and Sustainable Energy Reviews 41 (2015) 162–177

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A web-based participatory GIS (PGIS) for offshore wind farm suitability within Lake Erie, Ohio

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Multiple criteria evaluation

ABSTRACT

This study presents the design and implementation of a web-based Participatory Geographic Information System (PGIS) framework intended for offshore wind suitability analysis. The PGIS prototype presented here integrates GIS and decision-making tools that are intended to involve different stakeholders and the public for solving complex planning problems and building consensus. Public involvement from the early planning stage of projects with a spatial nature is very important for future legitimacy and acceptance of these projects. Therefore, developing and executing a system that facilitates effective public involvement for resolving contentious issues can help in fostering long-lasting agreements. The prototype here is a distributed and asynchronous PGIS that combines a discussion forum, a mapping tool and a decision tool. The potential strengths and benefits of this PGIS are demonstrated in a hypothetical case study in Lake Erie, northern Ohio. In the hypothetical case study, participants evaluate the importance of three decision alternatives using different evaluation criteria for expressing their individual preferences. The individual preferences are aggregated by Borda Count (BC) method for generating the group solution, which is used for synthesizing the different evaluation aspects such as the importance of criteria, ranking of the decision alternatives and planning issues related to environmental and socio-economic concerns from the participants.

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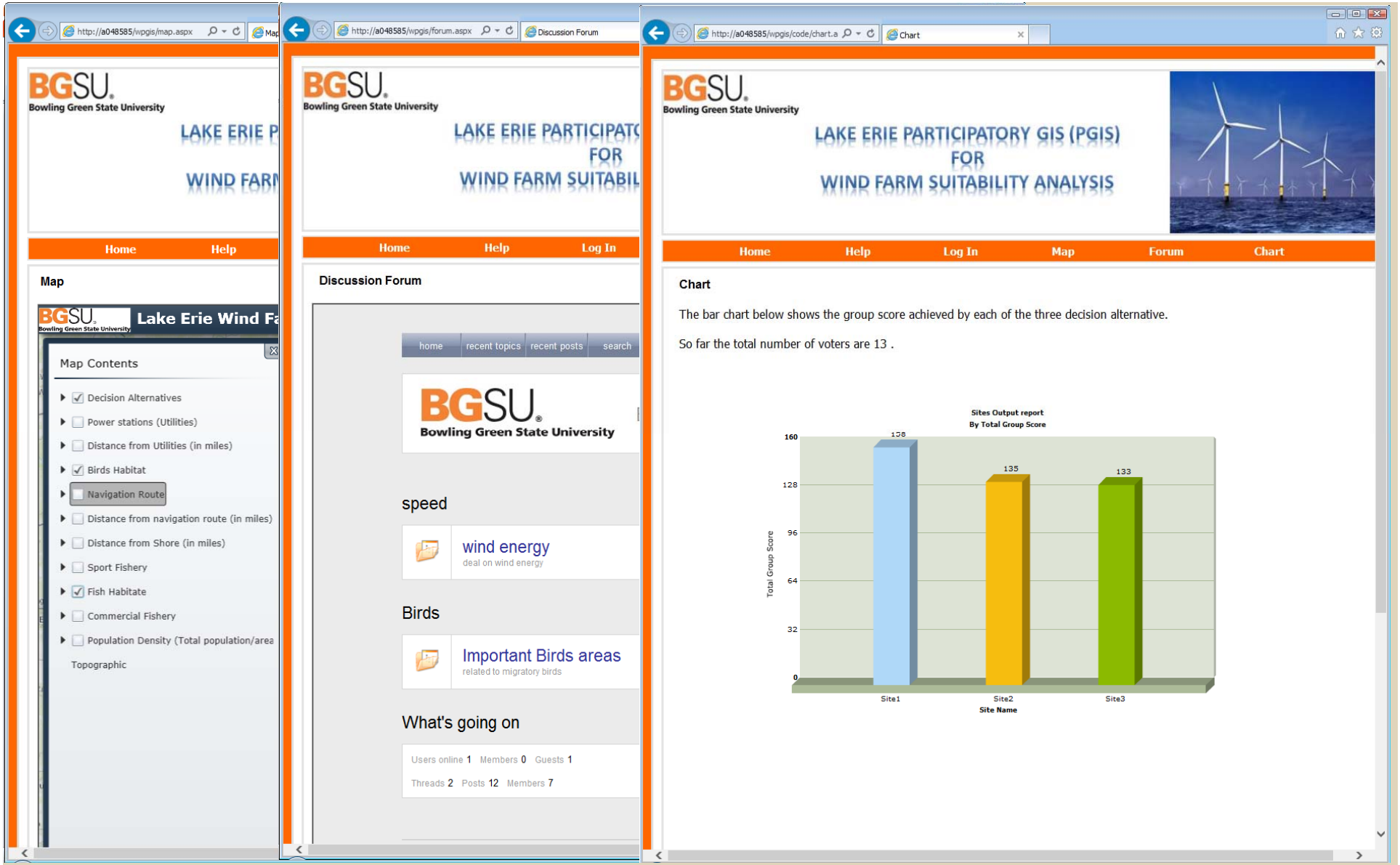

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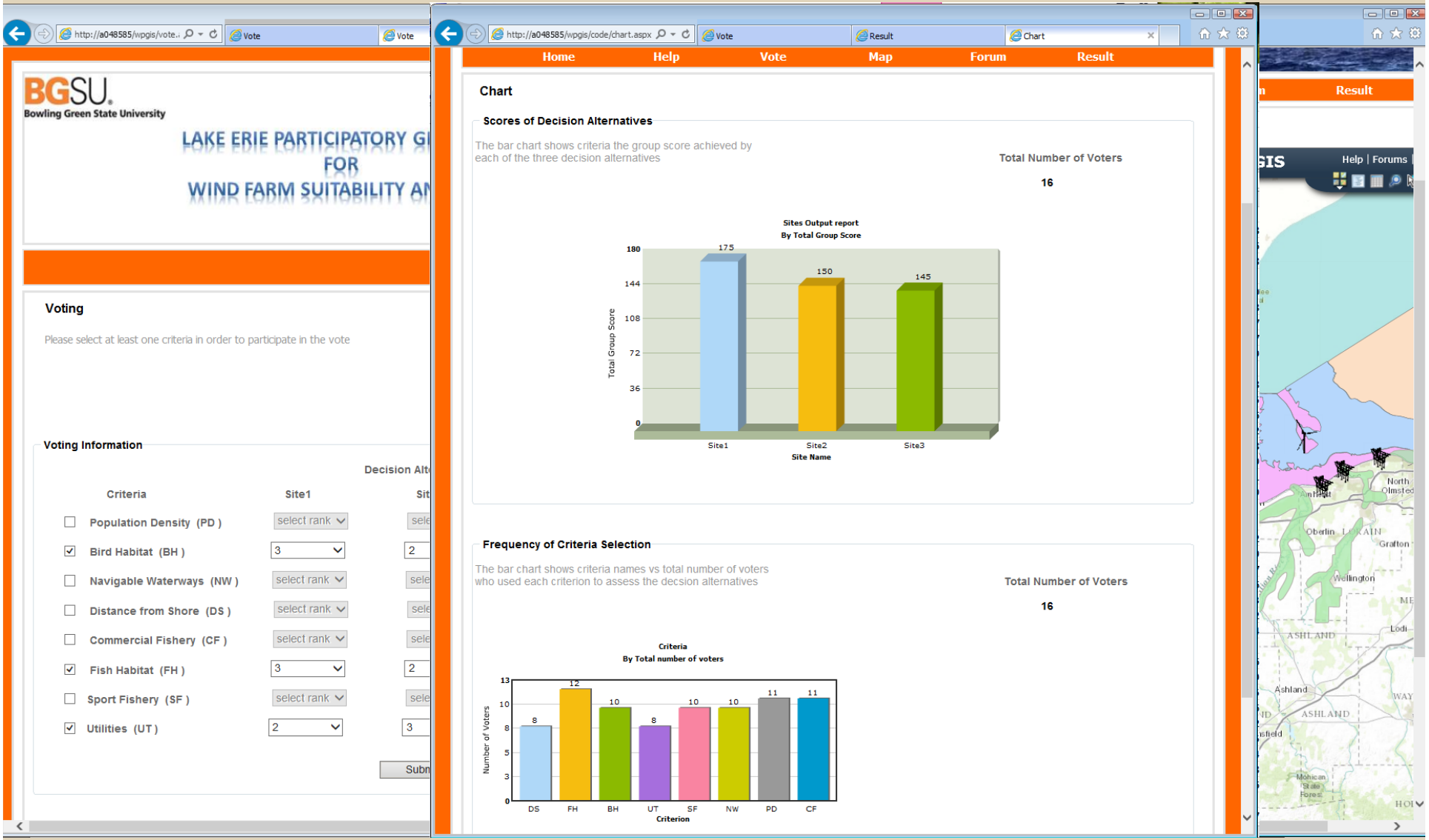

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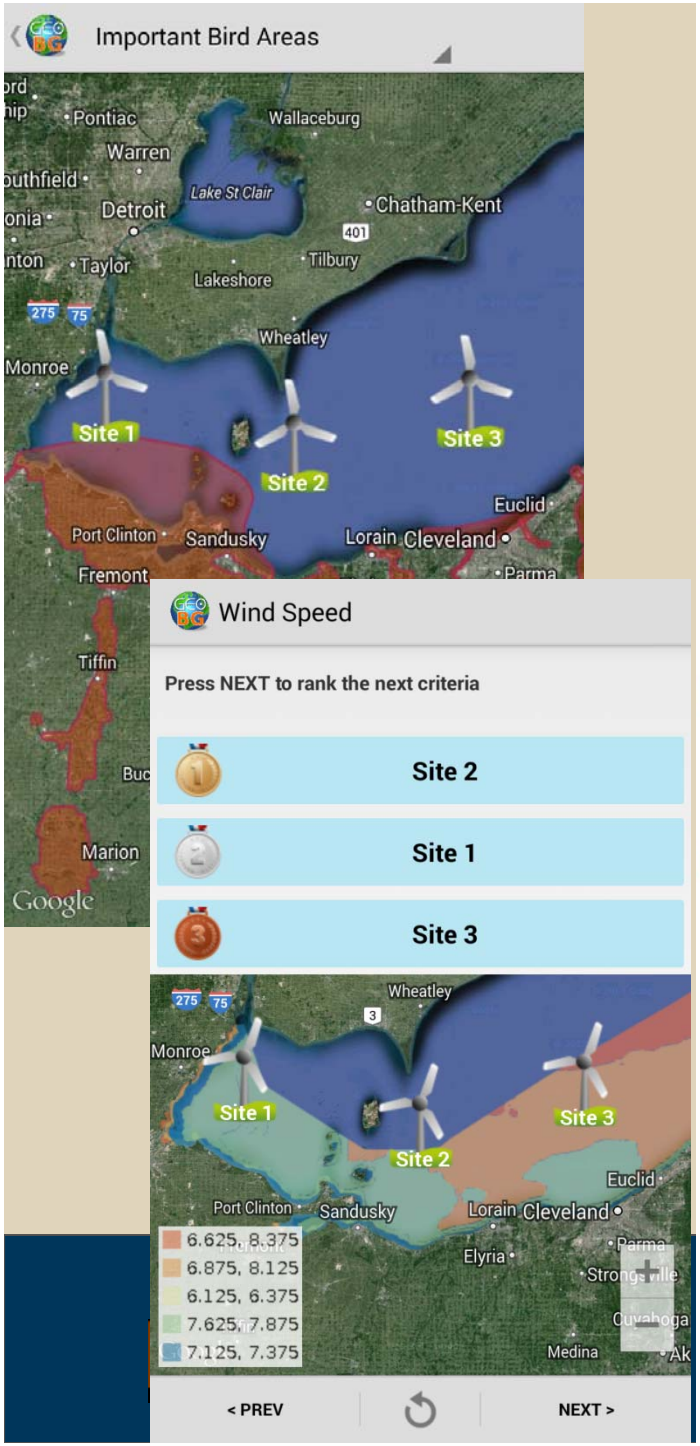
Important Bird Areas
Pontiac
Wallaceburg
Warren
Lake St Clair
Detroit
Chatham-Kent
401
Taylor
Tilbury
Lakeshore
Wheatley
Monroe
Site 1
Site 2
Site 3
Euclid
Port Clinton
Sandusky
Lorain
Cleveland
Fremont
Parma
Tiffin
Marion
Google
Wind Speed
Press NEXT to rank the next criteria
Site 2
Site 1
Site 3
Elyria
Medina
6.625, 8.375
6.875, 8.125
6.125, 6.375
7.625, 7.875
7.125, 7.375
< PREV
NEXT >

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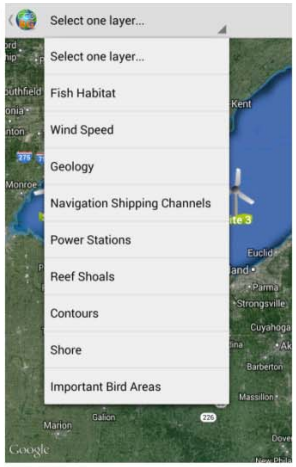
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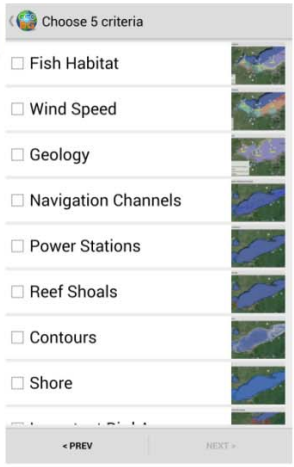
Select one layer...
Fish Habitat
Wind Speed
Geology
Navigation Shipping Channels
Power Stations
Reef Shoals
Contours
Shore
Important Bird Areas

c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Fish Habitat
Wind Speed
Geology
Navigation Channels
Power Stations
Reef Shoals
Contours
Shore
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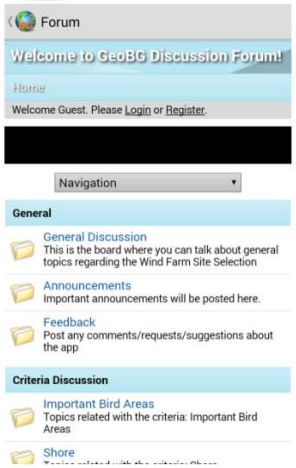
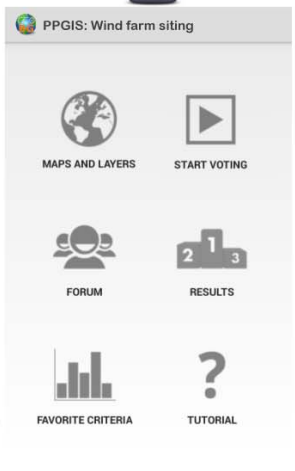
NEXT >

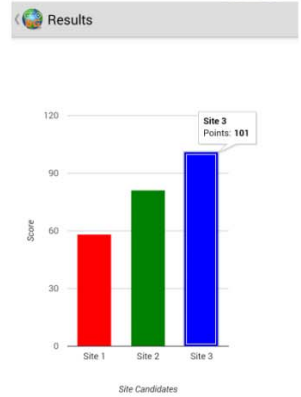
d


Forum
Welcome to GeoBG Discussion Forum!
Home
Welcome Guest. Please Login or Register.
Navigation
General
General Discussion
This is the board where you can talk about general topics regarding the Wind Farm Site Selection
Announcements
Important announcements will be posted here.
Feedback
Post any comments/requests/suggestions about the app
Criteria Discussion
Important Bird Areas
Topics related with the criteria: Important Bird Areas
Shore

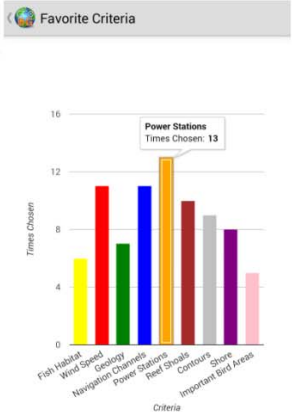
a


PPGIS: Wind farm siting
MAPS AND LAYERS
START VOTING
FORUM
RESULTS
FAVORITE CRITERIA
TUTORIAL

e


Results
Site 3
Points: 101
120
90
60
30
0
Score
Site 1
Site 2
Site 3
Site Candidates

f


Favorite Criteria
Power Stations
Times Chosen: 13
16
12
8
4
0
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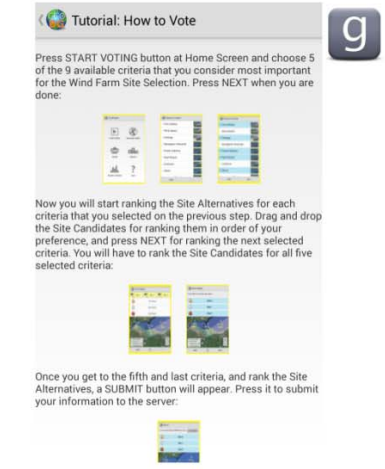
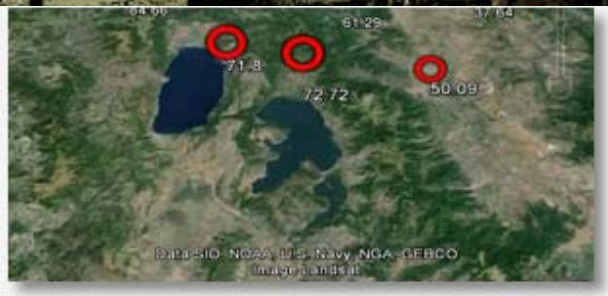
Fish Habitat
Wind Speed
Geology
Navigation Channels
Power Stations
Reef Shoals
Contours
Shore
Important Bird Areas
Criteria

g

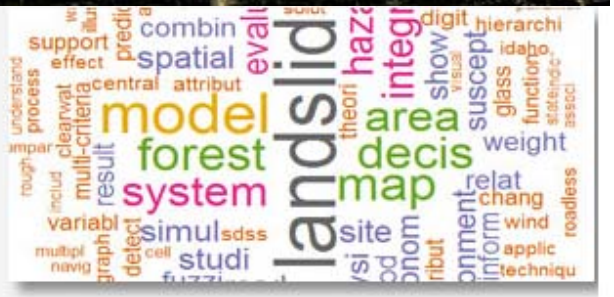

Tutorial: How to Vote
Press START VOTING button at Home Screen and choose 5 of the 9 available criteria that you consider most important for the Wind Farm Site Selection. Press NEXT when you are done:
Now you will start ranking the Site Alternatives for each criteria that you selected on the previous step. Drag and drop the Site Candidates for ranking them in order of your preference, and press NEXT for ranking the next selected criteria. You will have to rank the Site Candidates for all five selected criteria:
Once you get to the fifth and last criteria, and rank the Site Alternatives, a SUBMIT button will appear. Press it to submit your information to the server:

Questions????

Relationship between Leaf Area Index (LAI) estimated by terrestrial LiDAR and ...



Realtime geospatial computations and presentation using R



Latest research

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