Oregon State University
School of Mechanical, Industrial & Manufacturing Engineering

Heterogeneous Sensor Fusion for Autonomous Detection of Wildlife Collisions with Wind Turbines

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Outline

- Motivations
- Blade strikes impact birds / bats
- Current solution for event detection
- Proposed solution for event detection
- Future solution for event detection
- Conclusions
- Acknowledgements

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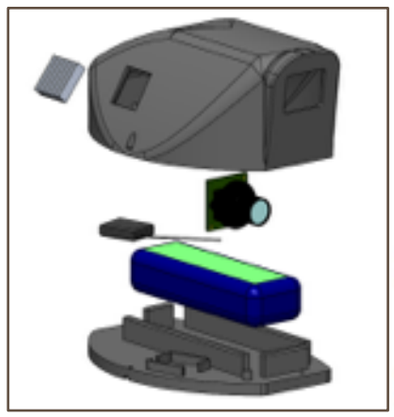
Conclusions

- A system for detection of blade strike with images capture for species recognition was developed to TRL 6
- The system's operation is automatic and can be installed on any wind turbine (new or retrofit)
- Sensors on all blades have detected an impact on one single blade
- A new system, **fully blade mounted**, is at conceptual design stage with improved sensors fusion, communication and post processing
- With specific post processing the system could be used for blade health monitoring

Motivations

- Blade strikes on birds and bats a HARD reality
- Blade strikes could be avoided or limited using detection and deterrent methods
- Such methods NEED to be validated and/or certified
- Automated strike detection and species recognition
  - **More efficient** than current methods on land
  - **Necessary** offshore



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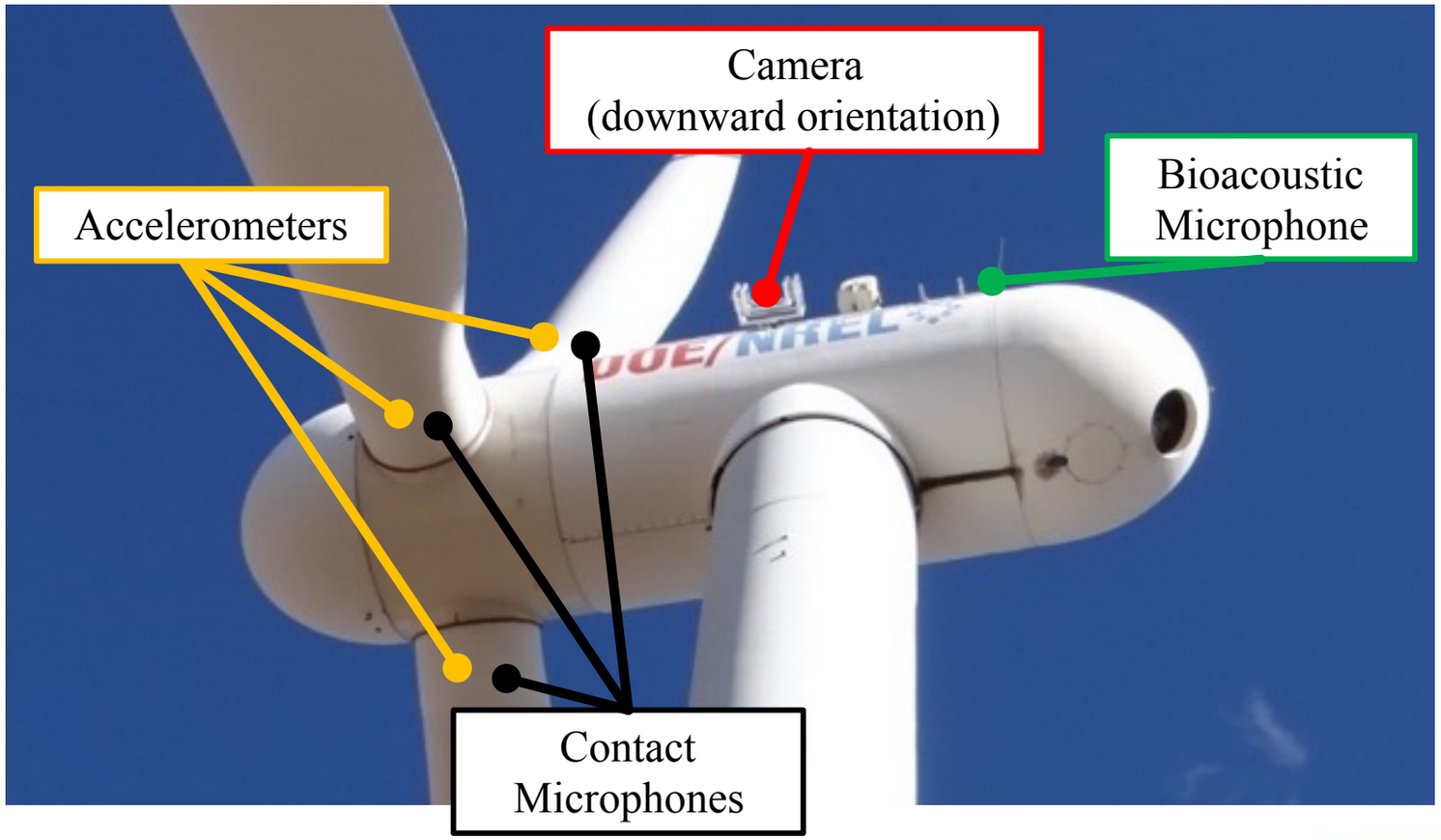
Current System

- General description
  - Event-based recording of video data
  - Central data processing on PC in turbine nacelle
  - Selected number of frames before and after event
  - Research funded by US DoE Golden Office



Suryan, R., Albertani, R., Polagye, A Synchronized Sensor Array for Remote Monitoring of Avian and Bat Interactions with Offshore Renewable Energy Facilities. Final report to the Department of Energy for project DE-EE0005363.

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Synchronized Sensors

- Three nodes controlled by central computer
- Real time vibrations processing for event detection
- Ring buffer with data from all sensor nodes

Vibration Node
Accelerometers & Contact Microphones

Optical Node
Stereo Infrared & Visual Spectrum Cameras

Bioacoustics Node
Acoustic and Ultrasonic Microphones

Central Processing
Onboard Turbine

Remote Transmission of "Event" Data

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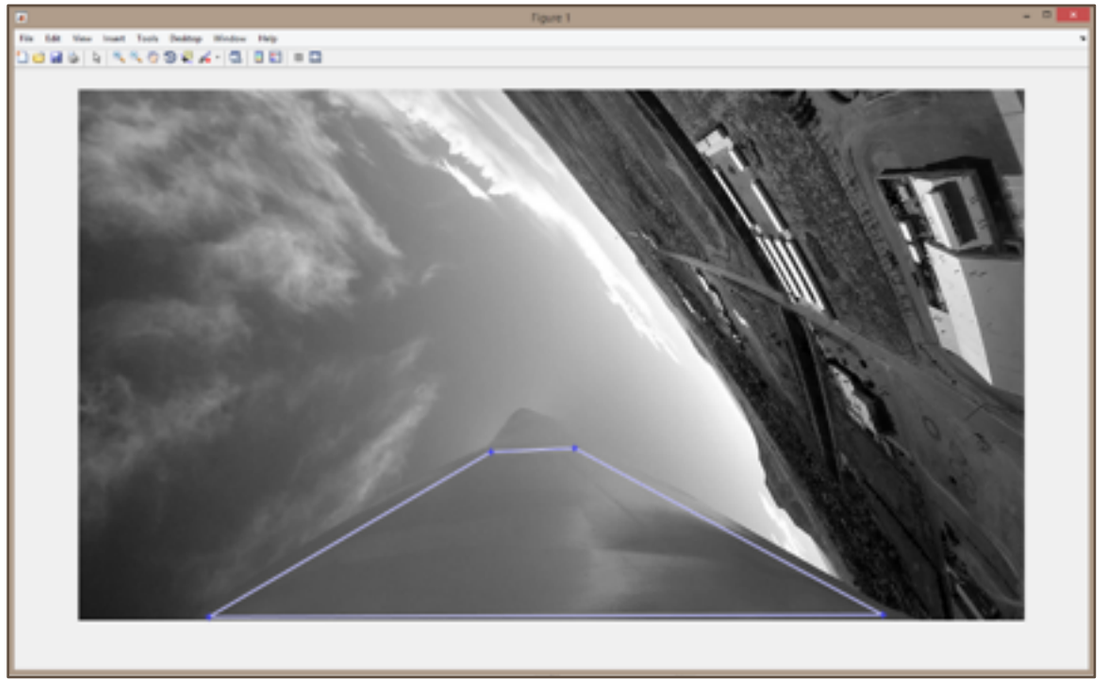
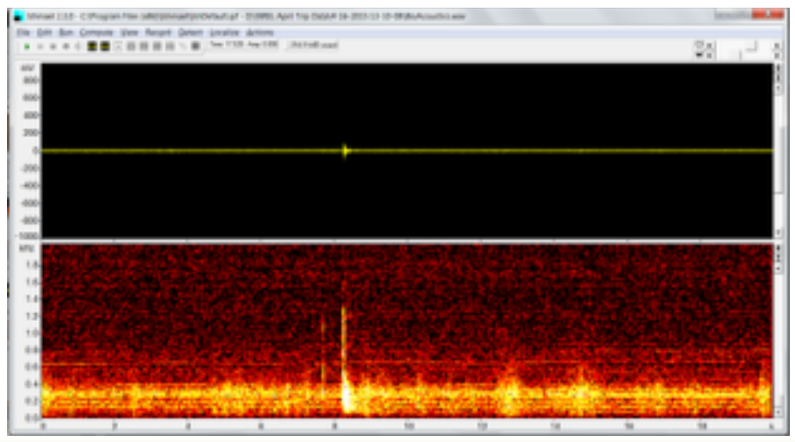
Acoustic Node and Imaging

- Microphone on nacelle for blade impact detection
- Camera on blade for best target identification

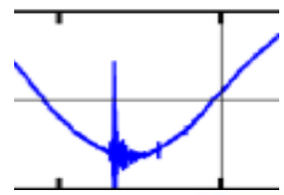


Cart 3 Idle Operation

microphone OUTSIDE nacelle with impact



Accelerometer



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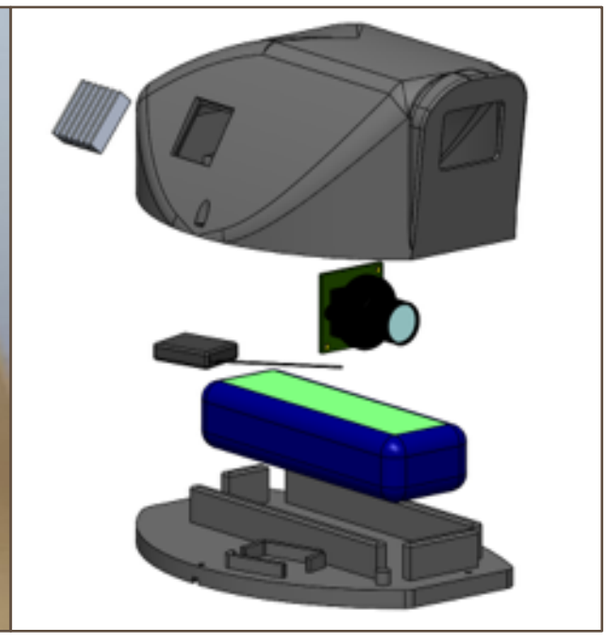
Blade Unit

- Camera, vibration and acoustic nodes
- 3D printed weatherproof case
- Location at blade root

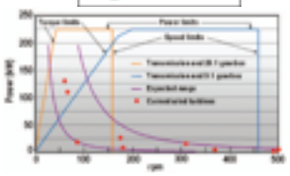


System Field Tests

- Tennis balls launched and hit by turbine blades
- Events detected and recorded by sensors

North American Wind Research and Training Center
Tucumcari, NM

National Wind Technology Center
Golden, CO



9 Flowers, J., Albertani, R., Polagye, B., Suryan, R, Harrison, T., "Remote Monitoring of Avian and Bat Interactions with Offshore Wind Energy Facilities," 2nd Annual Marine Energy Technology Symposium (METS), Seattle, WA, April 15-17, 2014.

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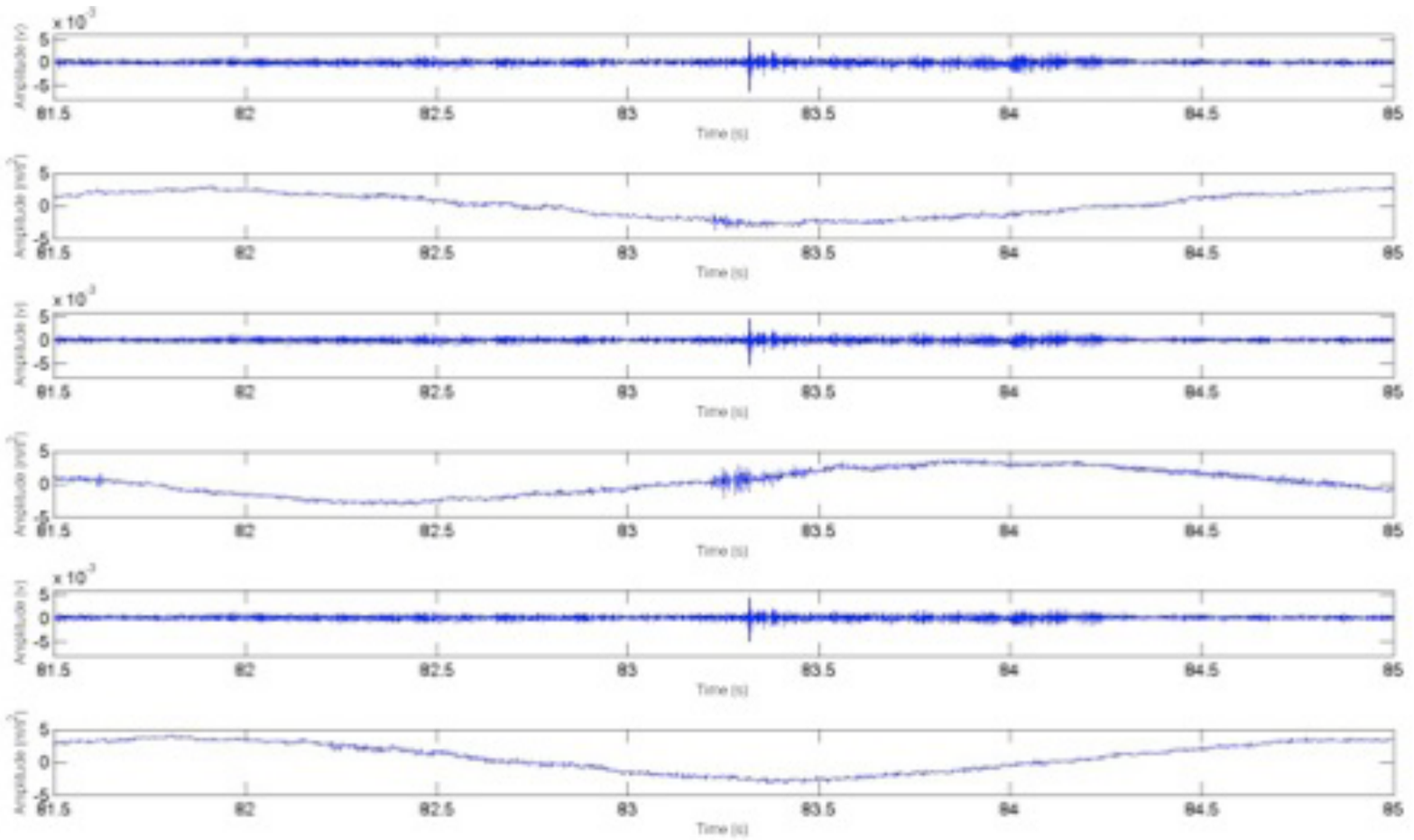
Experimental Results: Vibration Node

- Background noise and ONE blade hits tennis ball (57 g)
- Microphone detect impact from all three blades



Accelerometers & Contact Microphones – 3 blades

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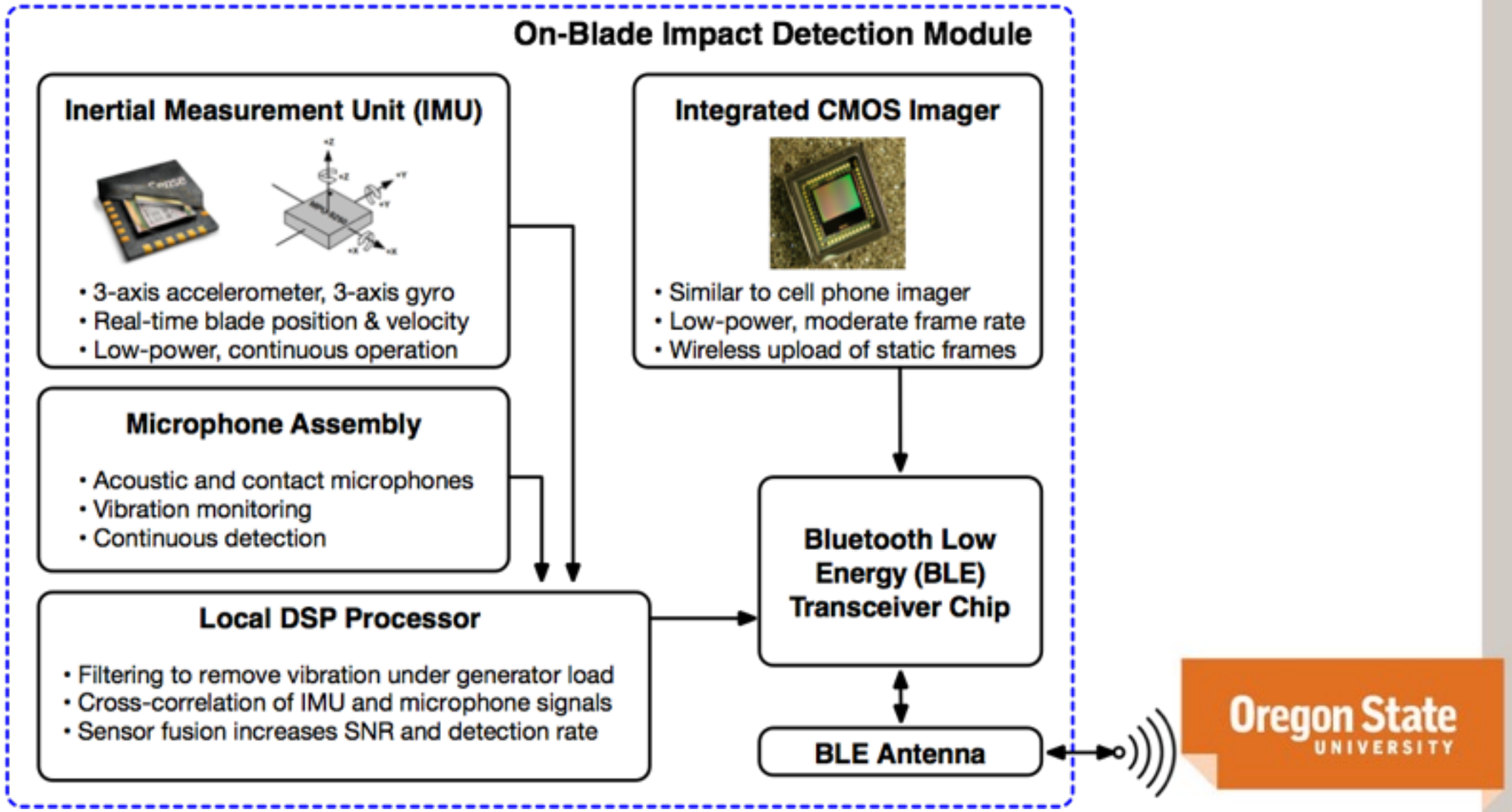
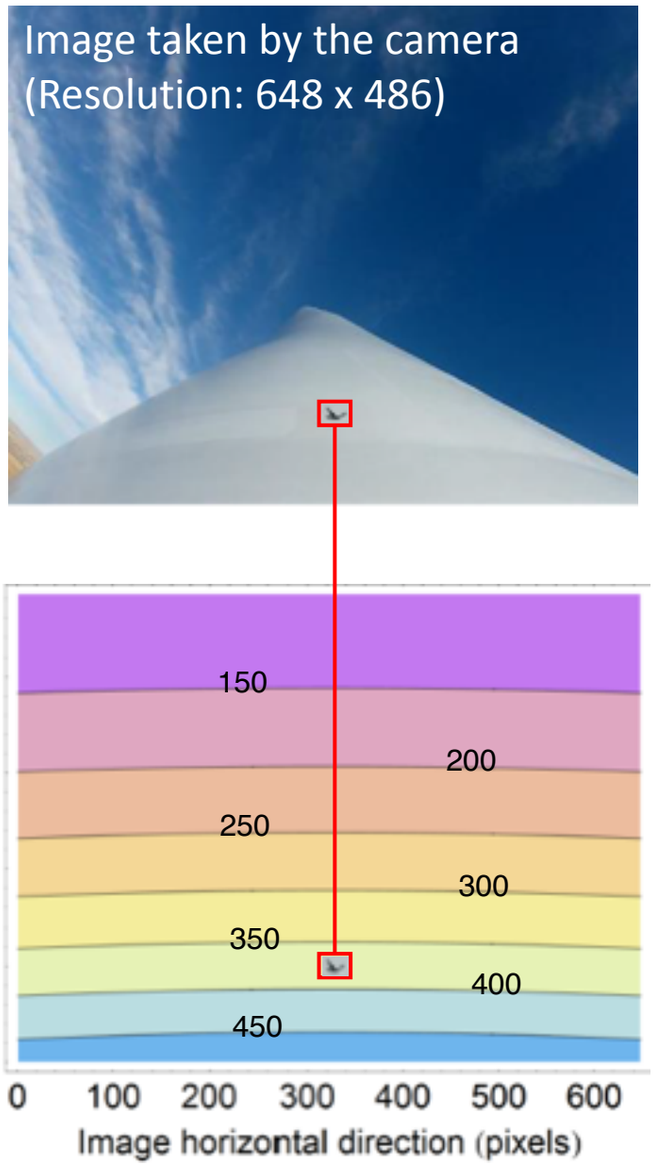
New System: Multi-sensor Module

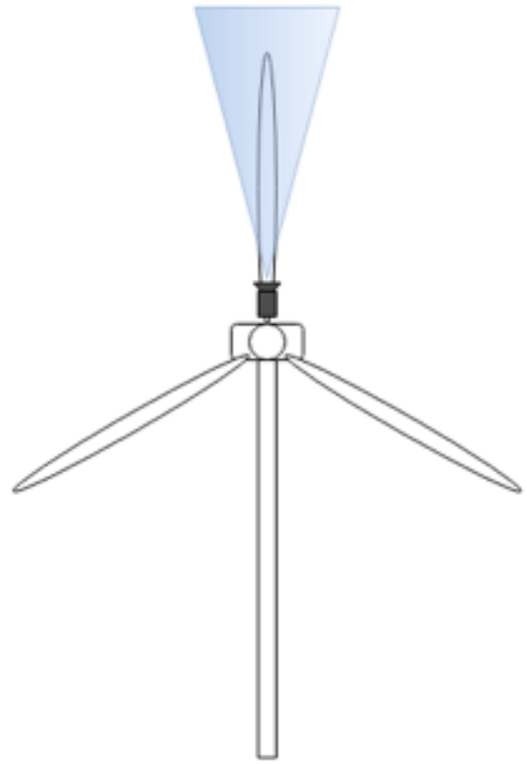
- Integrated IMU for position and blade velocity
- On-board signal processing and real-time event detection
- Cross-correlation of sensor signals removes noise and improves SNR
- **Sensor fusion to decrease missed detection rate and false alarm rate**



Pixel Density Estimation

- Image: 648 x 486 pixels ; target size: 10 x 10 cm
- Number of pixels on target approximately 325 (from plot)





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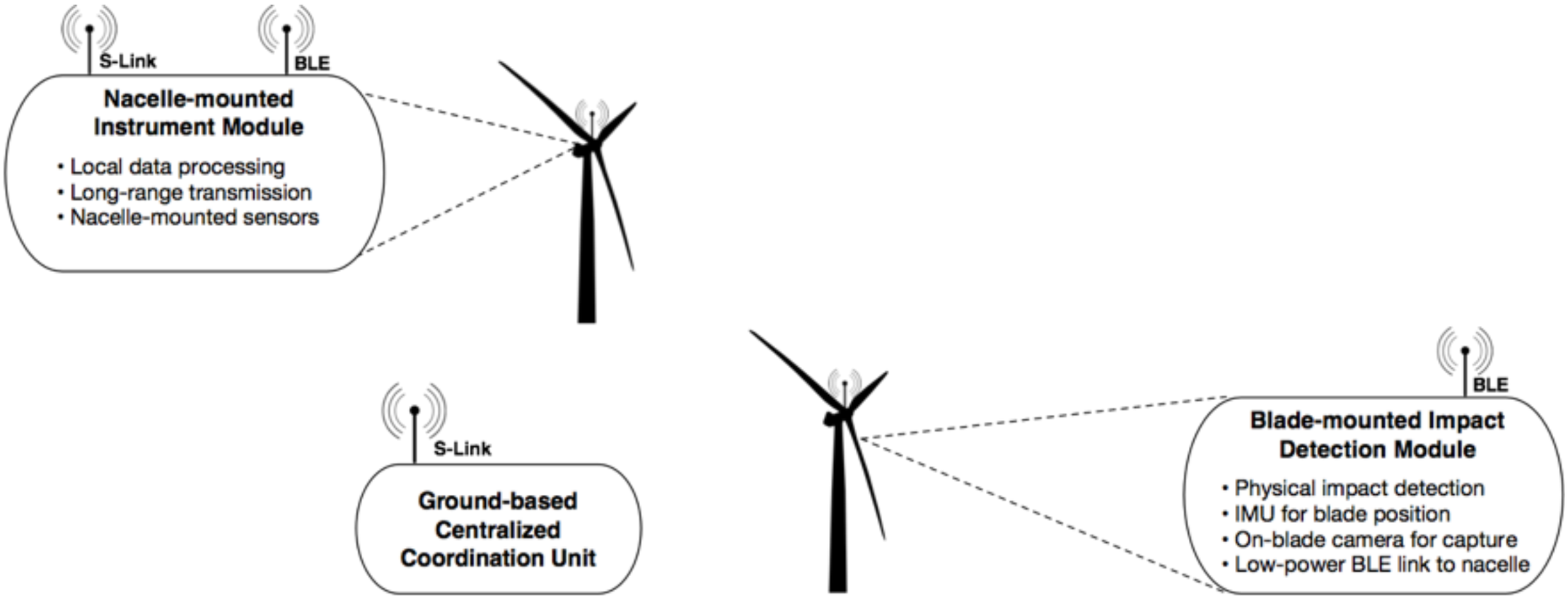
New System: Wireless Network Topology



- Bluetooth low energy (BLE) for short range communication provide maximum battery life for on-blade module
- Nacelle-mounted module acts as range extender, communicating with ground-based computer over long-range RF wireless channel (Symphony Link @ 915 MHz ISM band)

Conclusions

- A system for detection of blade strike with images capture for species recognition was developed to TRL 6
- The system's operation is automatic and can be installed on any wind turbine (new or retrofit)
- Sensors on all blades have detected an impact on one single blade
- A new system, **fully blade mounted**, is at conceptual design stage with improved sensors fusion, communication and post processing
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- National Renewable Energy Laboratory (NREL)

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- US Department of Energy
- Oregon State University
- University of Washington

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• Floating Power, Inc.
• Principal Power, Inc.
• CCAP – Coastal Energy Project
• NREL, National Wind Technology Center
• Bat Conservation International

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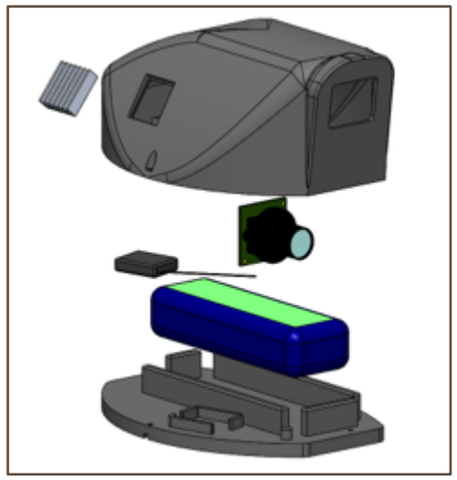

Questions ?

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