Remote Monitoring of Birds and Bats with Visual and Infrared Stereo Imagery

Trevor Harrison

Department of Mechanical Engineering
University of Washington
Northwest National Marine Renewable Energy Center

Dr. Brian Polagye

Co-Director
Northwest National Marine Renewable Energy Center
Department of Mechanical Engineering
University of Washington

Dr. Robert Suryan

Oregon State University
Northwest National Marine Renewable Energy Center
Department of Biology

Motivation: Offshore Wind

Carcass counts?

Observer…

So how?

Detection Methods

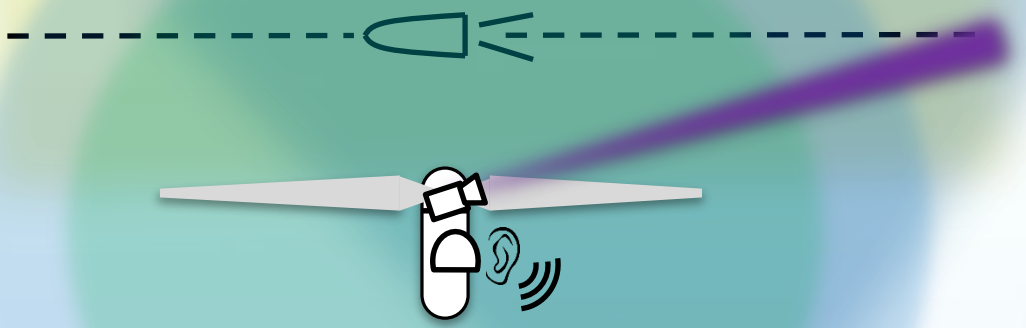
Transects

Tracking

Acoustic

RADAR

Optical

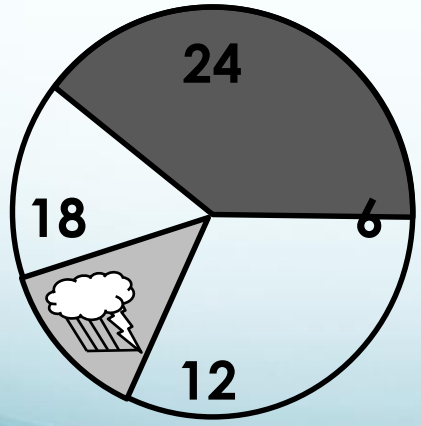


Evaluating near-field optical systems

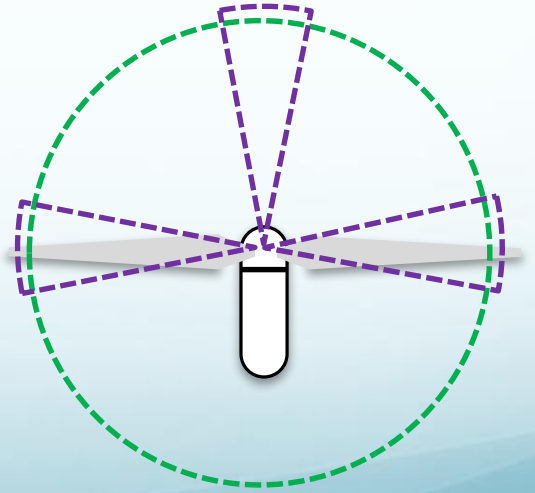
	Temporal Availability	Spatial Coverage
Visual	~	?
Thermal	+	?

Availability

Temporal availability



Spatial coverage



Evaluating near-field optical systems

	Temporal Availability	Spatial Coverage	Cost	Computation Demand	Hardware
Visual	~	?	$	?	~
Thermal	+	?	$$$	?	~

Practicality

Computation Demand

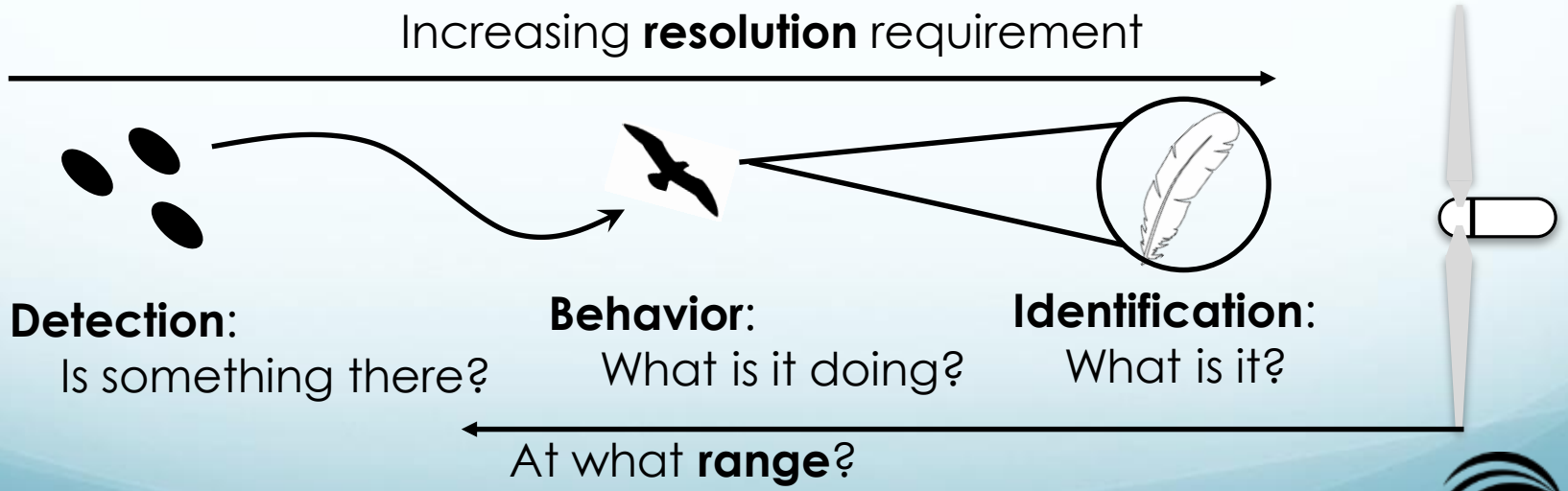
Storage

Processing

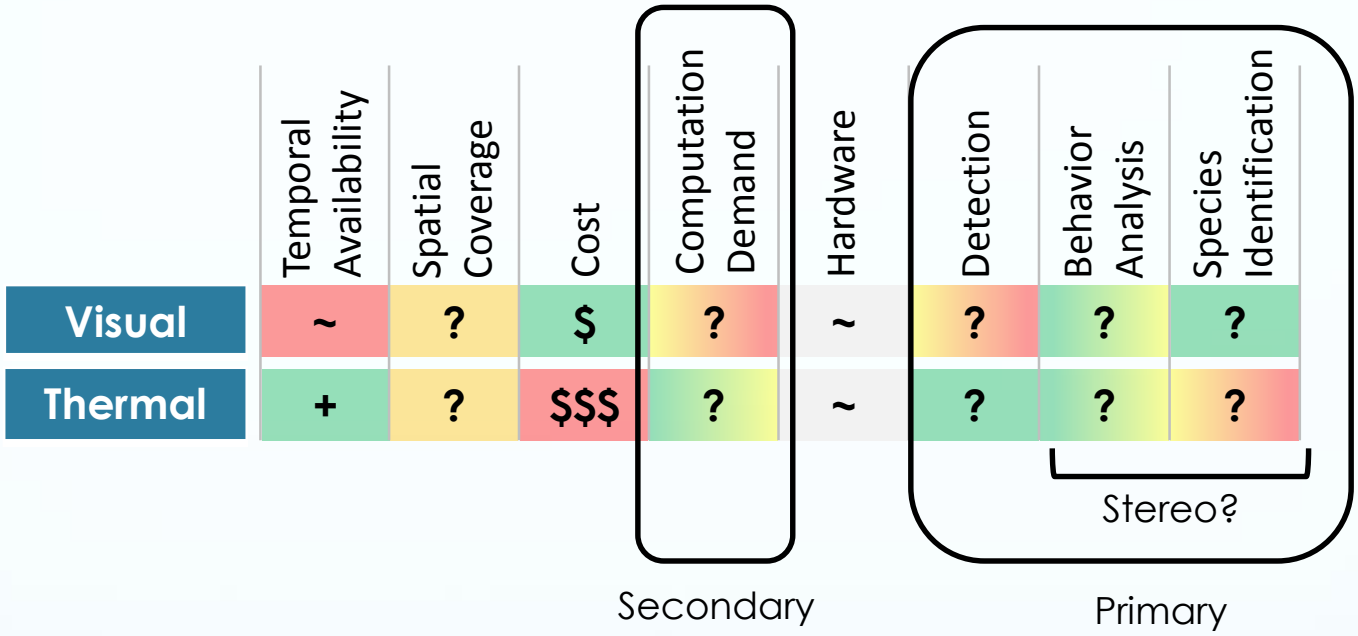
Evaluating near-field optical systems

	Temporal Availability	Spatial Coverage	Cost	Computation Demand	Hardware	Detection	Behavior Analysis	Species Identification
Visual	~	?	$	?	~	?	?	?
Thermal	+	?	$$$	?	~	?	?	?

Effectiveness



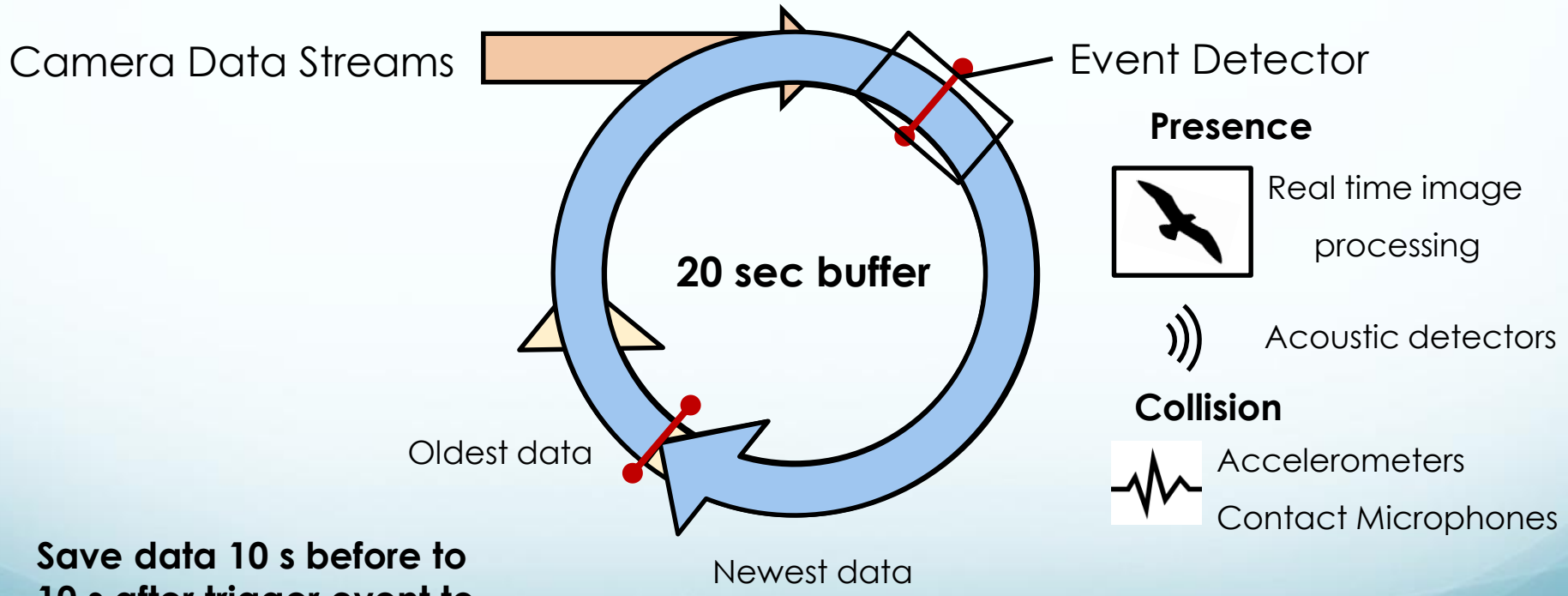
Evaluating near-field optical systems



Improving Computational Demand

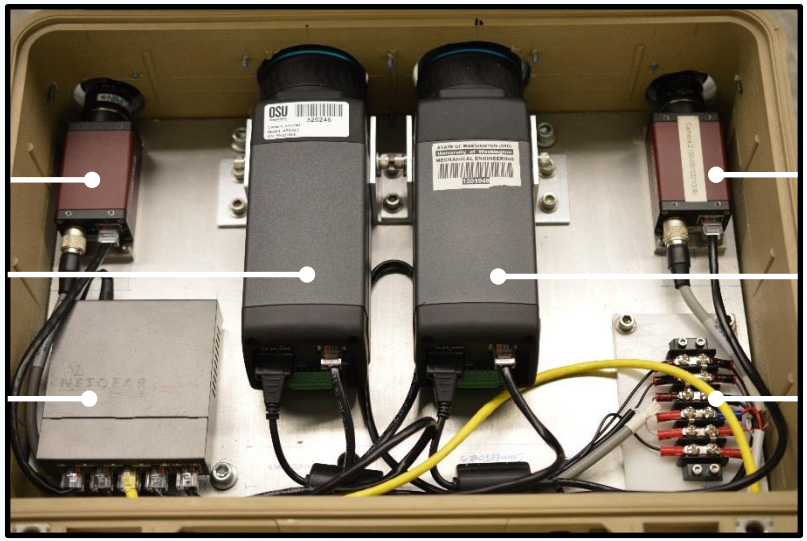
Problem: Continuous stereo IR + visual generates **20 TB Data/day**

Solution: Event based trigger of data recording

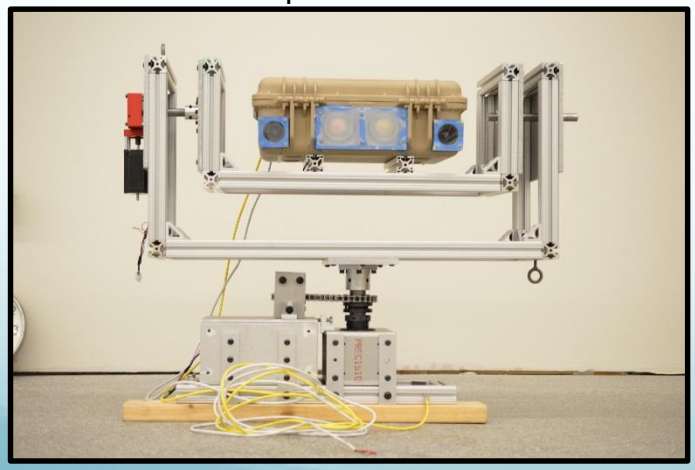


Save data 10 s before to 10 s after trigger event to permanent file.

The Optical Node



On turbine pan and tilt mount



Travel profile

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System specifications

	Thermal Infrared	Visual
Model	FLIR A615sc	Manta G-210
Resolution	640 x 480	1624 x 1234
Lens FOV	15° x 12°	52° x 45°
Frame rate	50 fps	12 fps
Bandwidth	0.25 Gbps	~ 1 Gbps
Interface	1 Gbit Ethernet	1 Gbit Ethernet
Trigger	Software	Hardware
Cost	~ $ 20 k	~ $ 3 k

Software Infrastructure: **Labview**

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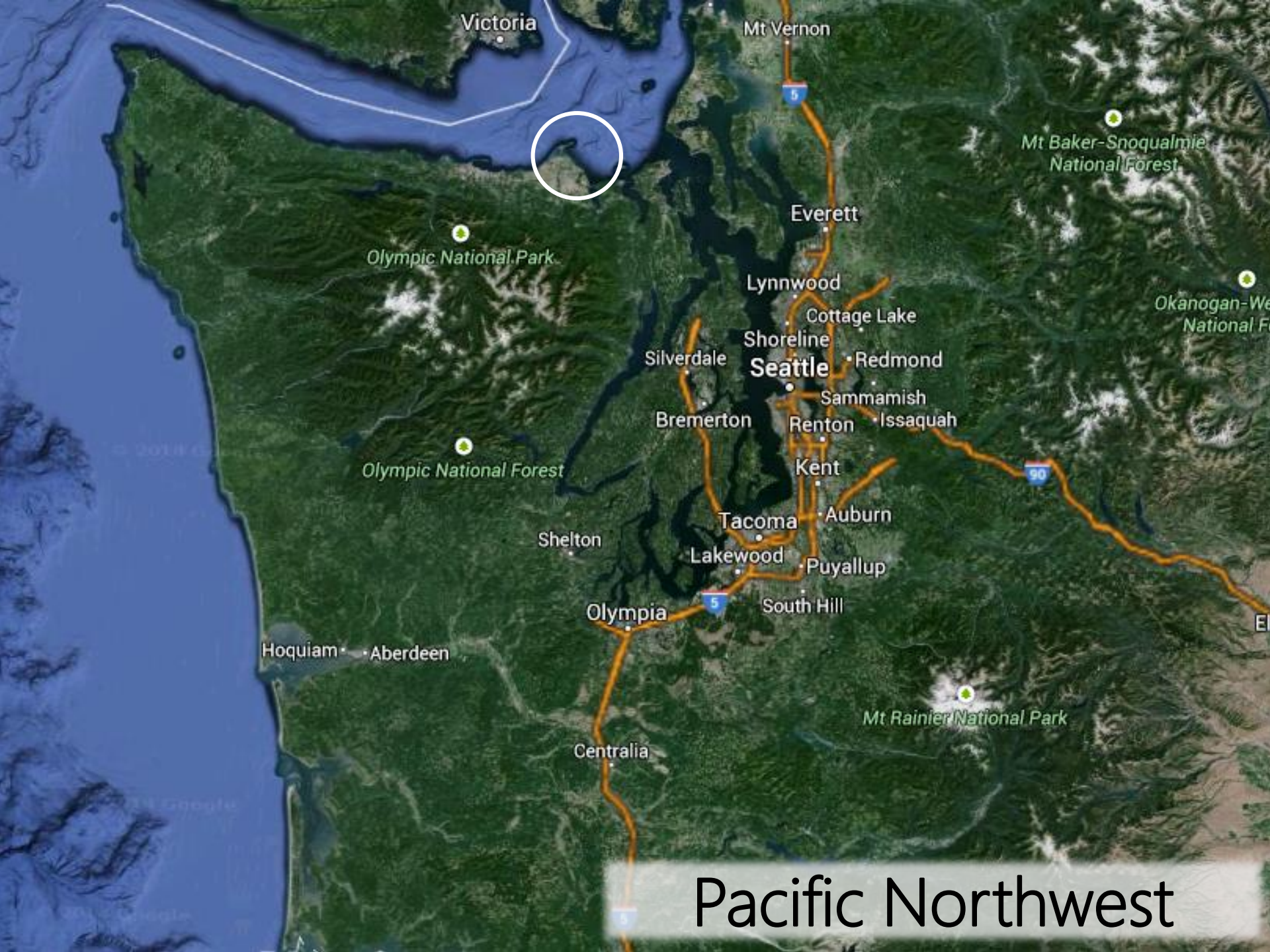
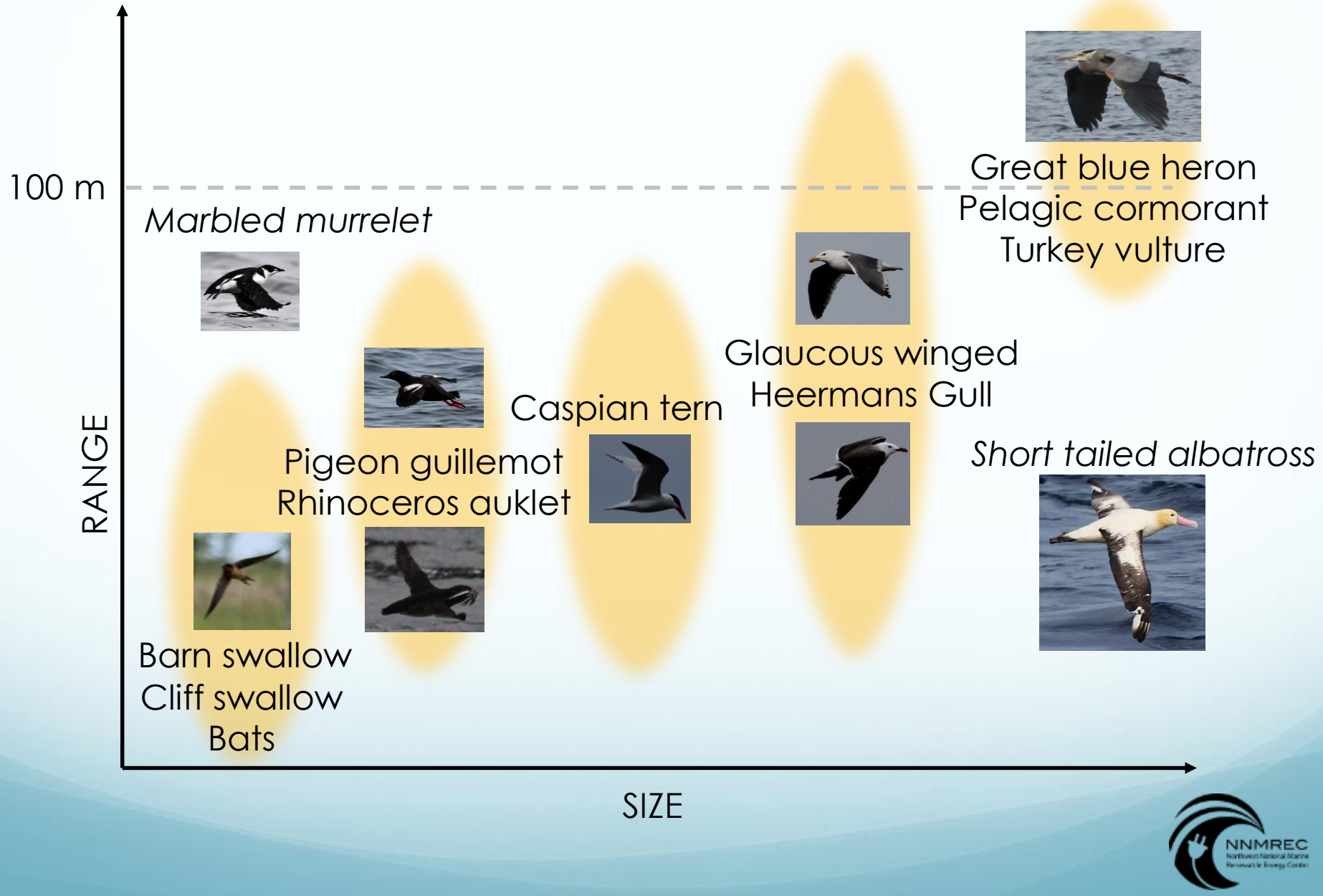

Victoria
Mt Vernon
Mt Baker-Snoqualmie National Forest
Everett
Olympic National Park
Lynnwood
Cottage Lake
Shoreline
Silverdale
Seattle
Redmond
Sammamish
Bremerton
Renton
Issaquah
Olympic National Forest
Kent
Tacoma
Auburn
Shelton
Lakewood
Puyallup
Olympia
South Hill
Hoquiam
Aberdeen
Mt Rainier National Park
Centralia
Pacific Northwest


Dungeness National Wildlife Refuge
Dungeness Bay
Three Crabs Beach
Marrowstone Point, Fort Flagler
Dock, PNNL – Sequim
Carlsborg
101
Sequim
Science Lab

Data Collection



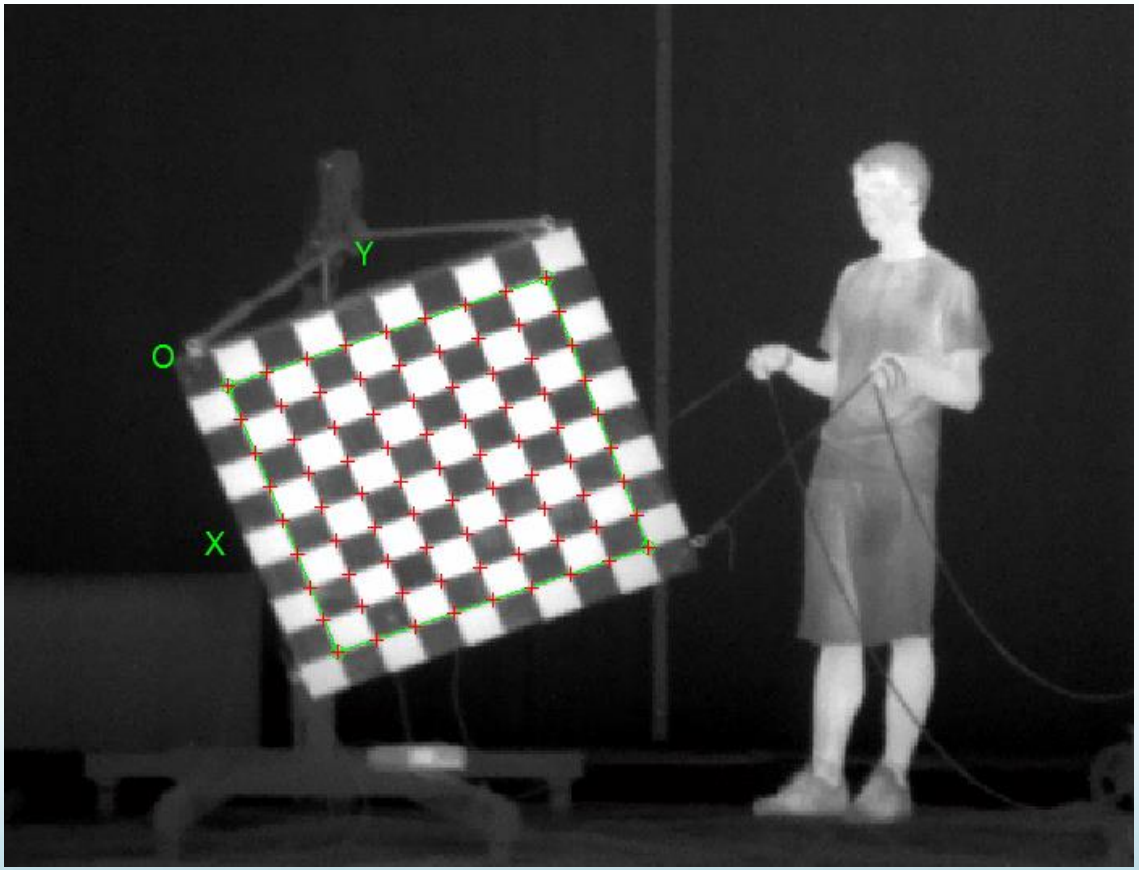
Field Setup


Command station
Optical node controls
Bird meta-data entry
Voucher DSLR
Optical Node
Me
Rob Suryan, OSU
Observers

Stereo Calibration

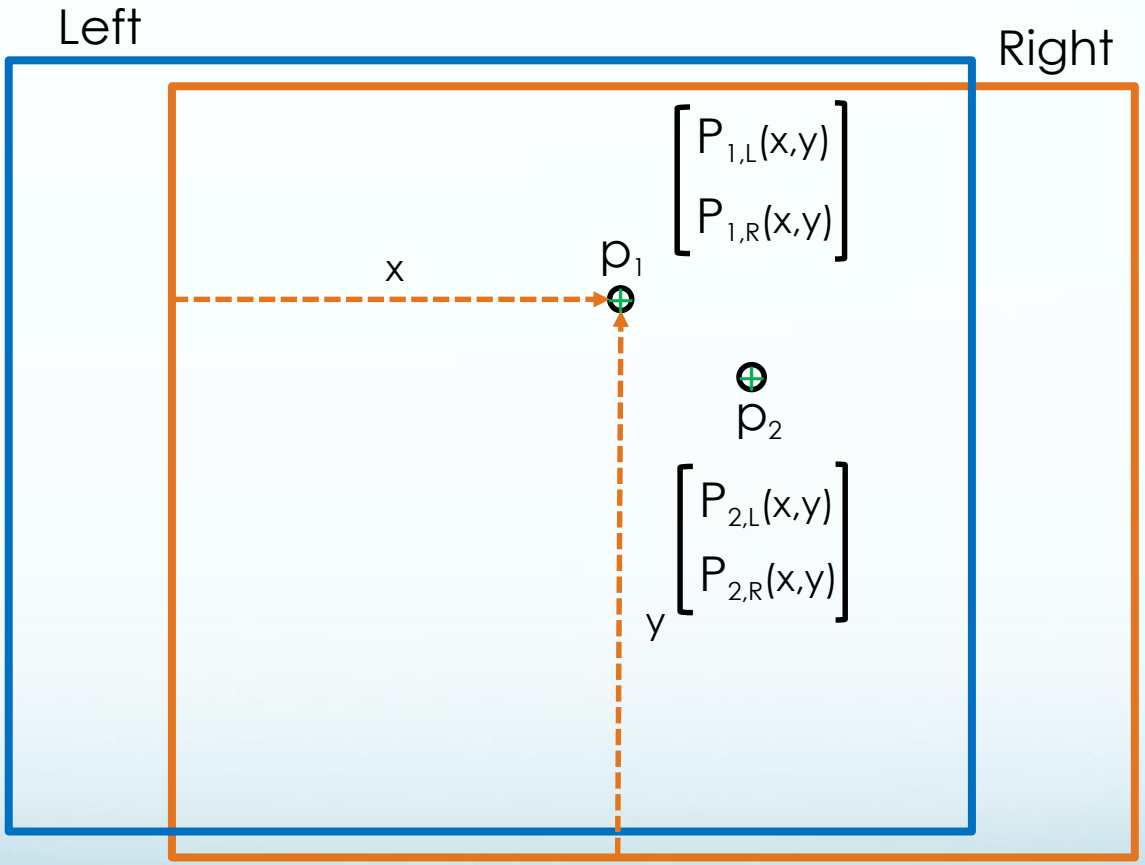
Camera Calibration Toolbox for Matlab

Jean-Yves Bougout, Caltech



Analyzing Stereo Data

Selecting points in the images



Analyzing Stereo Data

Converting points to real world data

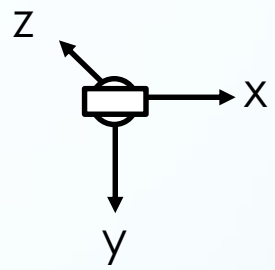
Pixel

$$\begin{bmatrix} P_{1,L}(x,y) \\ P_{1,R}(x,y) \end{bmatrix} \quad \begin{bmatrix} P_{2,L}(x,y) \\ P_{2,R}(x,y) \end{bmatrix}$$

→ Stereo Triangulation Transformation →

Real

$$\begin{bmatrix} P_1(x,y,z) \\ P_2(x,y,z) \end{bmatrix}$$



Real Position

$$\begin{bmatrix} P_1(x,y,z) \end{bmatrix}$$ → Displacement between frames → **Velocity**

Real Positions

$$\begin{bmatrix} P_1(x,y,z) & P_2(x,y,z) \end{bmatrix}$$ → Displacement within frames → **Length**

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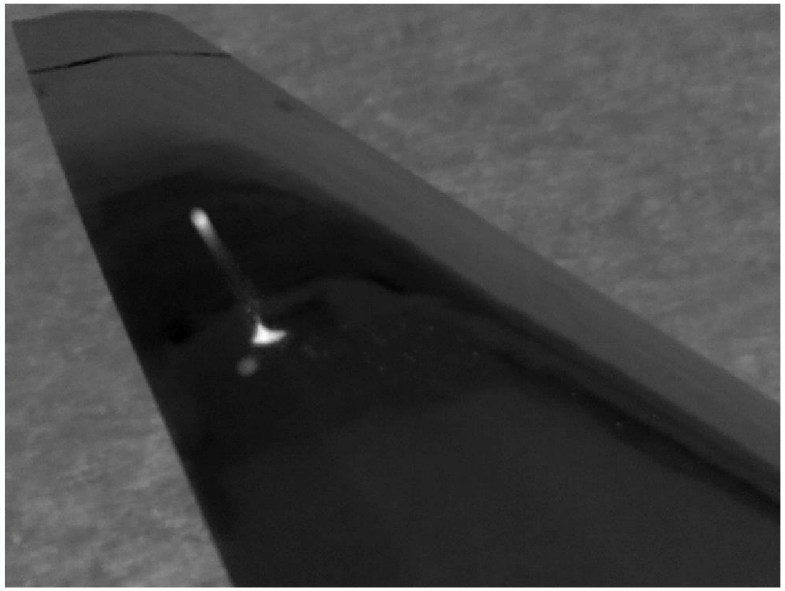
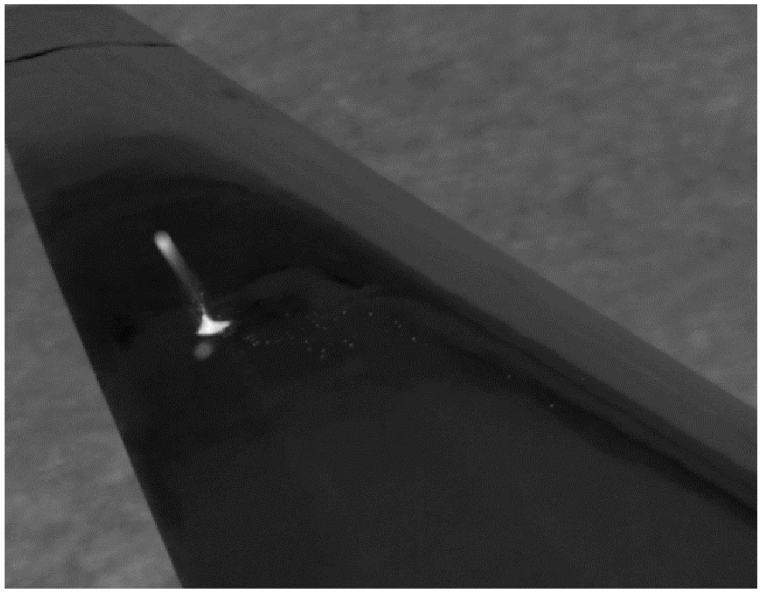
Tennis Balls: Test of Accuracy





Test 2	Mean	Std Dev
Velocity	7.4 m/s	2.7 m/s
Length	7.9 cm	2.3 cm

Test 11	Mean	Std Dev
Velocity	11.6 m/s	0.41 m/s
Length	7.4 cm	4 cm

Regulation Tennis Ball Size: 6.3 cm

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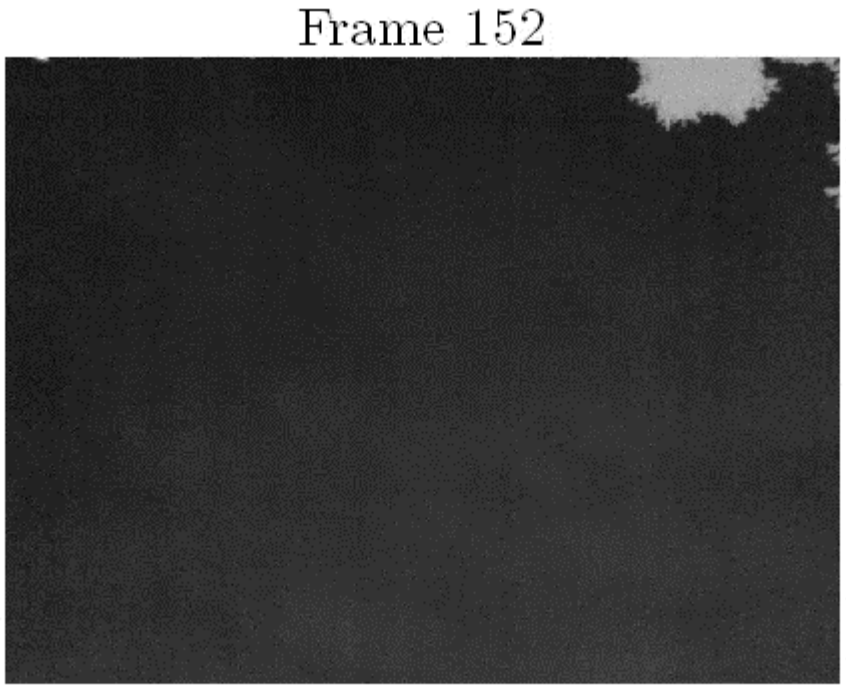
Bats



Track 1

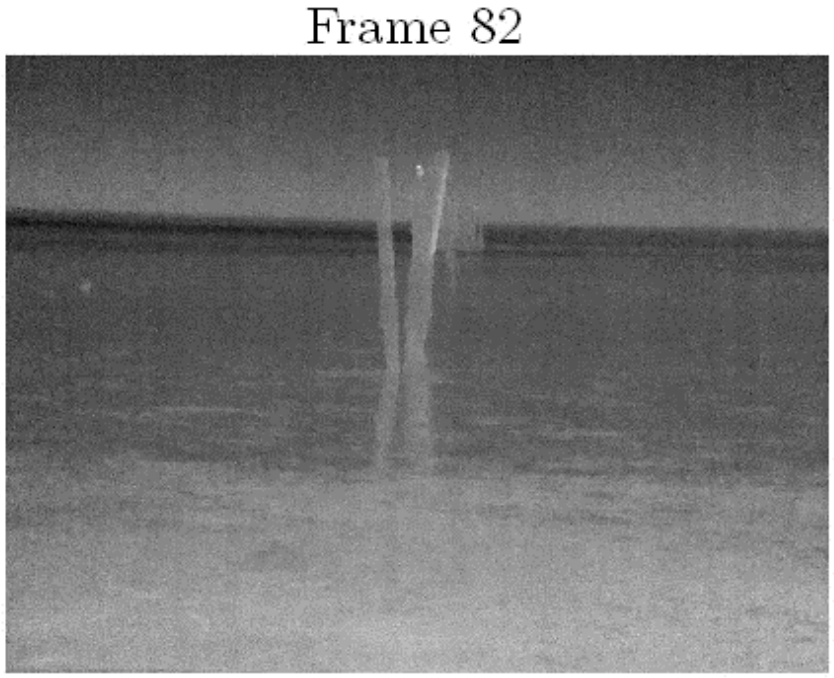
	Mean	Std Dev
Z	14.5 m	0.6 m
Velocity	7.14 m/s	2.28 m/s
Length	14.5 cm	0.03 cm

Track 2

	Mean	Std Dev
Z	14.6 m	1.0 m
Velocity	12.2 m/s	4.6 m/s
Length	14.2 cm	5 cm

Frame Rate: 50 fps

Birds

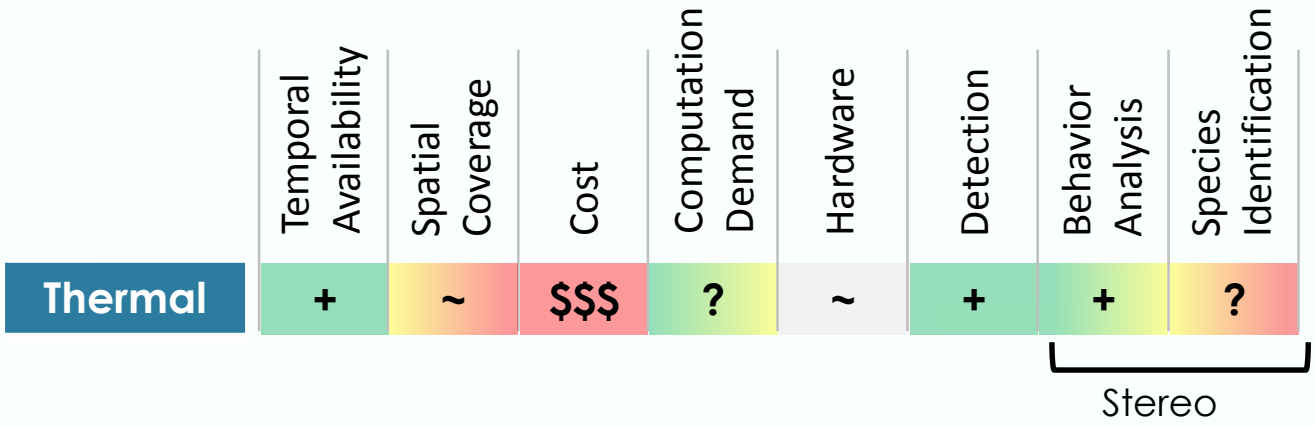


	Mean	Std Dev
Z	81.4 m	17.2 m
Velocity	31.2 m/s	7.5 m/s
Length	7.2 cm	3.3 cm

Brewers blackbird
Actual size: 20 – 26 cm

Frame Rate: 12 fps

Conclusions



Strengths:
- Detection
- Temporal Availability
- Automatic Processing

Promising:
- Behavior Analysis

Weaknesses:
- **Cost**
- Resolution ➔ Spatial Coverage

Applications:
- Validation of deterrence systems
- Quantification of collision

Acknowledgements

PNNL Sequim Marine Biological Laboratory

NREL Wind Energy Test Facility

Bird observers: Shari Matzner, Corey Duberstein, Valerie Cullinan, and Greg Spencer

Advisory panel for the overall system development

Stereo calibration: Chris Fisher and James Joslin