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An Automated Visual Scoring Algorithm for Assessing Gunfire Accuracy

ENGAGEMENT SYSTEMS DEPARTMENT

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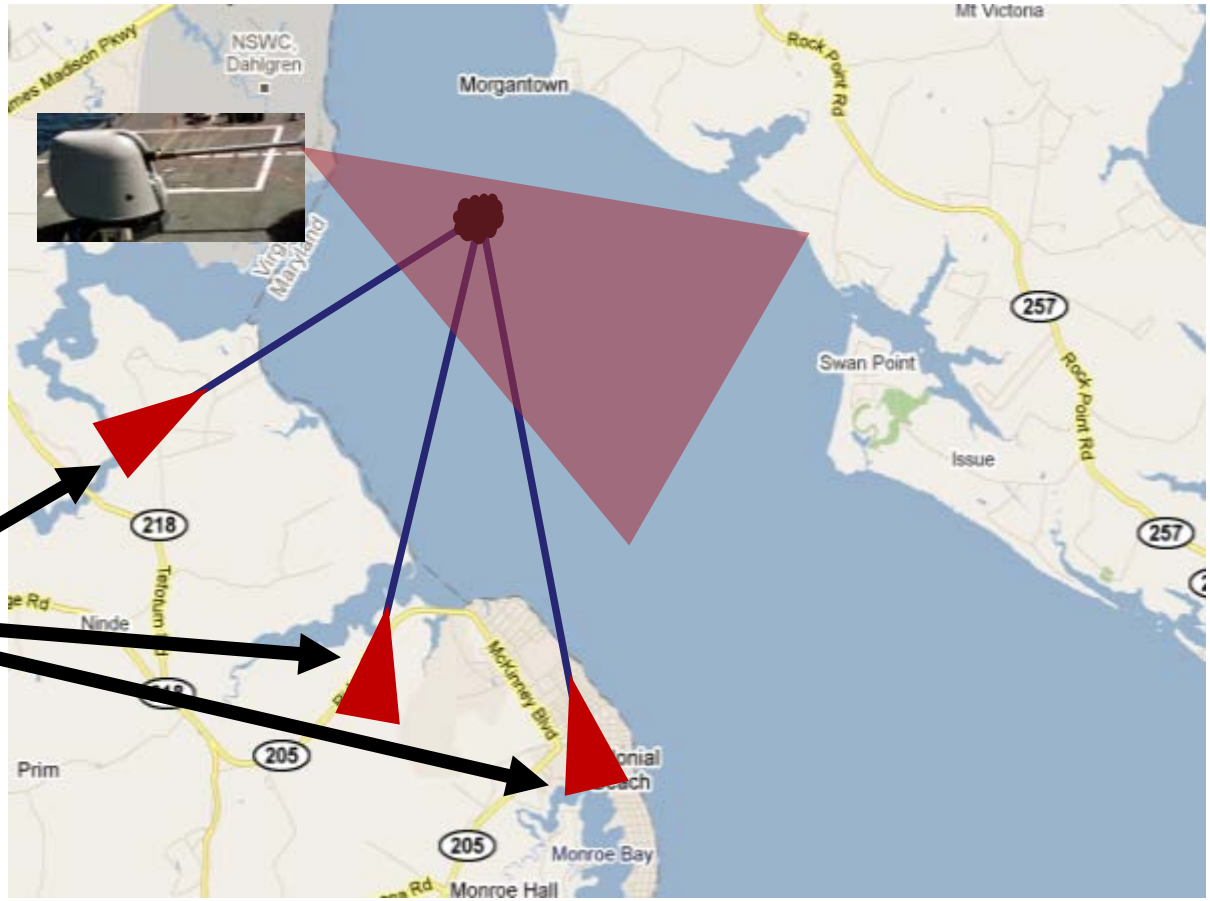
Scoring Gunfire on the Potomac River Test Range

- **One of the major tests NSWCDD does is to test and score naval gunnery**
- **The term scoring refers to quantitative measurement of fall of shot (FOS) location relative to the desired/intended target**

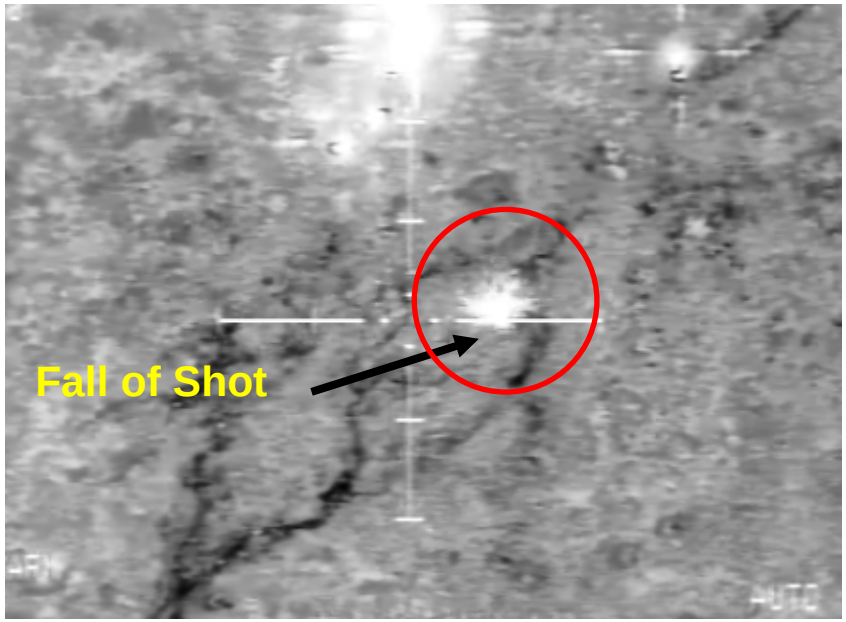
“Surveying Equipment”



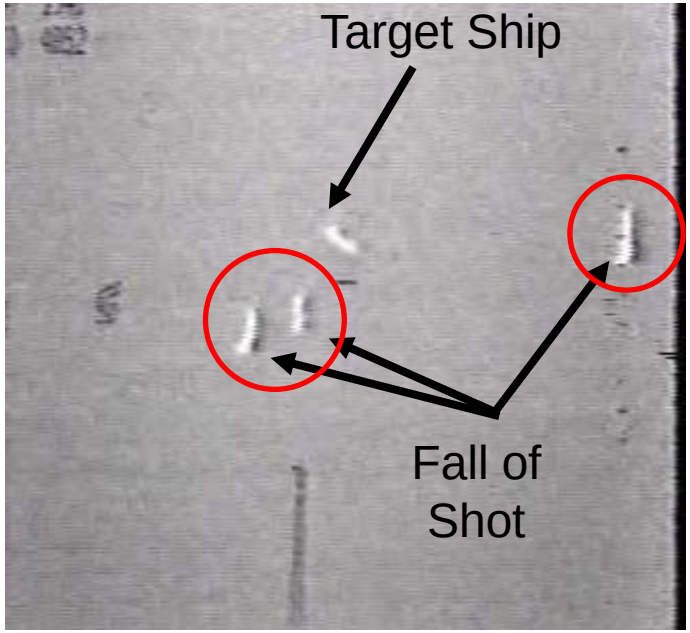
A Visual Automated Scoring System

- **This presentation focuses on a computer algorithm to autonomously compute the FOS from digital images**
  - Line of sight
  - Non-line of sight

LINE OF SIGHT (LOS)



NON-LINE OF SIGHT (NLOS)



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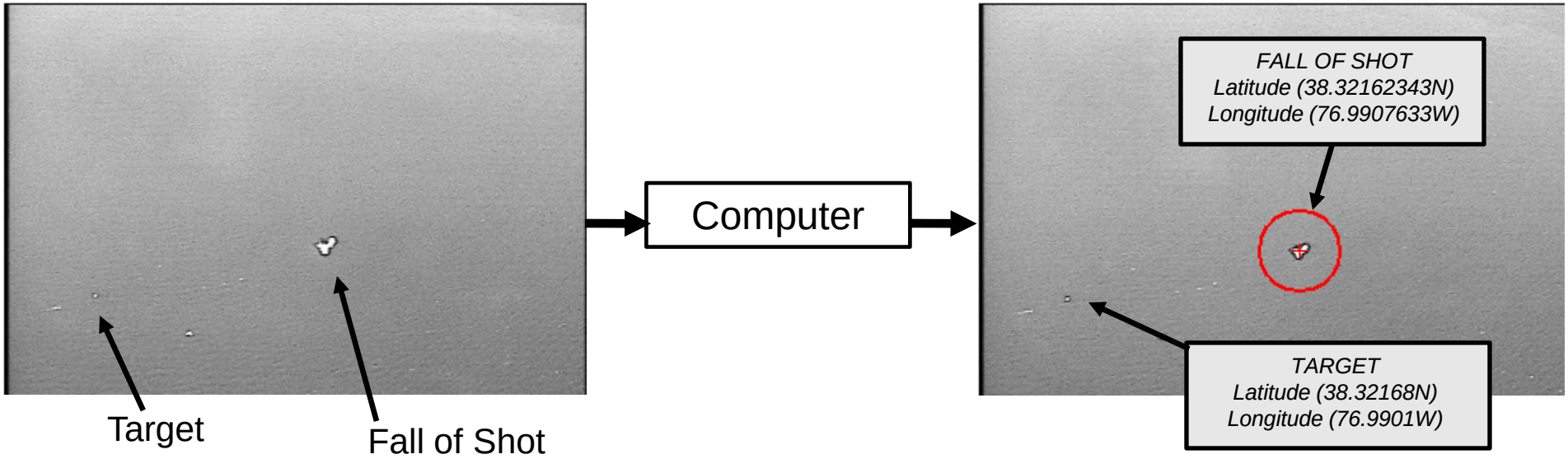
Scoring Non-Line-of-Sight Gunfire Systems

Video Images of Target From UAV Perspective

Data Scored by Computer Algorithm



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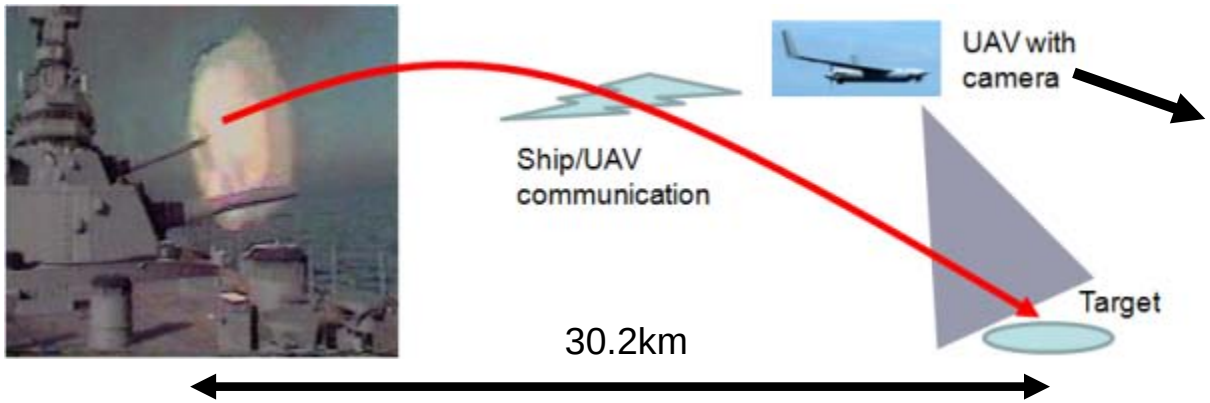
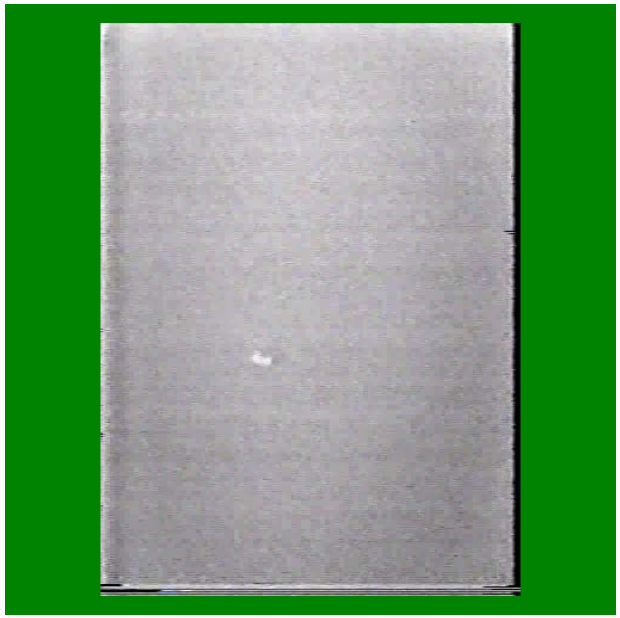
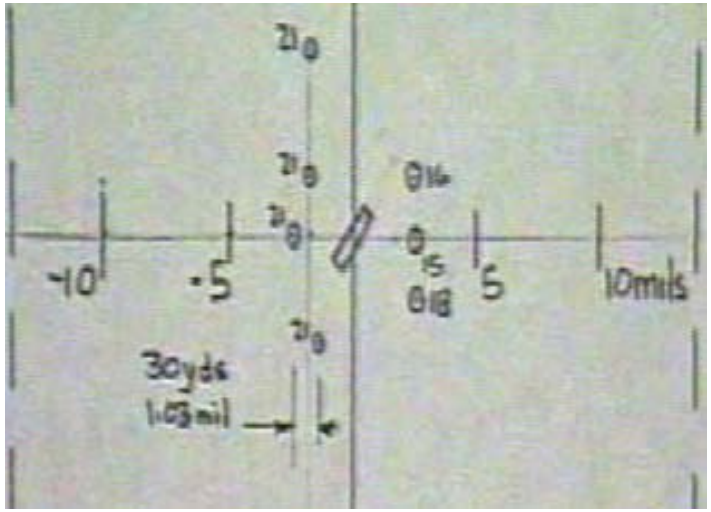
Historical Perspective: 16” Gunfire from USS IOWA





- Dr. Jon Yagla of NSWCDD conducted trials on the USS IOWA in July 1987
- UAV was flying near the target ship collecting video data
- Tests conducted on the open ocean

- Round splashes were observed and FOS were plotted manually (by a human)
- Advances in computer processing allows for near-real time analysis of fall of shot



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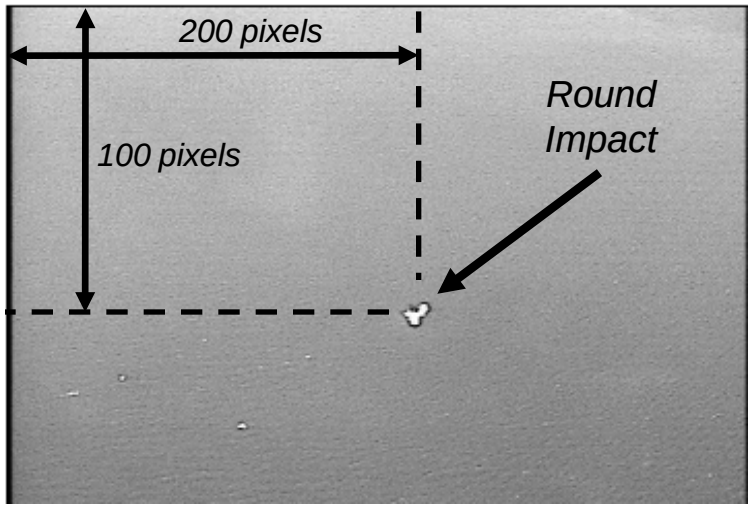
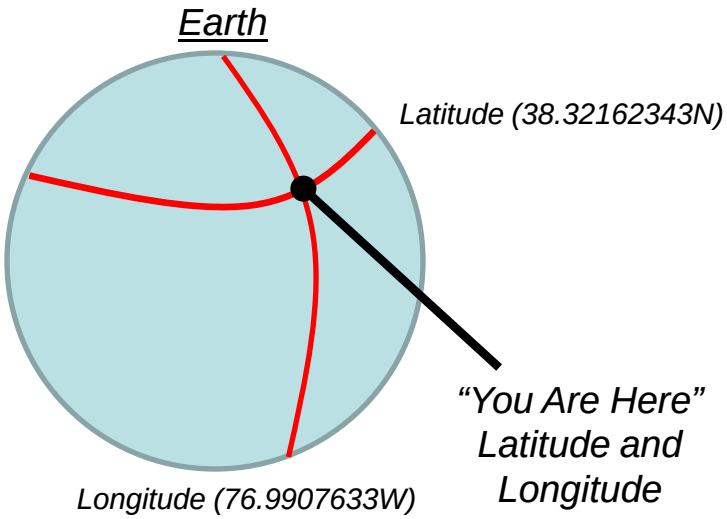
Quantitative Shot Spotting Using Video Data

- **How can we score FOS using video data using a computer algorithm?**
- **Tests on PRTR to confirm algorithms**
- **Two algorithms required:**
  - #1 Autonomous shot detection
  - #2 Computation of ground coordinates from aerial photography & miss distance calculation (geolocation)

Autonomous Shot Detection Algorithm



Geolocation Algorithm



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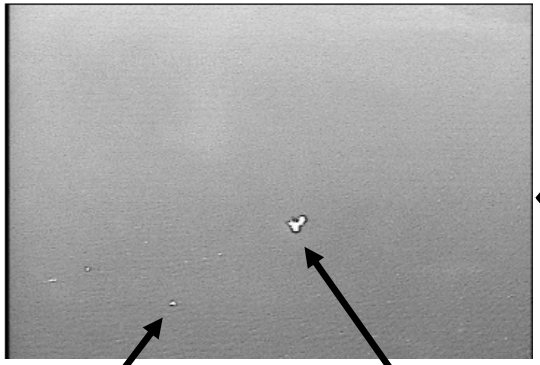
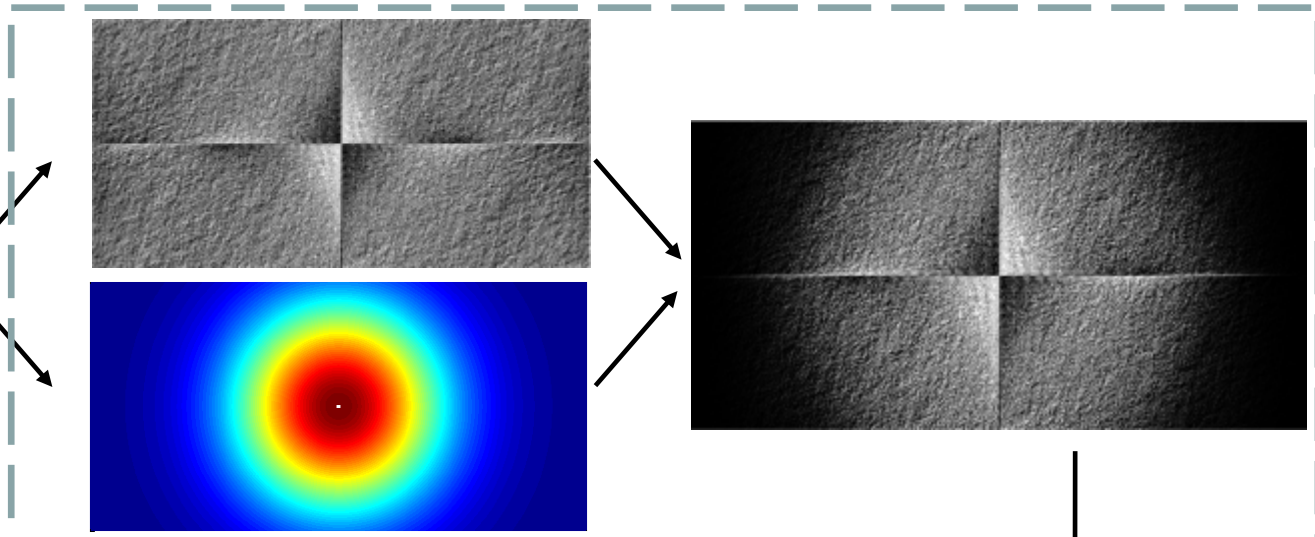
Shot Detection Algorithm

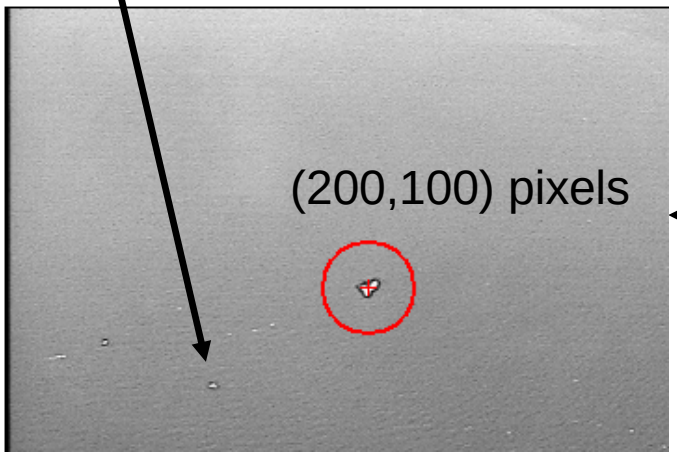
INPUT IMAGE



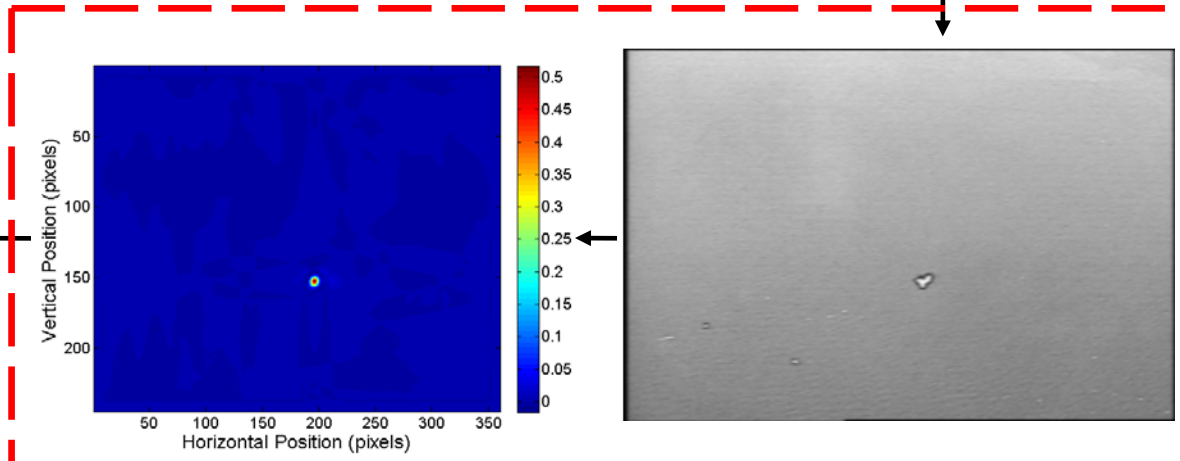
LOW-PASS FILTER OPERATION



IDENTIFY FOS



CHANGE POINT ANALYSIS



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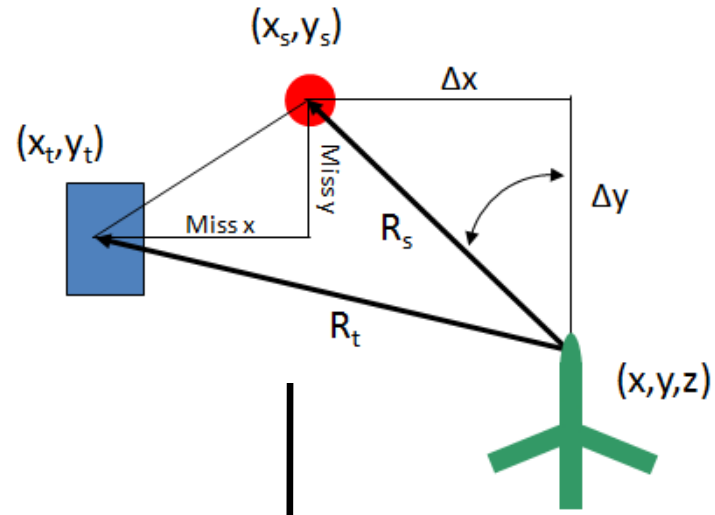
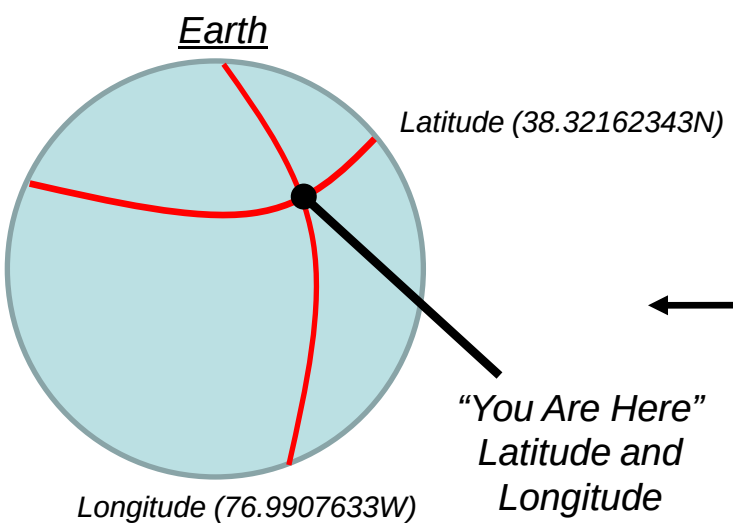
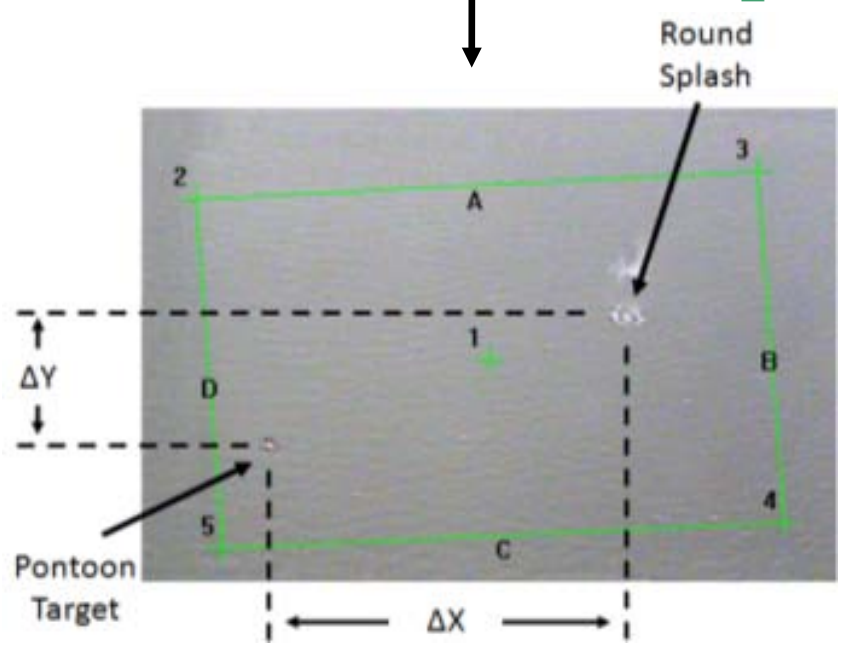
Geolocation Algorithm

- **Ground position calculation is handled internally in UAV software, but can be improved**
  - UAV was never intended for precise geolocation
  - Instruments could be improved





"You Are Here" Latitude and Longitude



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Scoring Line-of-Sight Gunfire Systems

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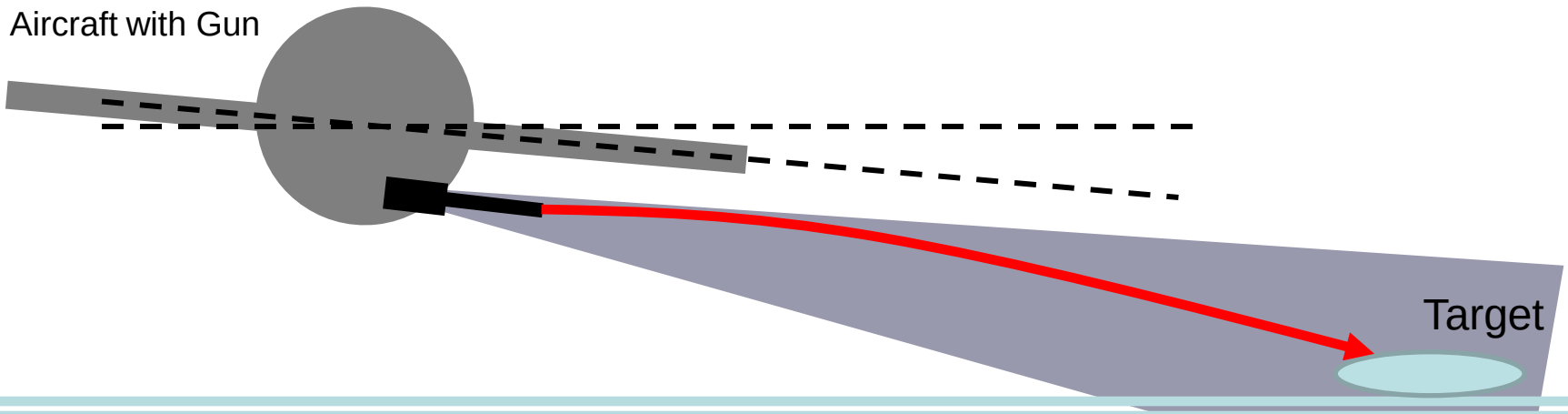
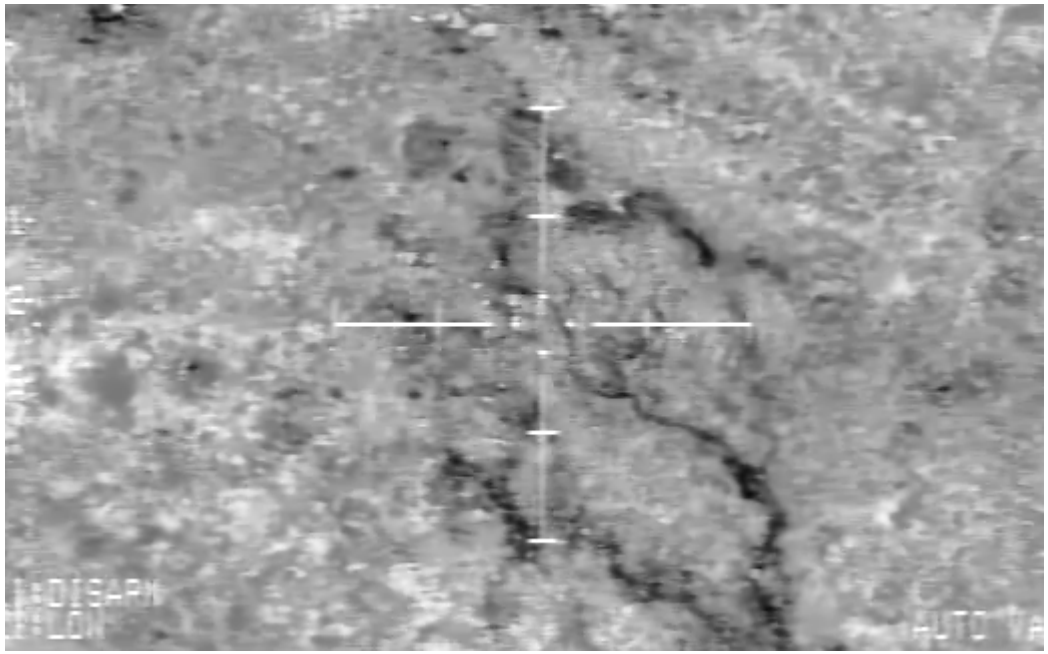
Line of Sight Example: Gun on Aircraft



- **Aircraft orbiting target while shooting**
- **How do you score these tests?**
  - Typically 3-4 seconds round time of flight
  - Ground is moving/aim point changing



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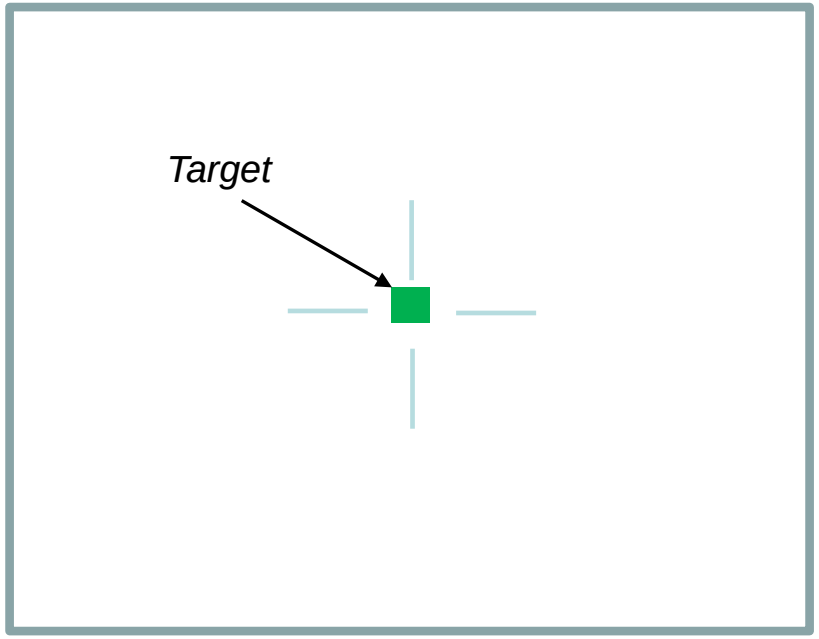
Scoring LOS Gunfire – Different from NLOS

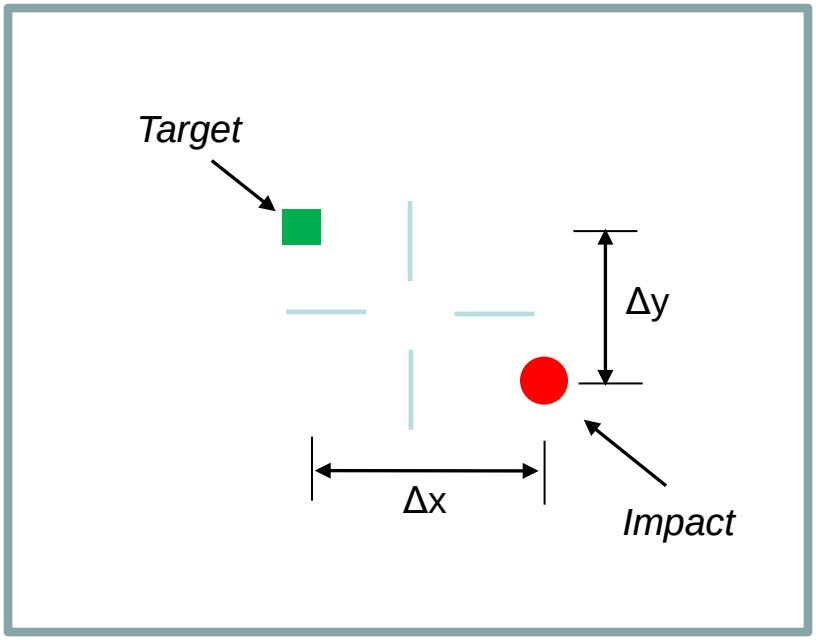
- **When the trigger is pulled, there is a bullet flight time depending on altitude, bullet speed, etc…**
  - Put crosshairs on target in Image 1 and pull the trigger
  - Bullet impact occurs several seconds later in Image 100
- **We must account for this later translation/rotation to score the bullet impact relative to the <u>original aim point</u>**

Image 1 (Trigger Pulled)



Δt →

Image 100 (Round Impact)



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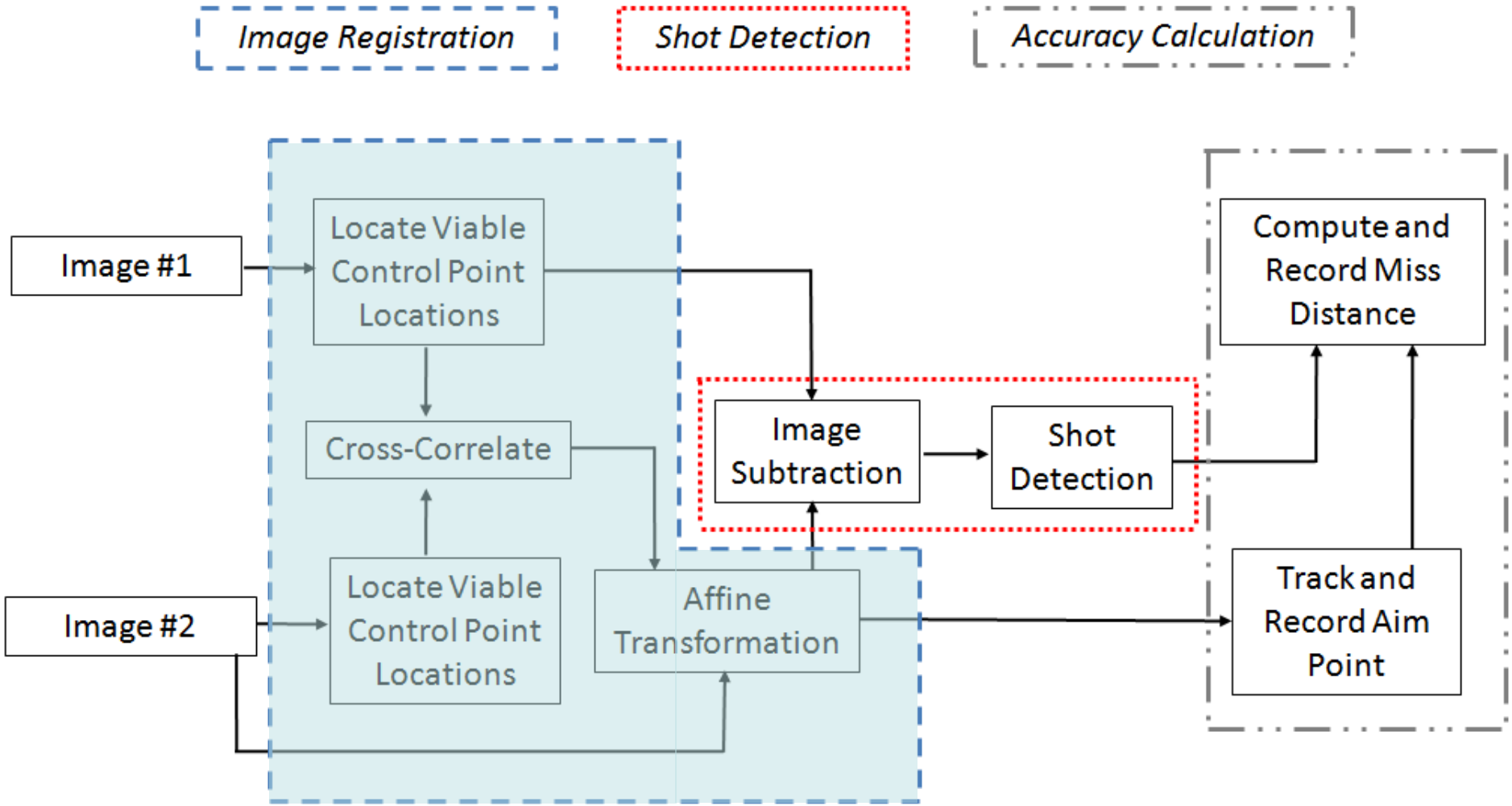
Quantitative Shot Spotting Using Video Data: LOS Algorithm



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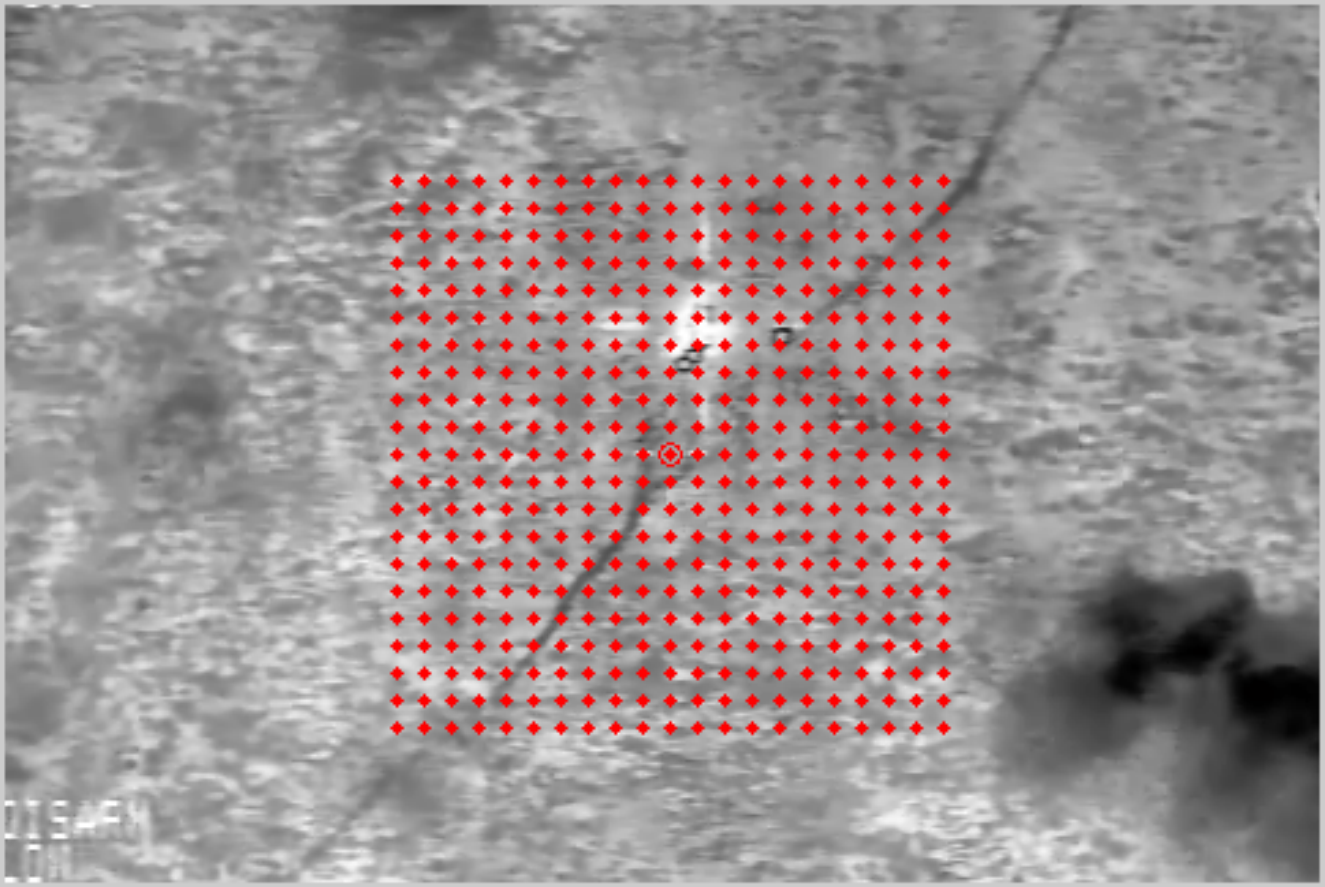
Quantitative Shot Spotting Using Video Data: LOS Algorithm



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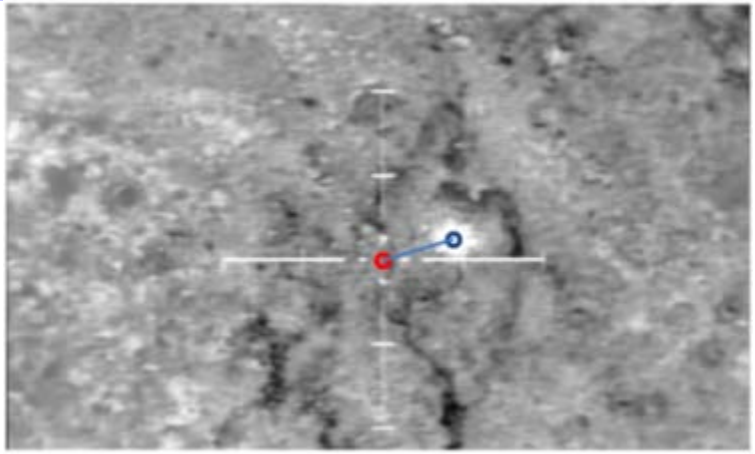
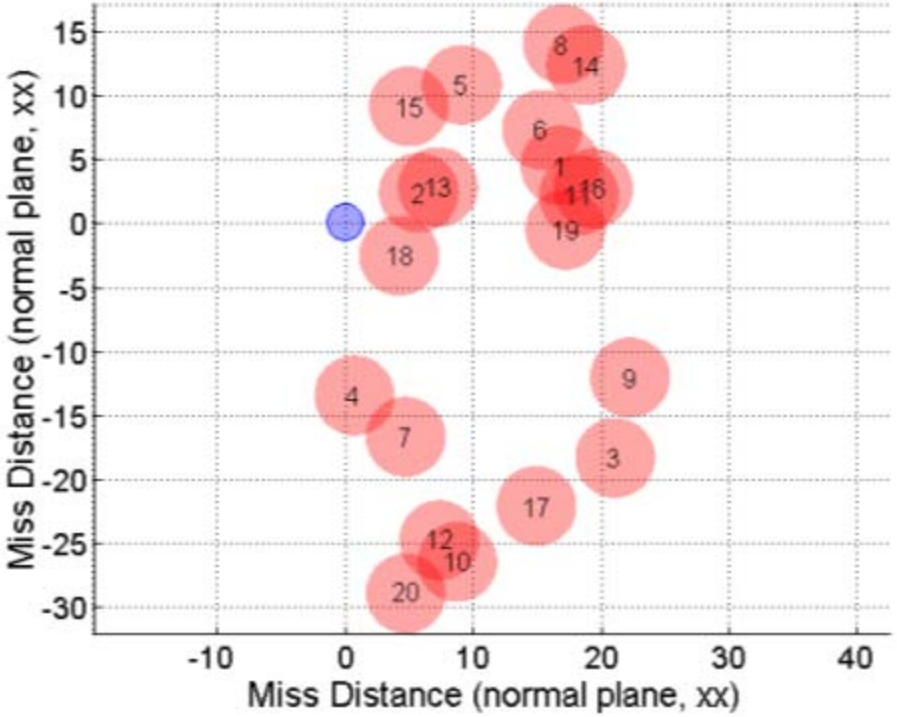
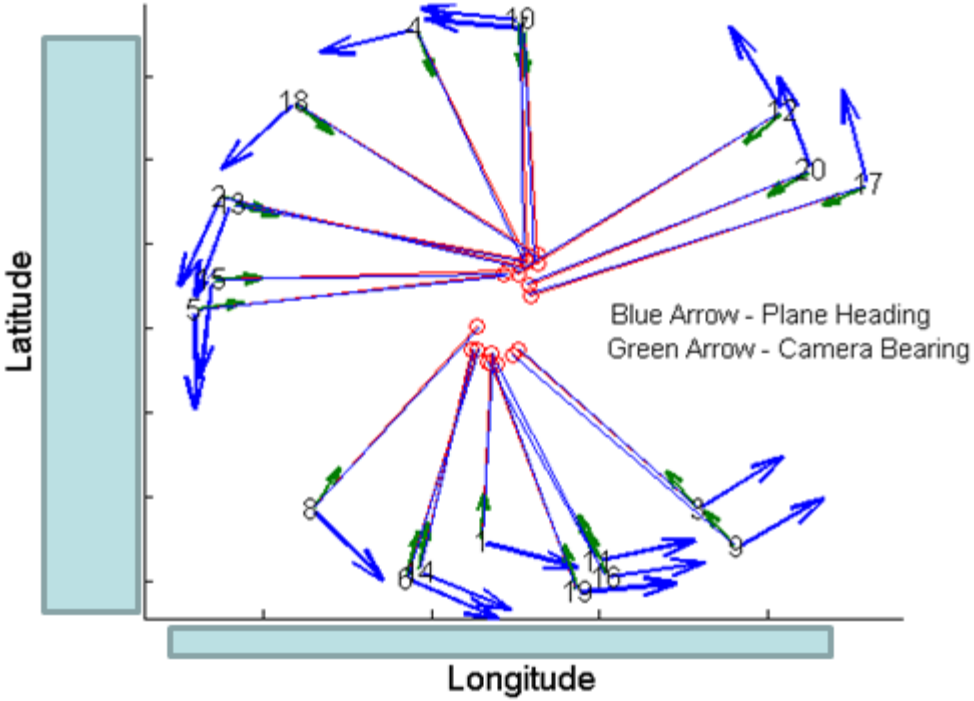
VASS In Operation – LOS

- What type of information do we gather?
  - Miss distance (miss in x & y coordinates)
  - Time of flight (if shot time is known)
  - Location of FOS
  - Kill/injure distances (for a given target)
  - Etc…







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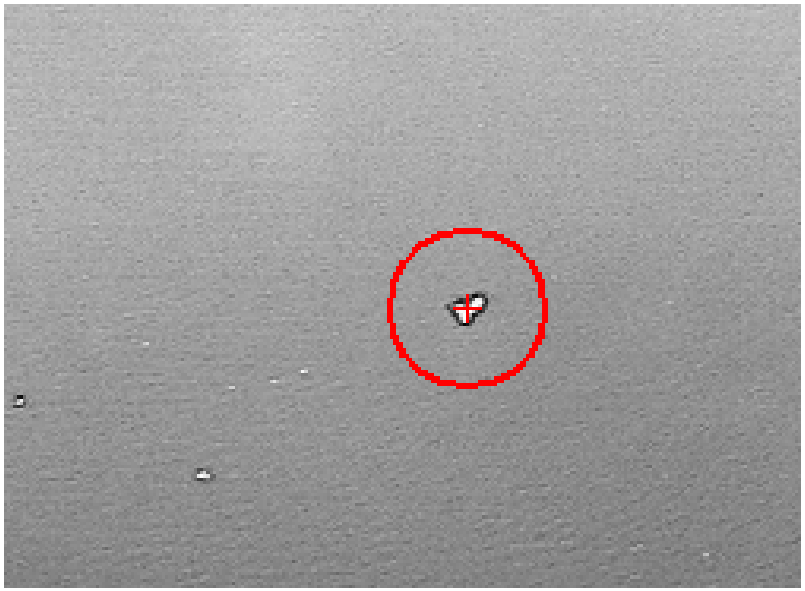
Summary: Using VASS to Score Weapon Systems

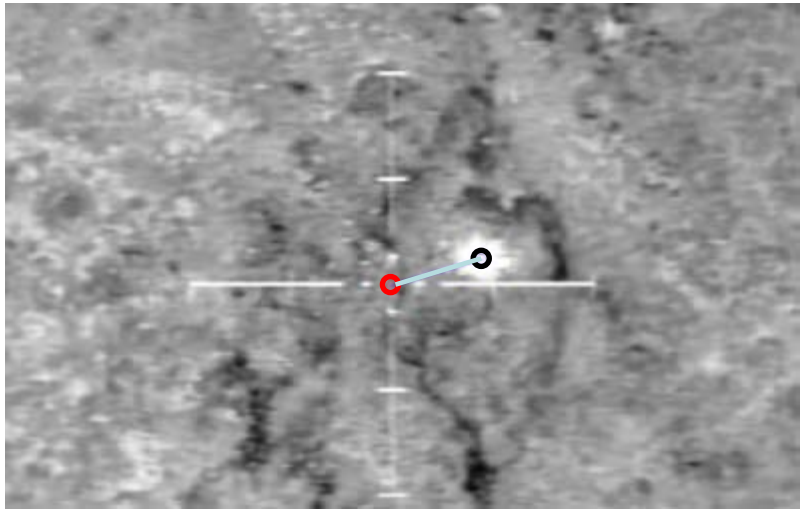
- **An algorithm was developed to autonomously score gunfire from video data**

- **VASS was demonstrated through live-fire tests on the PRTR**
  - Algorithm for auto-detection of FOS worked well
  - Algorithm for conversion of pixels to world coordinate system algorithm needs improvement

- **VASS also works for line of sight weapon systems**

- **Code is getting faster, potentially allowing for real-time adjustments to fire control**





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Questions?

Acknowledgements:

This work was sponsored by the NSWCDD Independent Applied Research Program. Several individuals provided key contributions to the PRTR scoring test: Barry Mohle, Patrick Boyd, Lorenz Eber, Cyrus Roohi, and Steve Klopp. The authors gratefully acknowledge their support.

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