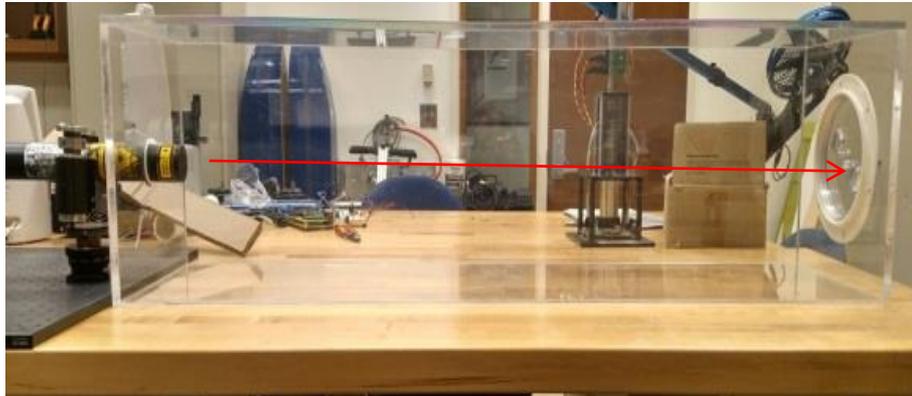


Modeling and sensing of laser off-axis detection and source geo-location

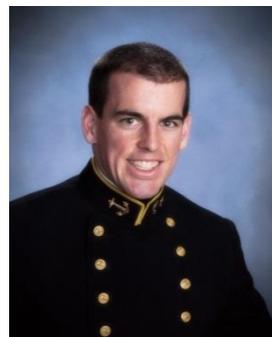
Svetlana Avramov-Zamurovic^a and Reza Malek-Madani^b

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US Naval Academy



MIDN Benjamin Etringer



MIDN Warren Rooney



MIDN Bryan Cully

Modeling and sensing of laser off-axis detection and source geo-location

Student Researchers and Collaborators

MIDN Benjamin Etringer, Applied mathematics, Honors, Trident

Computing PDFs for laser data in maritime environment

MIDN Warren Rooney, Weapons and Systems, Dept. Honors *Capturing lasers in maritime environment*

Independent research and Capstone project classes.

MIDN Bryan Cully, Aero Dept. Independent research

Laser Countermeasures

Introduction to laser research SM282, Spring 2014 and Spring of 2015

Sean O'Bryant, Sara Peeleman, Emma Carlson, Ben Carpenter and Tyler Vasconcz

Mary Kelsey, Robert Rosenthal, Thomas Giornelli, Brian Cully, Tahler Bandarra and Daniel Vege

Laser weapons and their naval application EM441 Spring 2014

Collaboration

Dr John Degrassie, SPAWAR

Dr Josef Penano, NRL

Professor Olga Korotkova, University of Miami

Professor Chris Davis, University of Maryland

Professor Guillaume Bal, Columbia University

Professor Lenya Ryzhik, Stanford University

Researchers from USNA, Professors **Svetlana Avramov-Zamurovic and Reza Malek-Madani**

Assistant Professor

Charles Nelson

Research assistant

Stephen Guth

Modeling and sensing of laser off-axis detection and source geo-location

OBJECTIVES

Educate US Naval Academy MIDN in mathematics, science and engineering of laser light

- Introduction to laser research course
- Laser weapons and their naval application course
- Independent laser research courses
- Introduction of laser light modules in Weapons and Systems Applications course
- Trident and Bowman research projects
- Summer internships

Detect laser path and direction from off-axis images of laser light in maritime environment

2014-2015 – *current midshipman projects*

- Developed experimental set up in laboratory
 - ✓ changing maritime environment (fog)
 - ✓ optimize laser beam off-axis detection from minimal number of single location camera images
- Performed initial measurements to demonstrate proof of concept
- Established collaboration with
NRL SPAWAR University of Miami

2015- 2016 – *future midshipman projects*

- Correlate off-axis laser light scattering modeling by NRL with experiments using Turbulence emulator made by USNA, with the goal to relate the Monte Carlo scattering simulations to experimental data.
- Perform experiments on USNA grounds in collaboration with SPAWAR, with a goal to compare the ANAM modeling with field experiments
- Develop mathematical modeling of laser light scattering off of irregular particles, with University of Miami.

Approach to detecting laser beam from off-axis observations

- Constructed enclosure to contain maritime environment rich in scatterers so that recorded image can be used to differentiate laser beam's path and the direction of propagation.
- Focus on
 - Characterizing the enclosed environment in terms of humidity, pressure and temperature
 - Optimizing camera location and position to capture beam parameters (path and direction)
 - Quantifying measurement errors