Aiding in the Prevention of Terrorist Attacks in the Hudson River Through Detection of Small Vessels with UHF Radar

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March 29th, 2011

Introduction

- NY/NJ Port is third busiest in the U.S. and first busiest on the East Coast
- Because of its economic importance, the port is a vital economic asset to protect, including: port infrastructure, cargo, people in surrounding areas, and the regional supply chain
- Small vessels can pose a threat to port security because they can: harbor terrorists, be used as a weapon, and threaten cruise ships

- Small vessels are a threat because they often go undetected by technology and humans due to:
  - Small size, low speed, and an absence of AIS (Automatic Identification System) requirement

- Small vessels and related threats can:
  - Impede the flow of cargo in and out of the port, affecting the economy of not just the tri-state area, but also other states where the cargo had its final destination
  - Produce toxic chemical and biological effects, which can cause harm to human, plant, and animal life in the Hudson River and on land

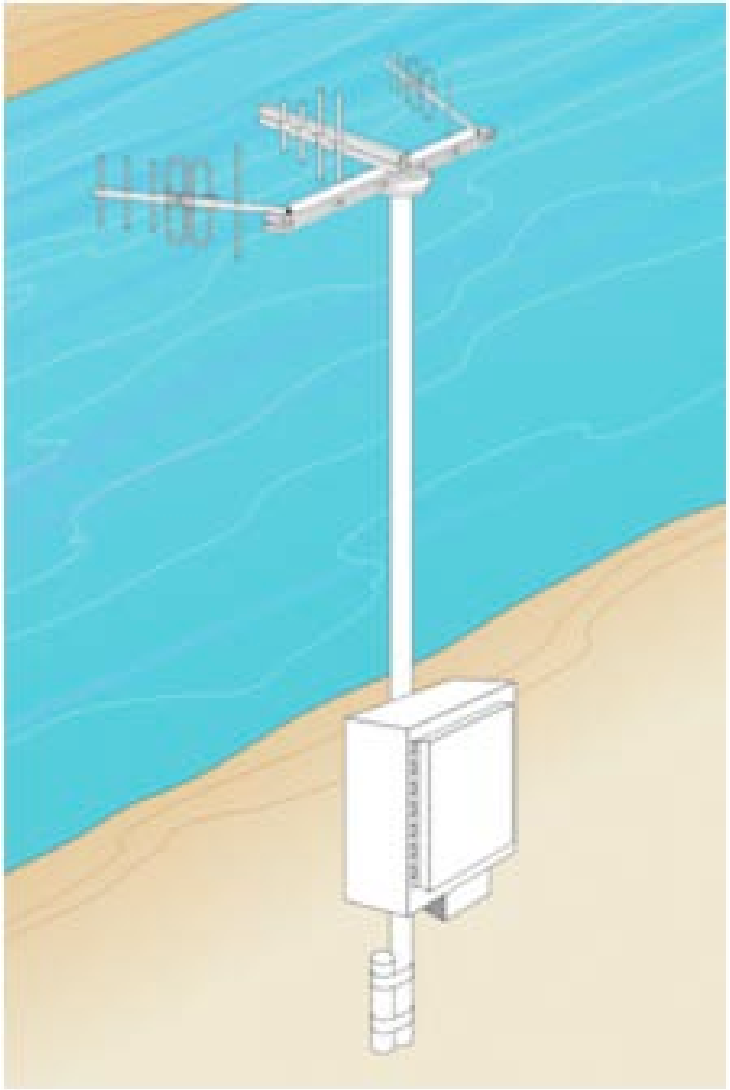
- This research:
  - Uses an Ultra High Frequency Radar system, the RiverSonde, developed by CODAR (Coastal Ocean Dynamics Applications Radar) Ocean Sensors
  - Aims to validate measurements of along shore and cross shore currents
  - Tries to determine if UHF radar can detect small vessels

- Research objectives
  - If the RiverSonde is able to detect and provide a tracking input for small vessels, the Port Authority of NY/NJ and the U.S. Coast Guard may be better able to detect the intentions (friend or foe) of small vessels, based on factors like the vessel's velocity and movements toward and away from the radar, which can ultimately increase the security of the port

Background

- RiverSonde
  - Shore based remote sensing Ultra High Frequency (UHF) radar system
  - Transmits vertically polarized electromagnetic energy
    - Frequency: 420 - 450 MHz
    - Wavelength: approximately 60 centimeters

- All weather capable
- Transmitted signal reflects off conductive material, such as metal, on ships



- RiverSonde works on the Doppler-Shift Principle
  - Traveling towards radar: shows an increase in frequency; positive Doppler
  - Traveling away from radar: shows a decrease in frequency; negative Doppler

- Doppler Spectrogram: a visual representation of what the RiverSonde is detecting
  - Vessel detection
    - Intensity, frequency, Doppler bins, range cells
  - Noisy Background: Bragg waves, stationary objects, and noise floor
  - Need to also consider the effect of other devices with same frequency

- RiverSonde Settings and Parameters
  - Settings and parameters affect what we see and how we see it
  - For example: a higher sweep rate allows for a higher velocity that could be measured

Hypothesis

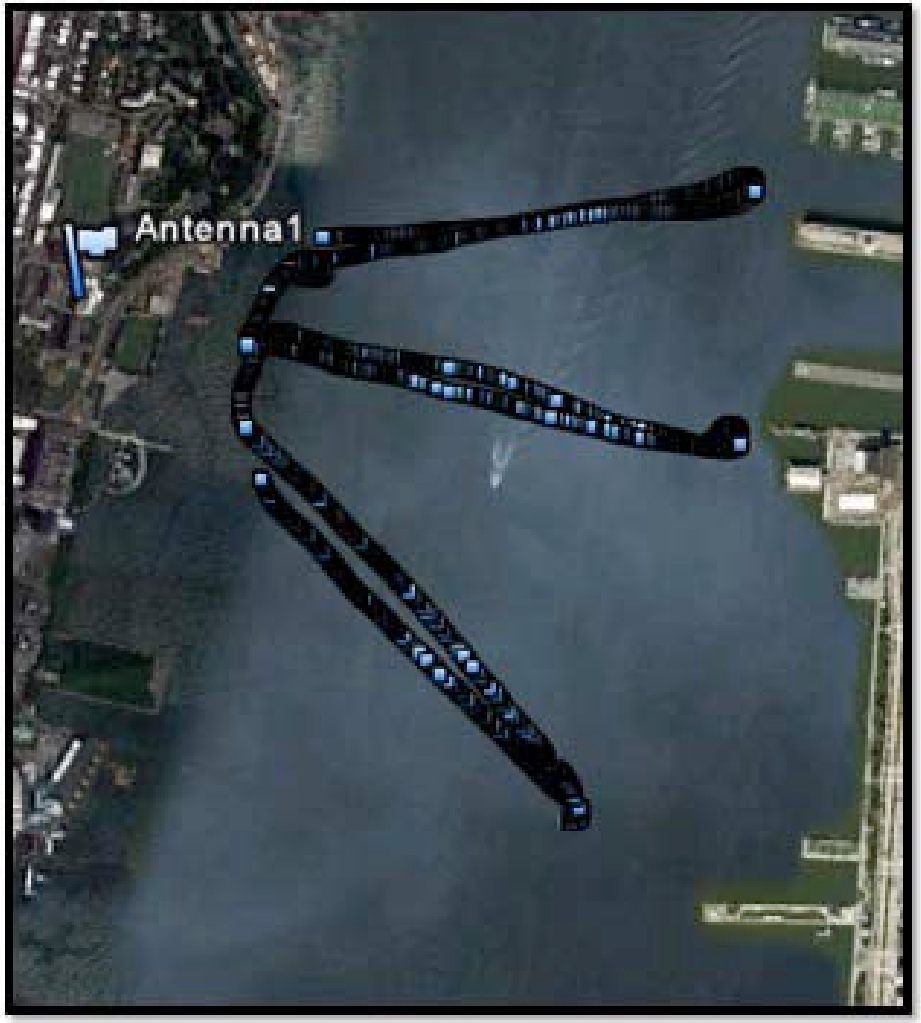
- The hypothesis for the study is that the RiverSonde is capable of identifying small vessels in the Hudson River
- Small vessel movement will be reflected on the RiverSonde such that the radial vector field will be disrupted on a small time scale

Methodology

- RiverSonde installed on the patio of the 6th floor at the Babbio Center at Stevens Institute of Technology (Hoboken, NJ)
  - About 40 m above water and 140 m from the Hudson River
- Calibration and validation via surface current velocity measurements compared to existing NYHOPS (New York Harbor Observing and Prediction System) data

- Data extracted from the RiverSonde's computer system and plotted using MATLAB
- Pilot boat experiment – June 30th, 2010
  - The RV Savitsky, owned and operated by Stevens Institute of Technology, was used to determine what the RiverSonde can and cannot detect
  - The vessel went in front of the antenna, across and along the channel, and towards and away from the antenna
  - Data collected: pictures of other boats, AIS data, spectra map snapshots, radial velocities of vessels detected, and surface water velocities

- Next experiment with the RV Savitsky
  - July 13th, 2010
  - Same objectives, different approach
  - Path was simplified to a crow's foot pattern with a constant radial velocity

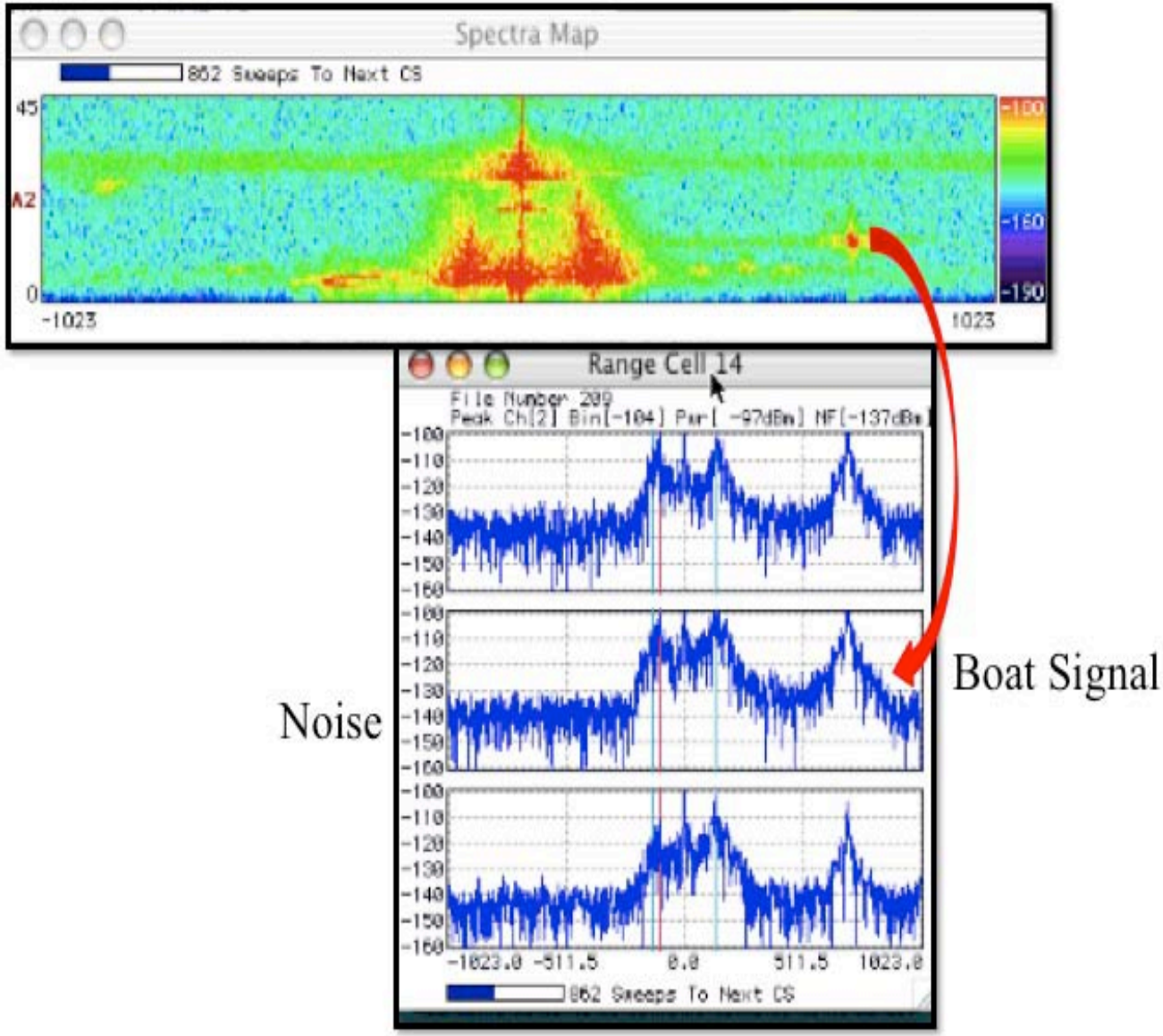


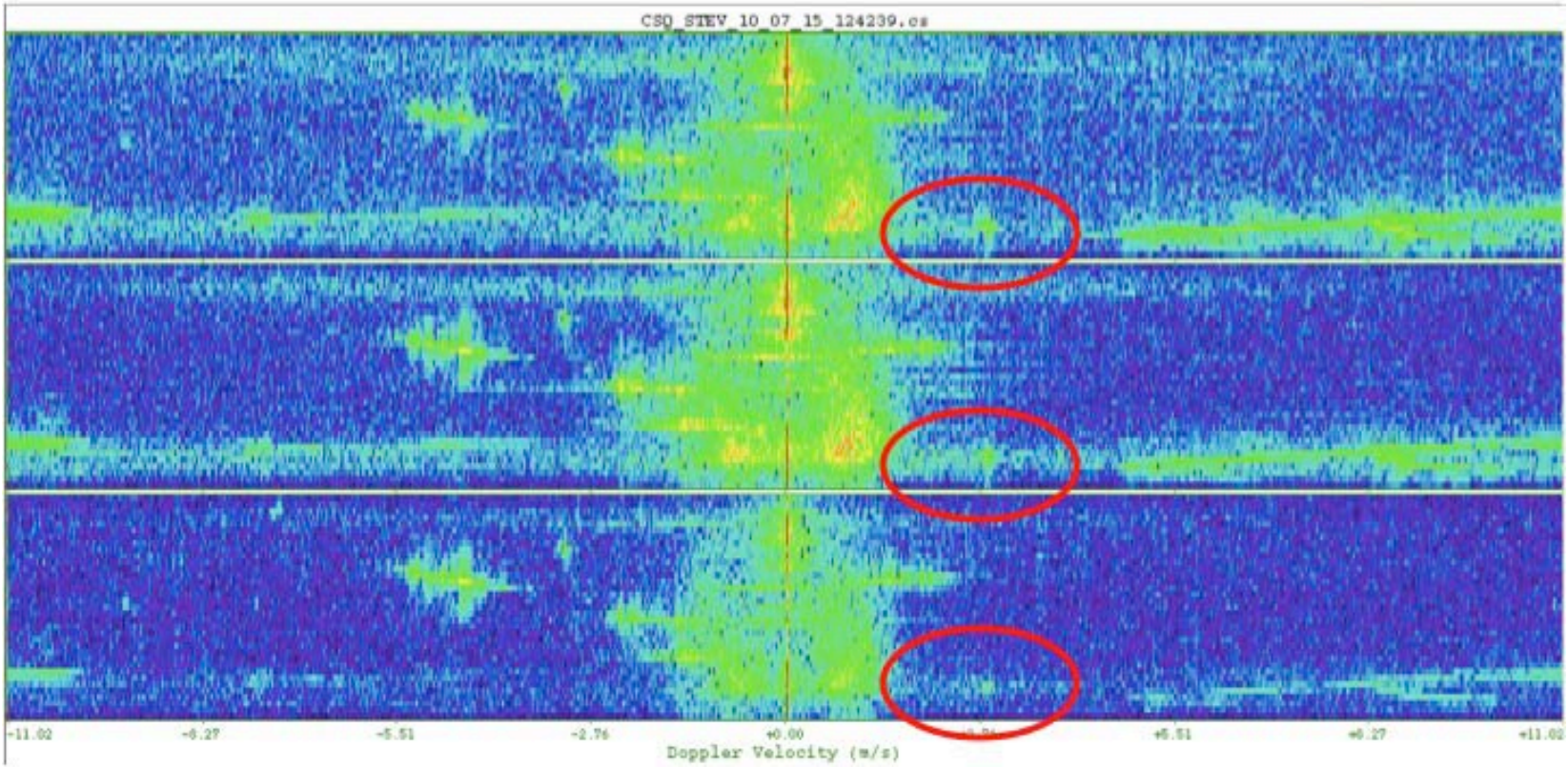
- Vessels were noted for their names, approximate sizes, speeds, AIS data, and directions of travel along the Hudson
- Took images of other vessels and matched photos with the corresponding spectra images

Results and Analysis

- Spectra map showed direction of vessels, away and towards the radar

- Range cell graphs identify which antenna is tracking the boats radial speed more precisely; the antenna with most intensity tells you relative area of boat (example: high intensity in left antenna indicates vessel location left of the radar)


Spectra Map
862 Sweeps To Next CS
45
A2
0
-1023
1023
-100
-160
-190
Range Cell 14
File Number 209
Peak Ch[2] Bin[-104] Pwr[-97dBm] NF[-137dBm]
-100
-110
-120
-130
-140
-150
-160
-1023.0 -511.5 0.0 511.5 1023.0
862 Sweeps To Next CS
Noise
Boat Signal


CSO_STEV_10_07_15_124239.cs
-11.02
-8.27
-5.51
-2.76
+0.00
+5.51
+8.27
+11.02
Doppler Velocity (m/s)

- Best parameters and settings for observation of small vessels
  - Bandwidth: 3 MHz
  - Doppler bins: 2048
  - Range cells: 45

- Settings optimal for small vessel detection are not very effective for current velocity measurements and vice versa

- The main factor in detecting small vessels is not just the size of the vessels; one must consider boat movement and amount of conductive materials on the boat

- Boats with a larger surface area appear more intense on spectra because RiverSonde receives more signal wave feedback

- RiverSonde could detect boats of size ~15 feet high

- The test Boat, RV Savitsky, and other unidentified vessels were effectively tracked at different directions and different velocities

Conclusions and Recommendations

- Limitations
  - Spatial resolution: Boats traveling close together at the same velocity at adjacent range cells might be too difficult to differentiate
  - One RiverSonde may not be enough to precisely location the exact location of a vessel

- A single RiverSonde has benefits, but a network of radars can better track and monitor the movement of the ships and triangulate positions
- Benefits exist for developing a dual use capability system for both vessel and current detection
- Cognitive methods can vary system parameters with environmental conditions to allow for multiple uses

- A network of radar systems could allow the Port Authority of New York/New Jersey and the U. S. Coast Guard to better and more accurately detect and track small vessels

- Concentration on factors such as suspicious movements and erratic speeds, which can be indicators of threats, can prevent terrorist attacks and enhance port security

Acknowledgements

- I would like to acknowledge the National Center for Secure and Resilient Maritime Commerce, and the faculty and staff who contributed to the 2010 Summer Research Institute. I would also like to acknowledge the faculty leaders of my research team, Drs. Scott Glenn and Hugh Roarty, as well as the other members of the team: Lenny Llauger, Omar Lopez, Shankar Nilakantan, Danielle Holden, and Dakota Goldinger.