National Center for Secure and Resilient Maritime Commerce and Coastal Environments (CSR)

Scott Glenn
Rutgers University

March 20, 2008

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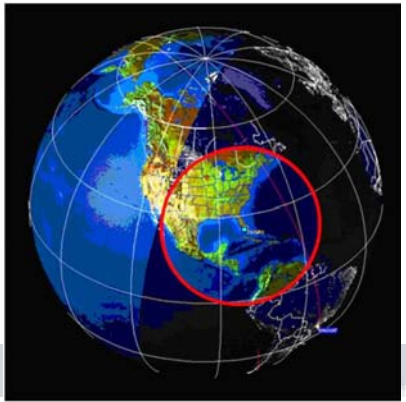
- **CSTARS/U of Miami:** Satellite Based Maritime Monitoring of High Seas and Sea Lanes; Detection, Classification and Tracking of Vessels in Near-Real Time
- **Rutgers University:** HF RADAR and Gliders
- **University of Puerto Rico, Mayaguez:** HF RADAR
- **Stevens Institute of Technology:** High-Resolution Multi-Sensor Surveillance of Estuaries and Harbors

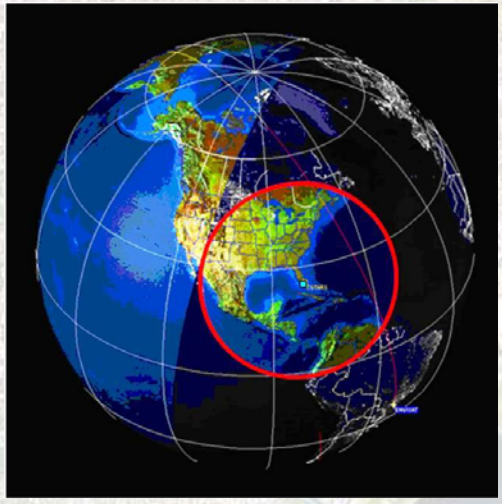


Present Capabilities and Research Areas of CSR Partners
Space-Based to Fine-Scale Maritime Sensing Systems
Integrated Supply Chain Management, Coastal Hazards Management, Systems Engineering
Information Fusion, Hostile Intent Assessment, Optimization
Reduced Latency in Response
Resiliency Analysis, Strategic Planning, Design of Resilient Extended Enterprises
Analysis of Security Measures, including Technical, Legal, Organizational, Political, and Policy Issues, Economic Benefits of Security Measures
Assessment of Policy and Regulatory Impacts from Local to Global Scale

A Satellite Data Reception and Analysis Facility

for Environmental Monitoring and Time Sensitive Tactical Applications in the Southeastern US, Gulf of Mexico, Caribbean Basin and Equatorial Atlantic

Former U.S. Naval Observatory Alternate Time Tracking Station



Sponsors:
Office of Naval Research (DoD) and NASA

CSTARS Current and Future Satellite Reception Capabilities

Current Agreements:

RADARSAT-1	*(microwave SAR)*
ERS-2	*(microwave SAR)*
SPOT 2/4	*(hi-res electro-optical visible)*
ENVISAT-ASAR	*(microwave SAR)*
ENVISAT-MERIS	*(med-res electro-optical visible)*
MODIS-TERRA/AQUA	*(med-res electro-optical visible)*
SPOT-5	*(very hi-res electro-optical visible)*
QuickBird-2 (Demo)	*(very hi-res electro-optical visible)*

Future and Planned Agreements:

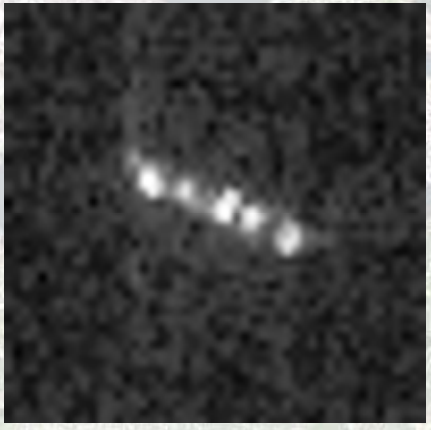
RADARSAT-2	*(very hi-res microwave SAR)*
TerraSAR-X	*(very hi-res microwave SAR)*
ALOS/PALSAR	*(hi-res optical & microwave SAR)*
FormoSat 2	*(very hi-res electro-optical visible)*
SarLupe	*(very hi-res microwave SAR)*
CosmoSkyMed	*(very hi-res microwave SAR)*

Lahore Express – Cargo Ship

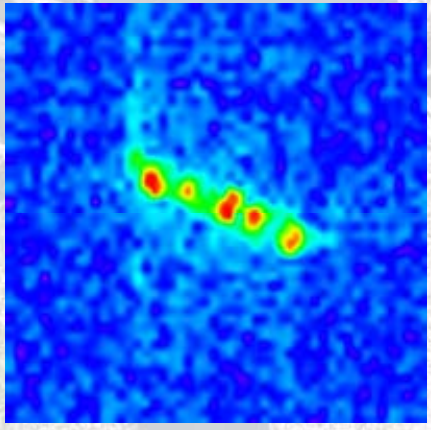
ENVISAT ASAR: Beam IS 6; HH

20 September 2006

CSTARS



Full Resolution Chip

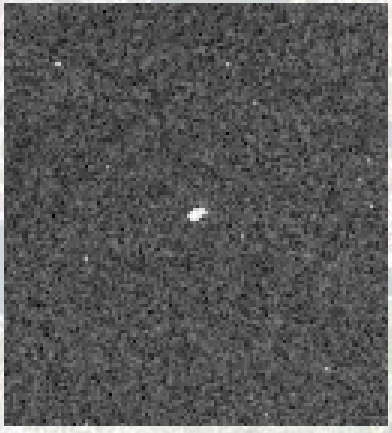


ENVI Rainbow Color Mapping

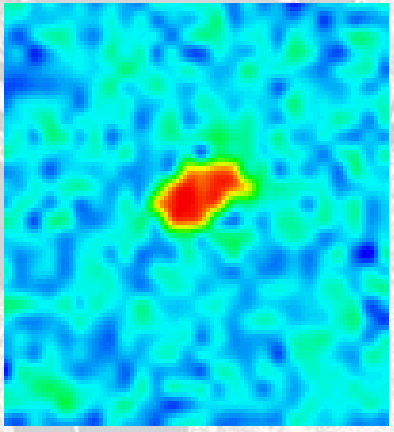
Dimensions from AIS:
Length: 260 m
Beam: 32 m

ENVISAT ASAR (30 m). Typical details of container ship signature are visible showing smoke stack and bridge (back), forward half presumably containers at this resolution. Note ship was on maiden voyage, so don't know exact loading of vessel at time.

Intuition II – Passenger Ship



Full Resolution Chip



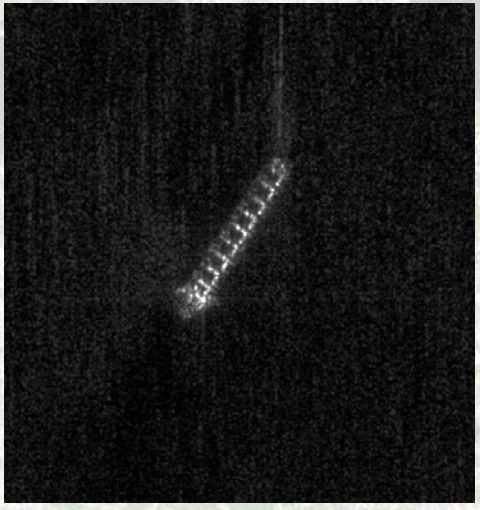
ENVI Rainbow Color Mapping

Dimensions from AIS:
Length : 55 m
Beam : 10 m

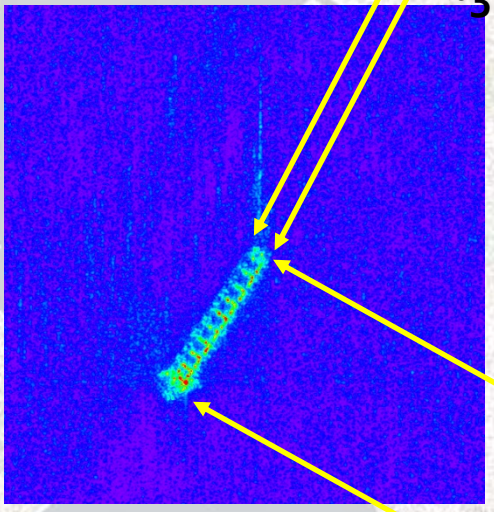
ENVISAT ASAR (30 m). Note uniformity of backscatter, little distinguishing signatures at this resolution

New SARs with Higher Resolution

TerraSAR-X Stripmap: 4 September 2007



Full Resolution Chip



ENVI Rainbow Color Mapping

Ship width - ~30 meters

UI Vessel
Possible Container Ship

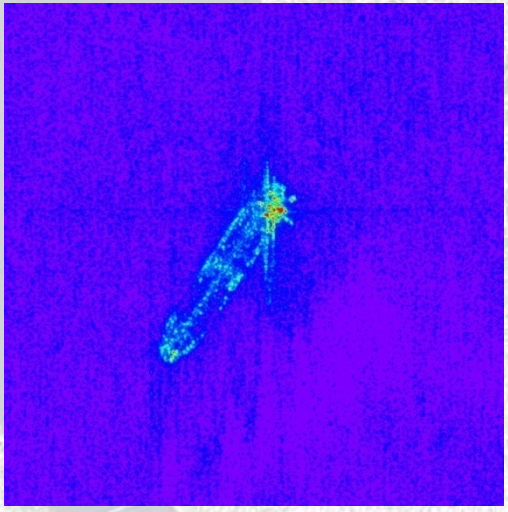
Ship length - ~256 meters

TerraSAR-X (X-Band, 3 m).
Now lots of details visible. Resolution approaching EO sensors. Bridge (back), rows of containers easily detected at this resolution. Note don't know exact loading of vessel at time.

New SARs with Higher Resolution

TerraSAR-X Stripmap: 4 September 2007

Full Resolution Chip



ENVI Rainbow Color Mapping

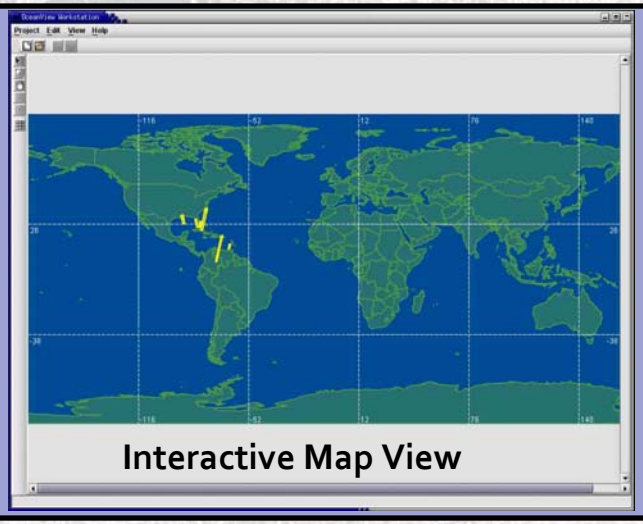
UI Vessel
Possible Cargo Ship / Freighter

TerraSAR-X (X-Band, 3 m). Again lots of details visible. Resolution approaching EO sensors. Signature quite different from container type vessels. Bridge (corner reflector in back), different types of structure, possibly cranes, piping.

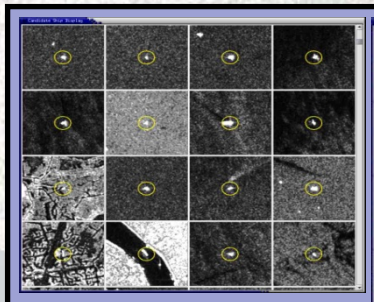
OceanView™

OceanView™

- Multi-satellite sensor
- Multi-frequency
- Queuing of short and long-term targets
- Ship analysis (size, type, heading and speed)
- Ship prediction of future location
- Environmental conditions (i.e. sea state, winds and currents)
- Projection of target advance (i.e. next sat obs)
- Optimized target identification
- Wake analysis
- Java-based display, accessible over internet
- OTH Gold report
- Jointly developed by CSTARS & Vexcel



Interactive Map View



Likely ships (including ships in rivers)

Unlikely ships

Rutgers New Brunswick Campus
School of Environmental & Biological Sciences

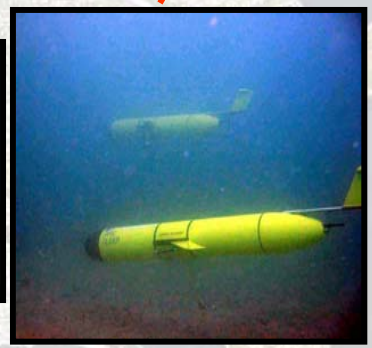
Rutgers University - Coastal Ocean Observation Lab Operations & Data Fusion Center

Field Communications

CODAR Network

L-Band & X-Band Satellite Systems

3-D Nowcasts & Forecasts



Glider Fleet

Coastal Observation and Prediction Sponsors:

ONR Office of Naval Research
National Science Foundation Celebrating 50 Years
NOPP
The G. Unger Vetlesen Foundation
BPU new jersey board of public utilities
PSEG We make things work for you.
Department of Defense
U.S. Department of Homeland Security
NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce
Cook College Rutgers

MACOORA
Mid-Atlantic Coastal Ocean Observing Regional Association

Success Stories – Making a Difference

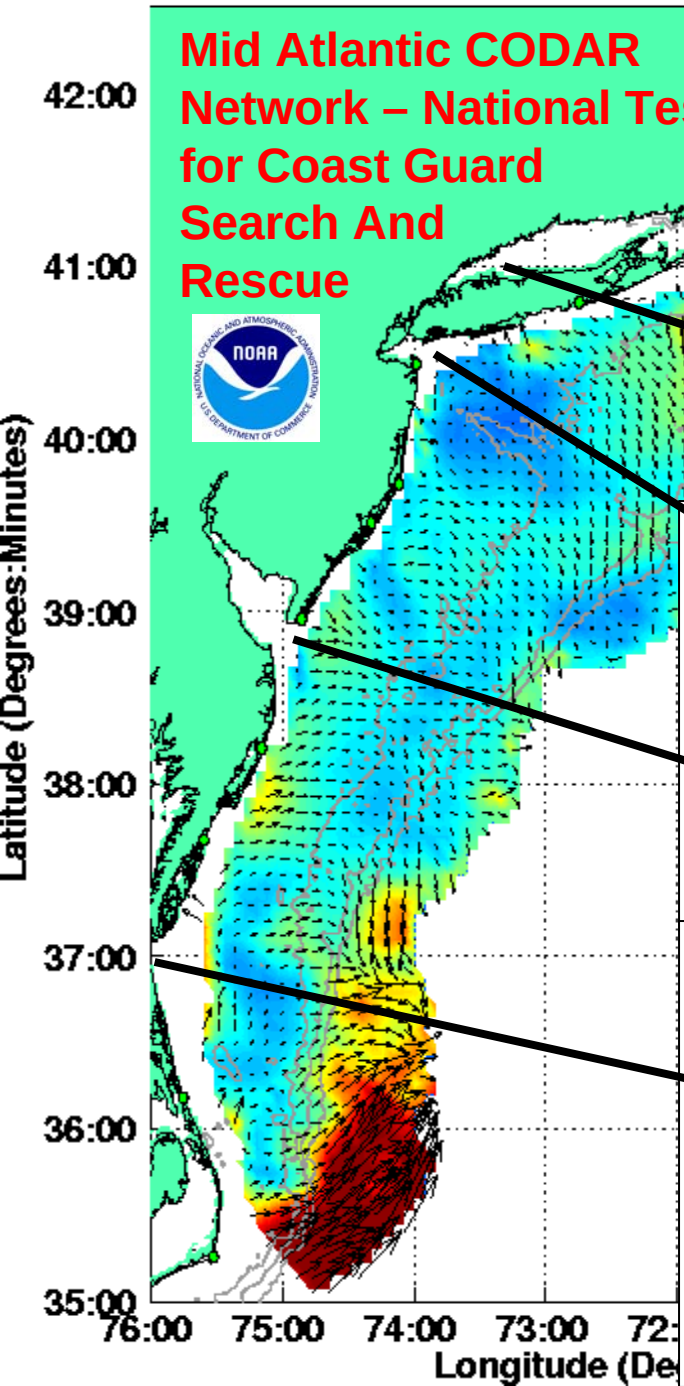
Optimizing HF Radar for SAR using USCG Surface Drifters

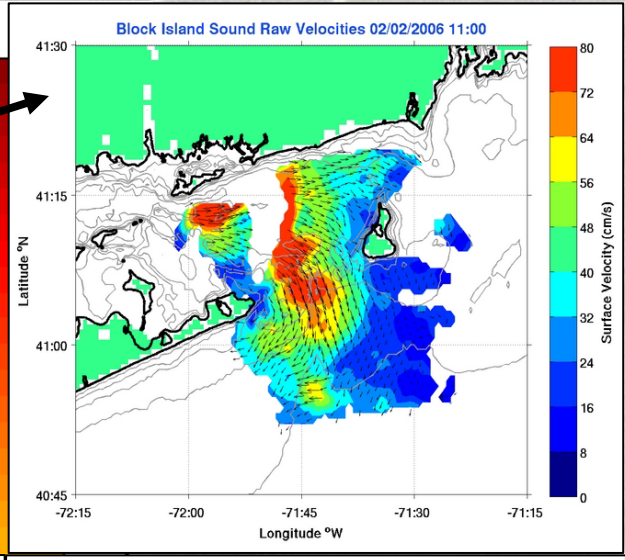
Art Allen
U.S. Coast Guard

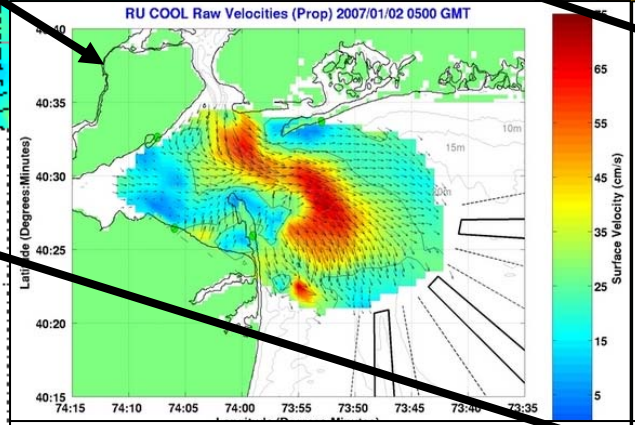
Scott Glenn
Rutgers University

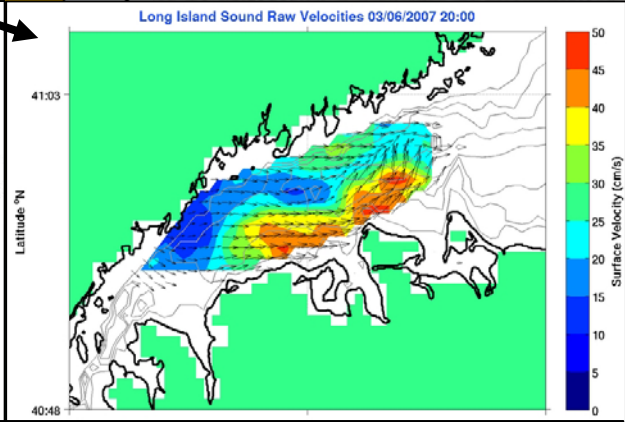
and the Mid-Atlantic Regional Coastal Ocean Observing System

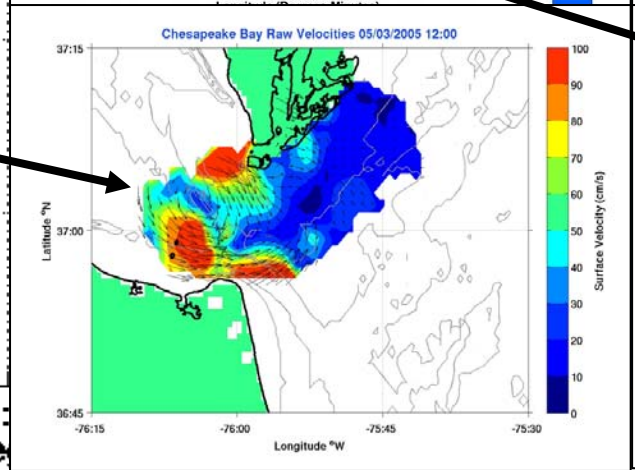
Mid–Atlantic Raw Velocities (1 Day Avg) 2007/05/26 0500 GMT

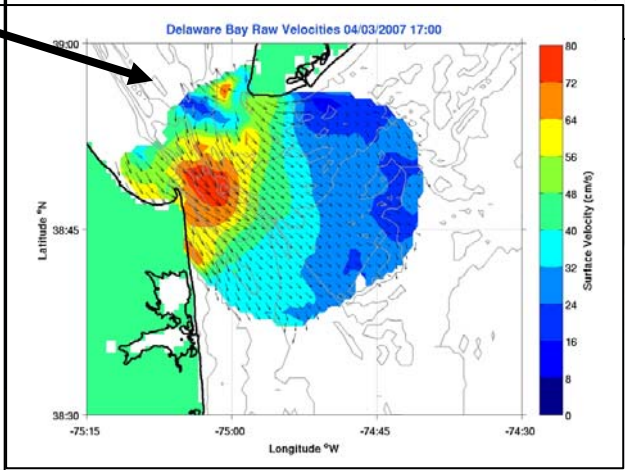






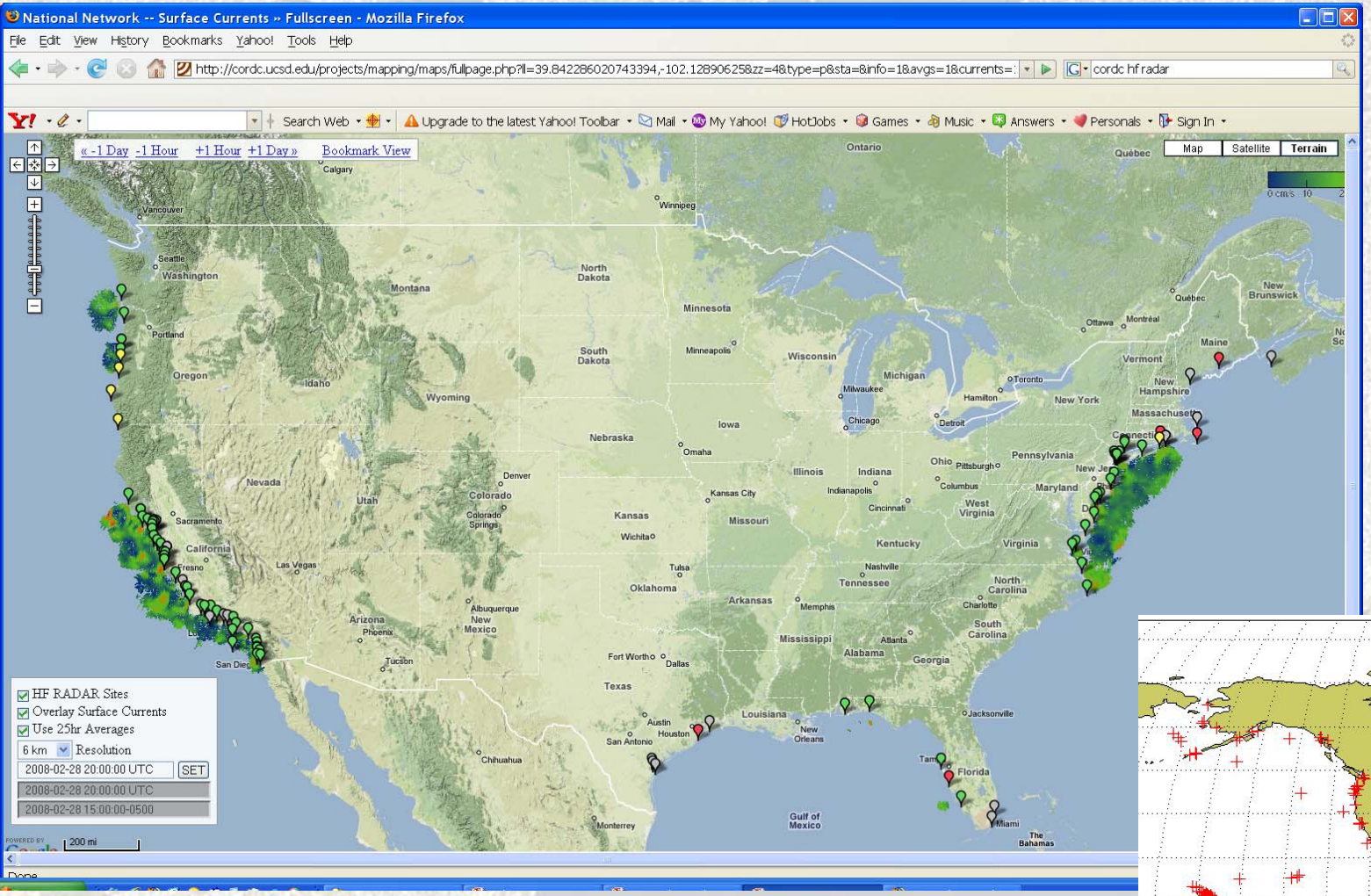






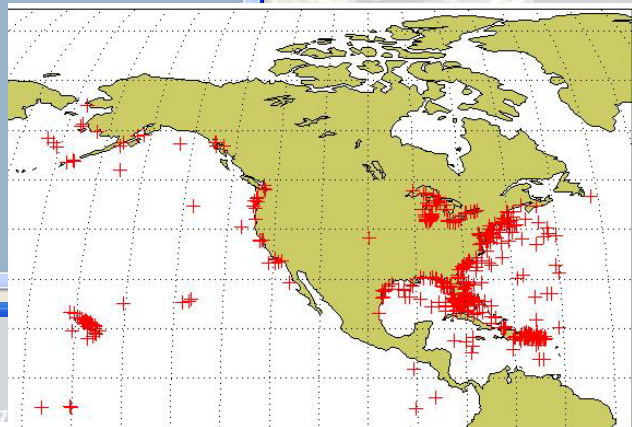
Emerging National HF Radar Network
Rutgers – East Coast NOAA Hub
Scripps – West Coast NOAA Hub

National HF Radar Network: 96 Sites from 22 Institutions

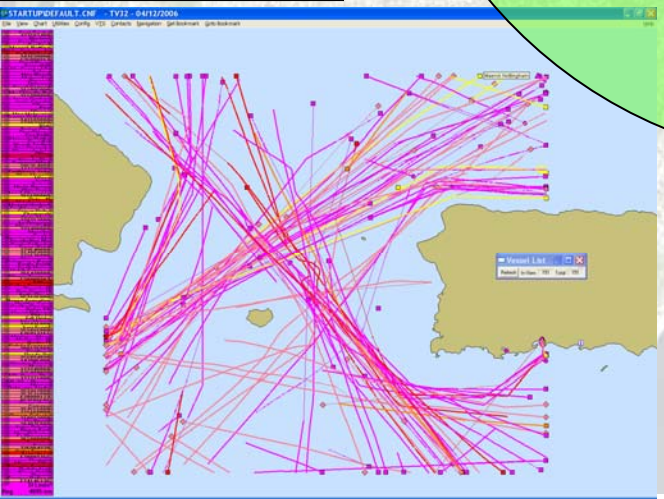


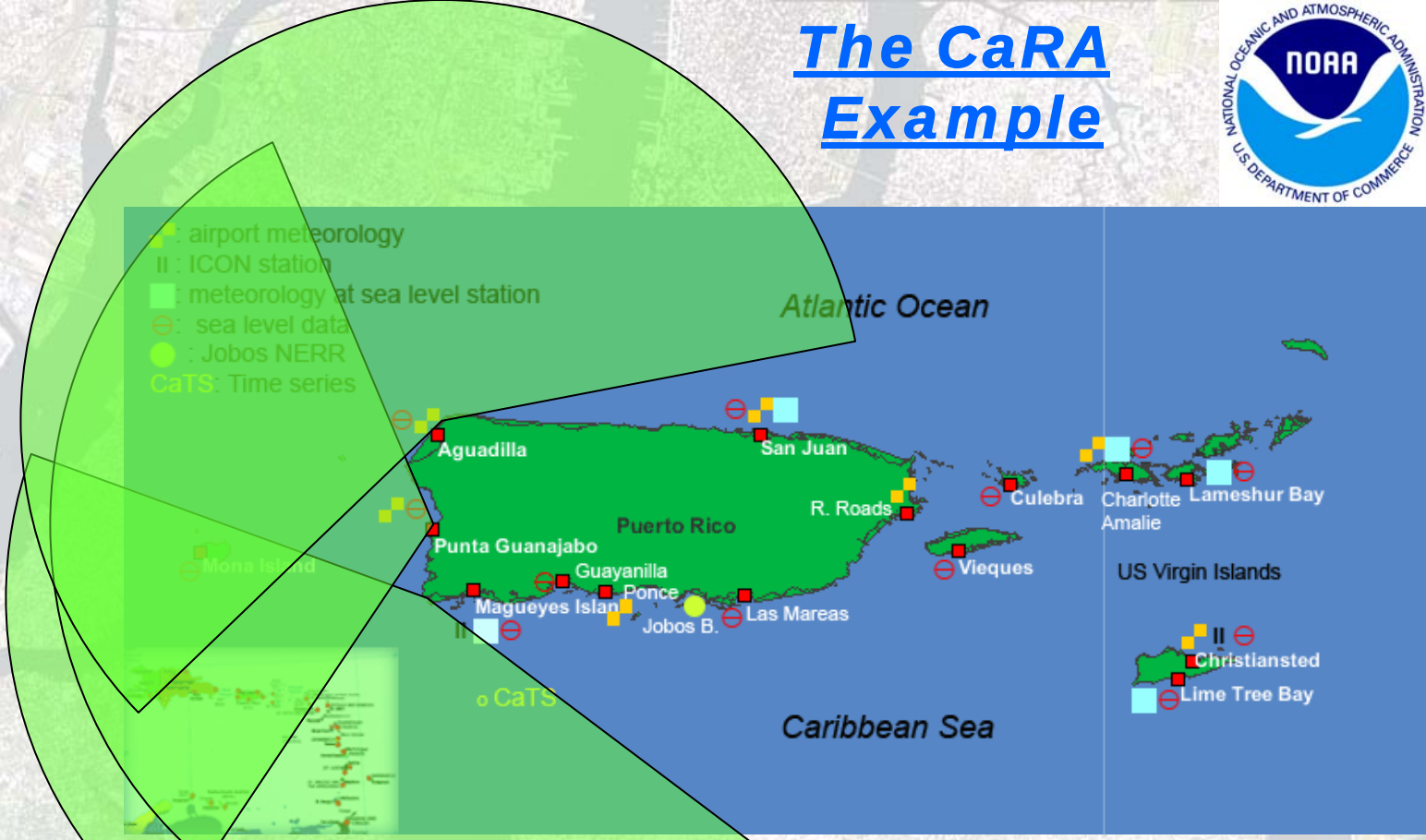
NOAA National HF Radar Network

USCG Drifter Deployments For Search And Rescue



The CaRA Example





Planned HF Radar Sites In Puerto Rico

AIS Vessel Traffic in the Mona Passage

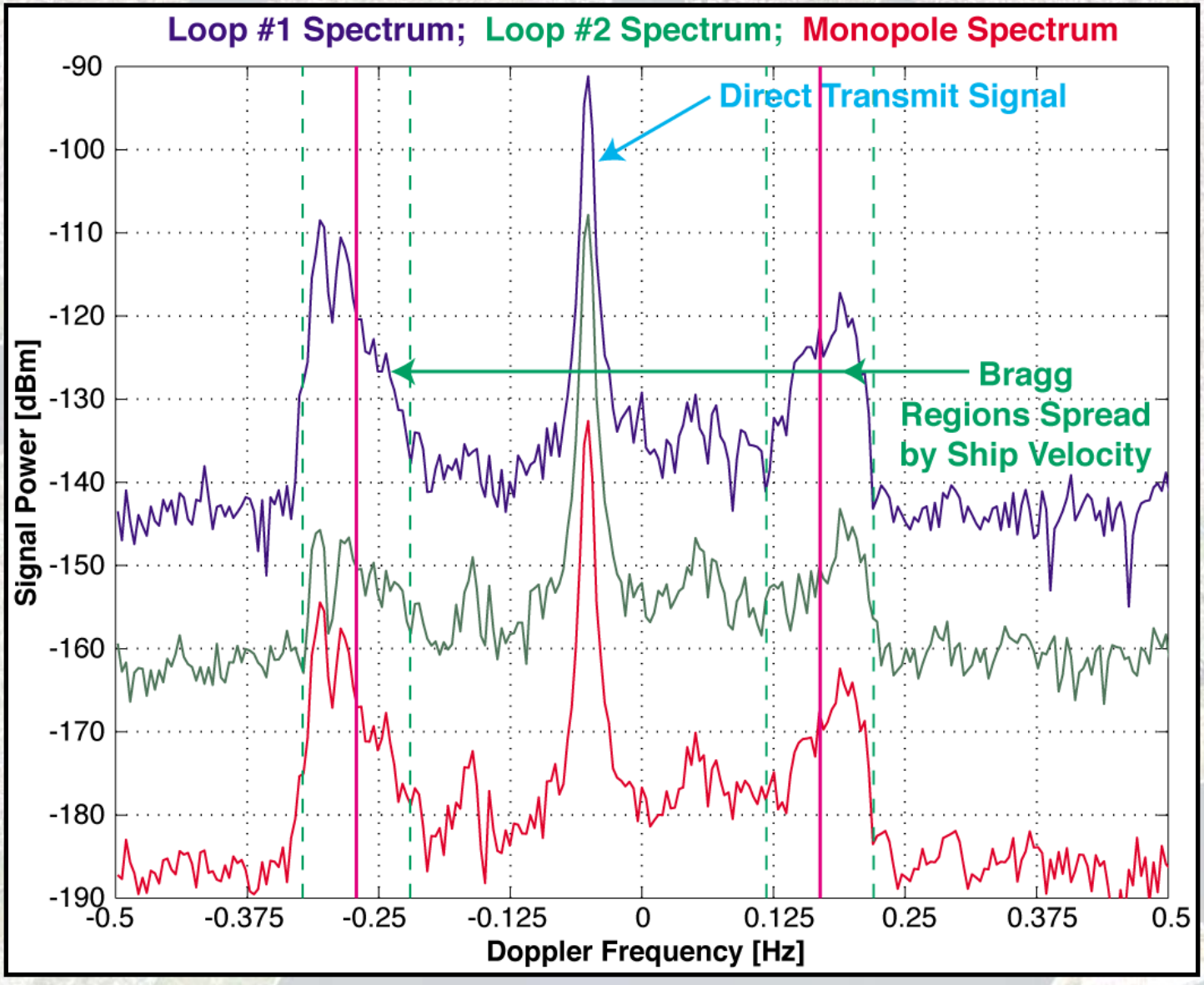
uprm.edu
universidad de puerto rico
Recinto Universitario de Mayagüez

HF Radar for Over-the-Horizon Vessel Detection & Tracking

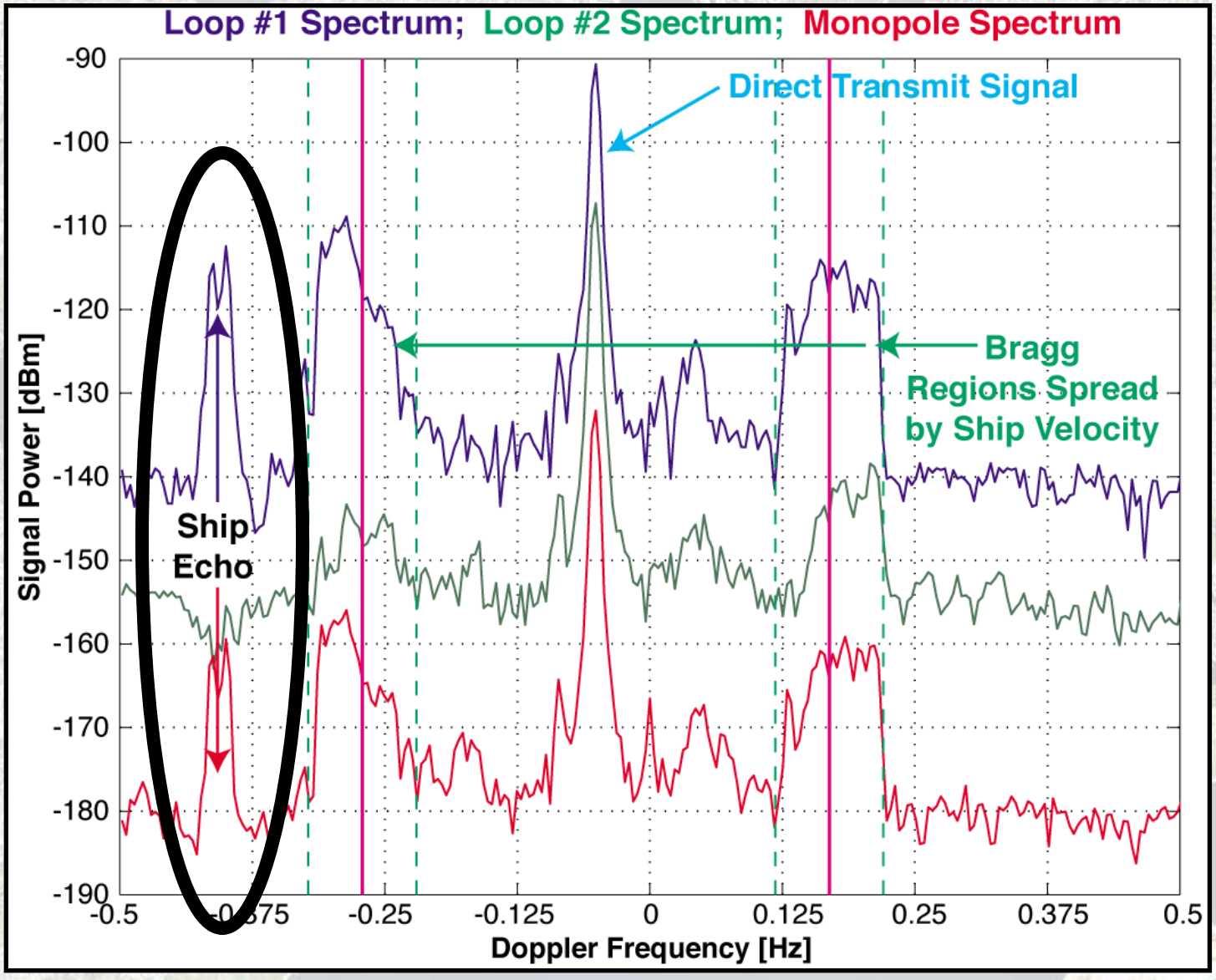
Rutgers Coastal Ocean Observation Lab
Rutgers Computational Biomedicine Imaging and Modeling Center
CODAR Ocean Sensors

<u>Dual use</u> from the same Radar network– Currents (SAR) & Ships (MDA)
Distributed network is robust to countermeasures
Multi-static operations further increases coverage

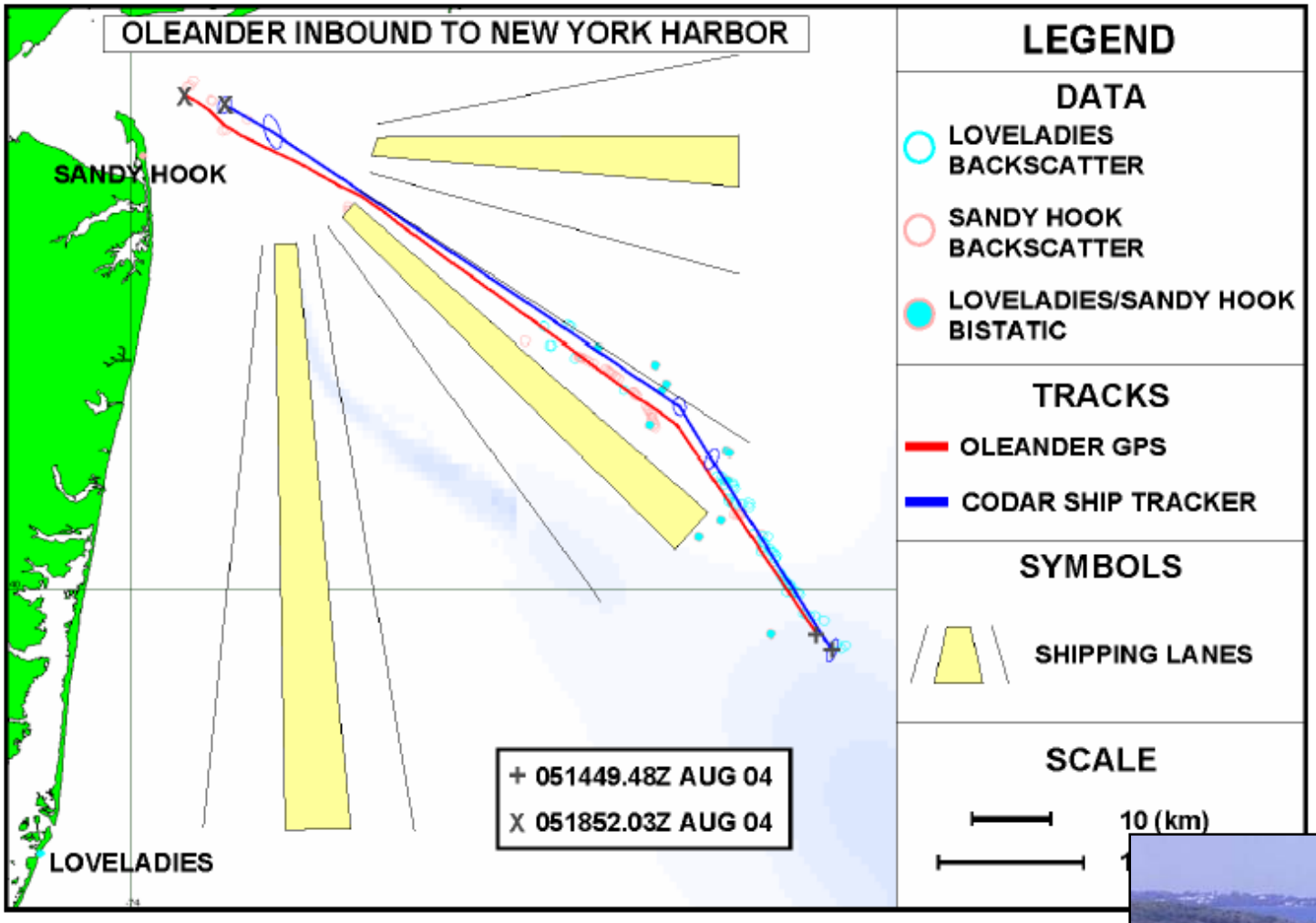
Bragg Peaks from a Moving Transmitter (4.66 MHz)



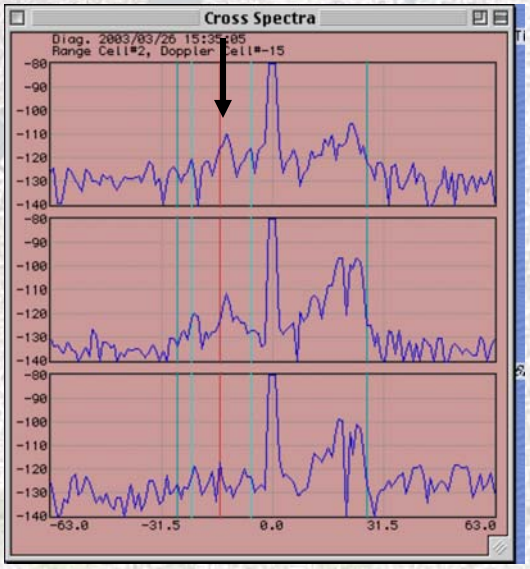
Bragg Peaks from a Moving Transmitter (4.66 MHz)

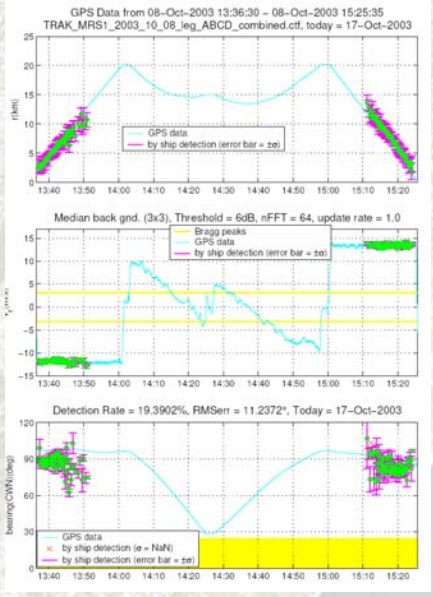


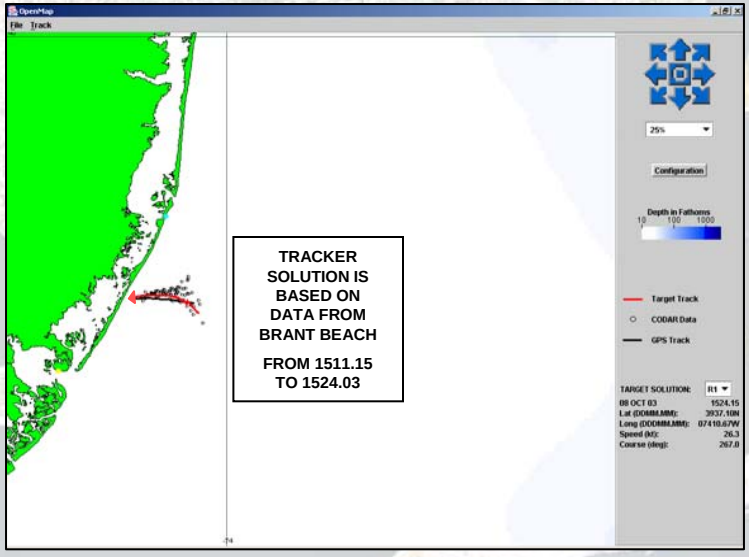
Vessel Detection and Tracking



SeaTow 25



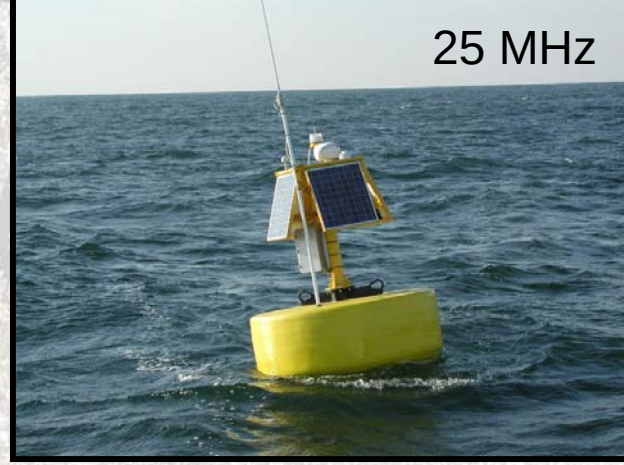


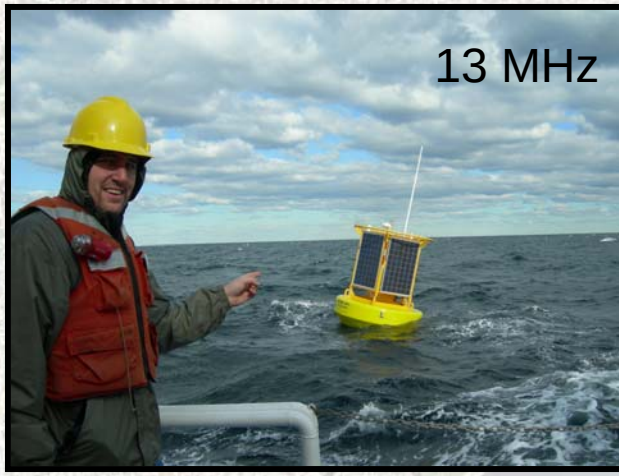


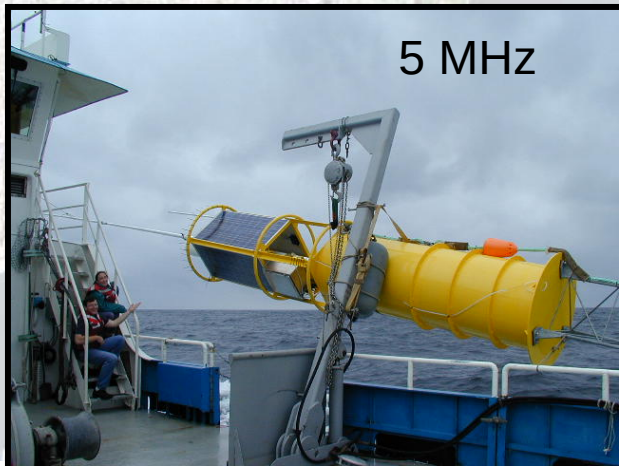
TRACKER SOLUTION IS BASED ON DATA FROM BRANT BEACH

FROM 1511.15 TO 1524.03

Bistatic Augmentation – Ambrose Light







Maritime Security Laboratory (MSL)

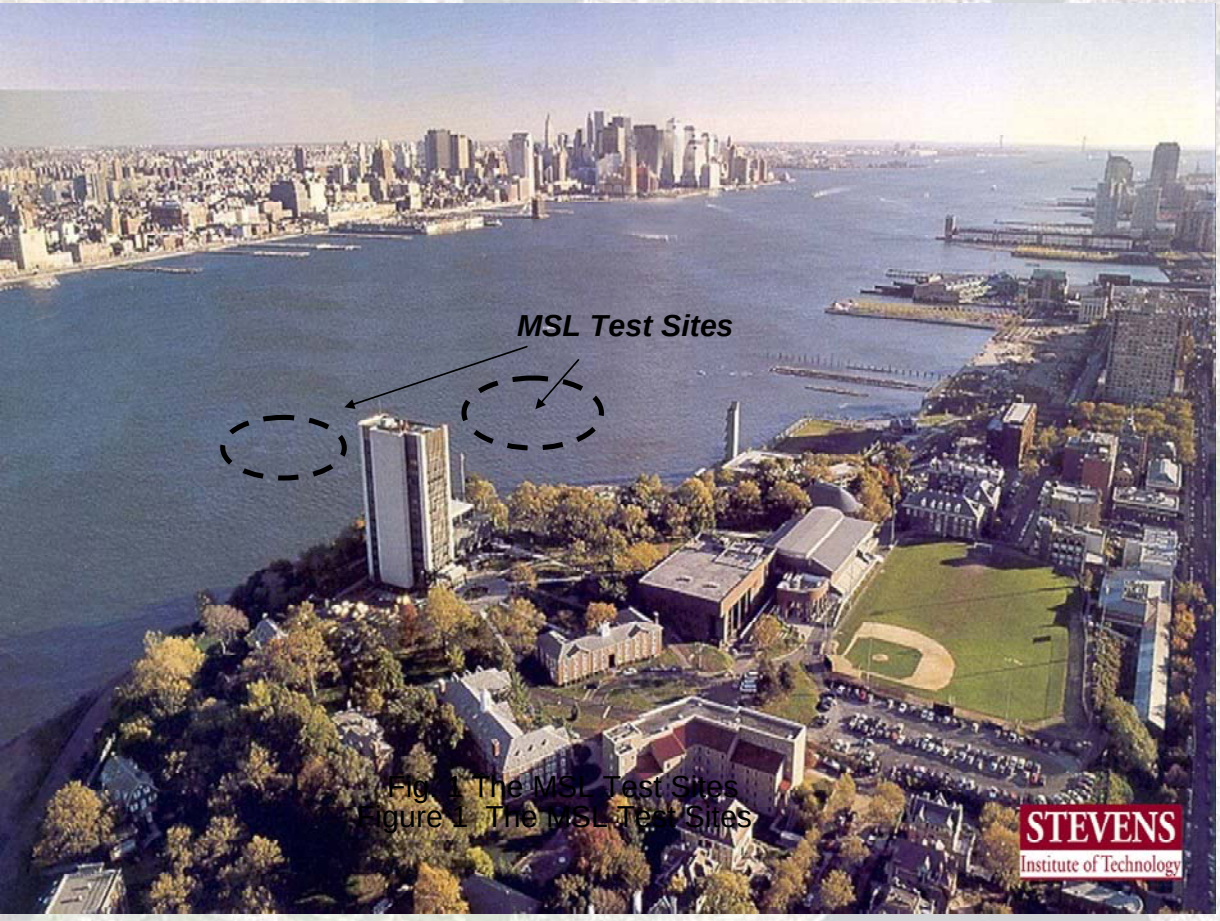
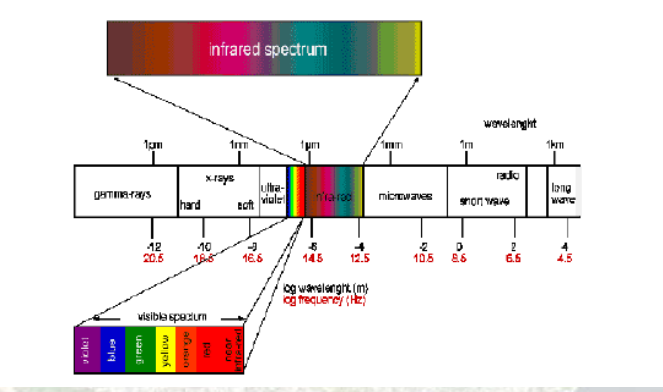


Fig. 1 The MSL Test Sites
Figure 1 The MSL Test Sites

Laboratory features:

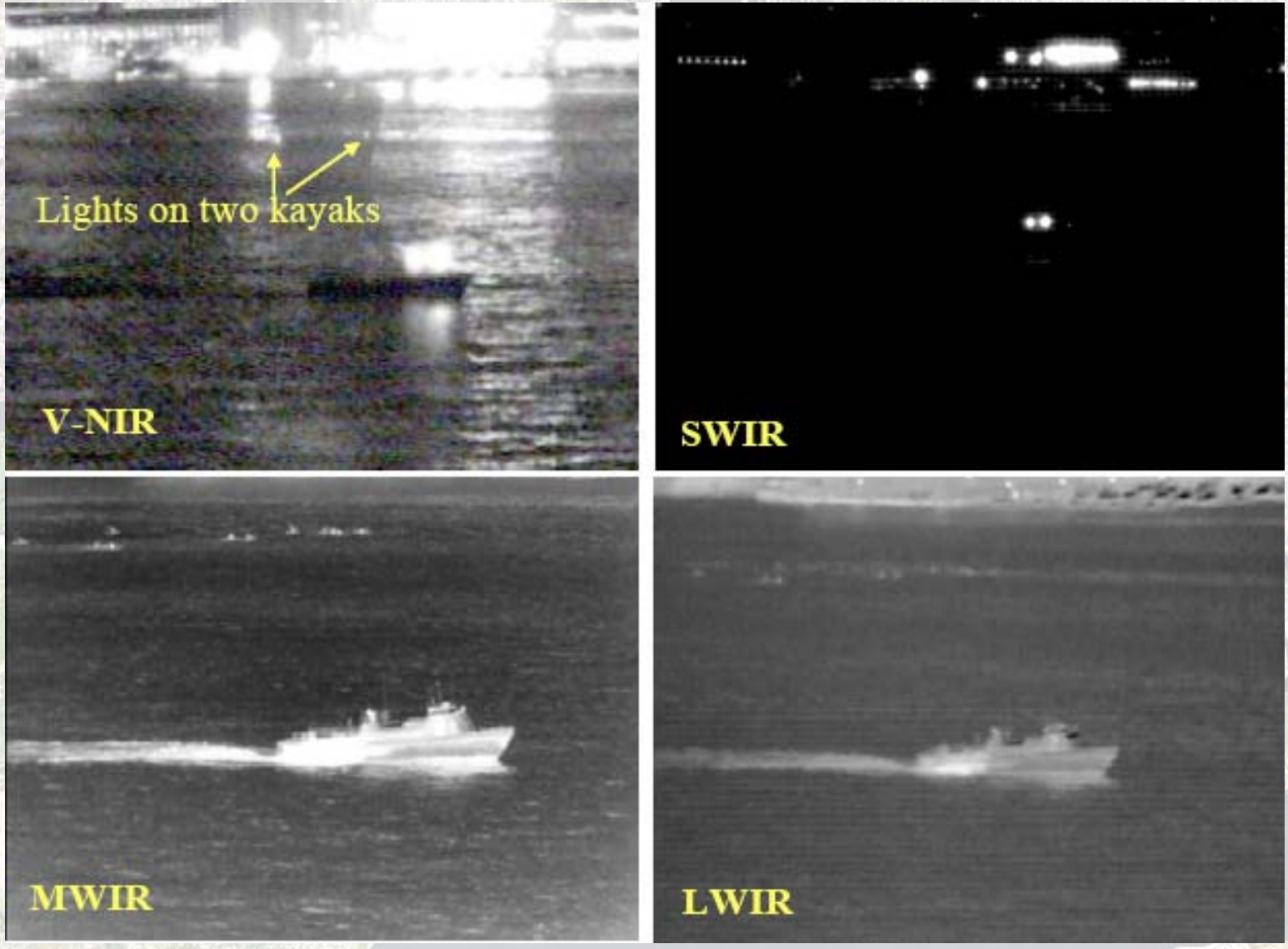
- **Real-time command & control**
- **Systems-level experiments & integration**
- **Relevant environments and scenarios**

Maritime Security Laboratory (MSL)



Four High-Resolution High-Speed Visible-Infrared Cameras

Maritime Security Laboratory (MSL)

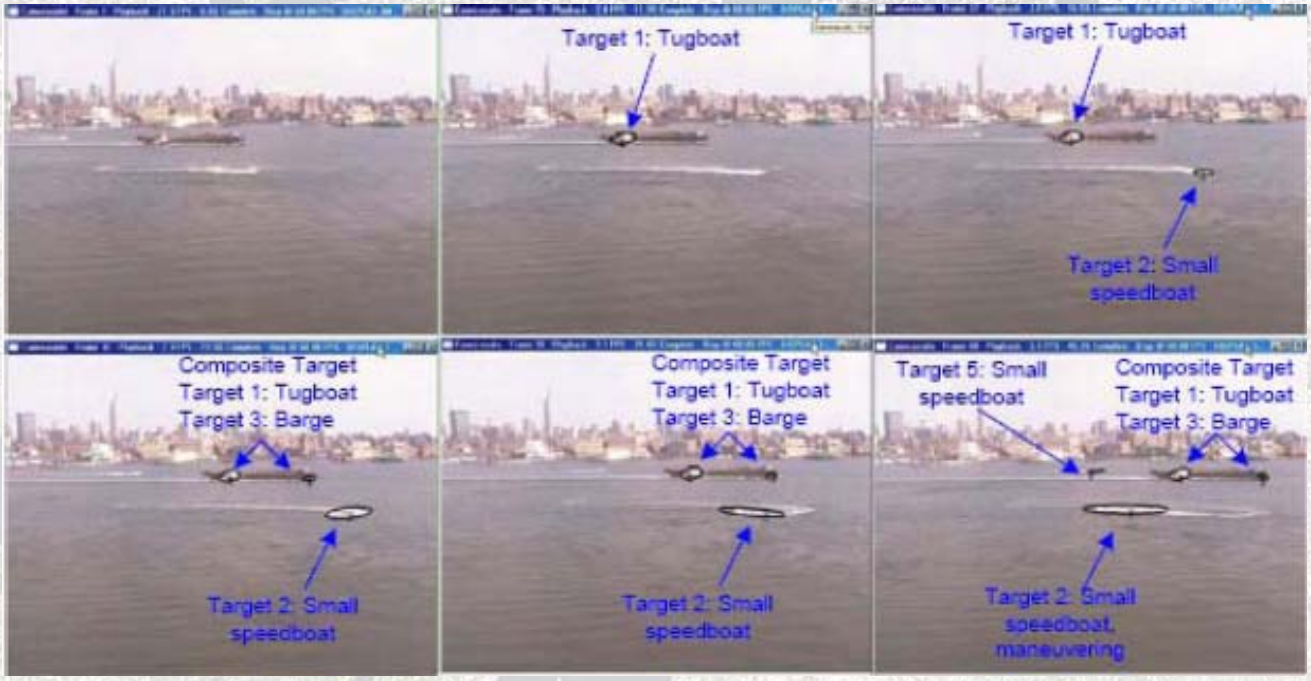


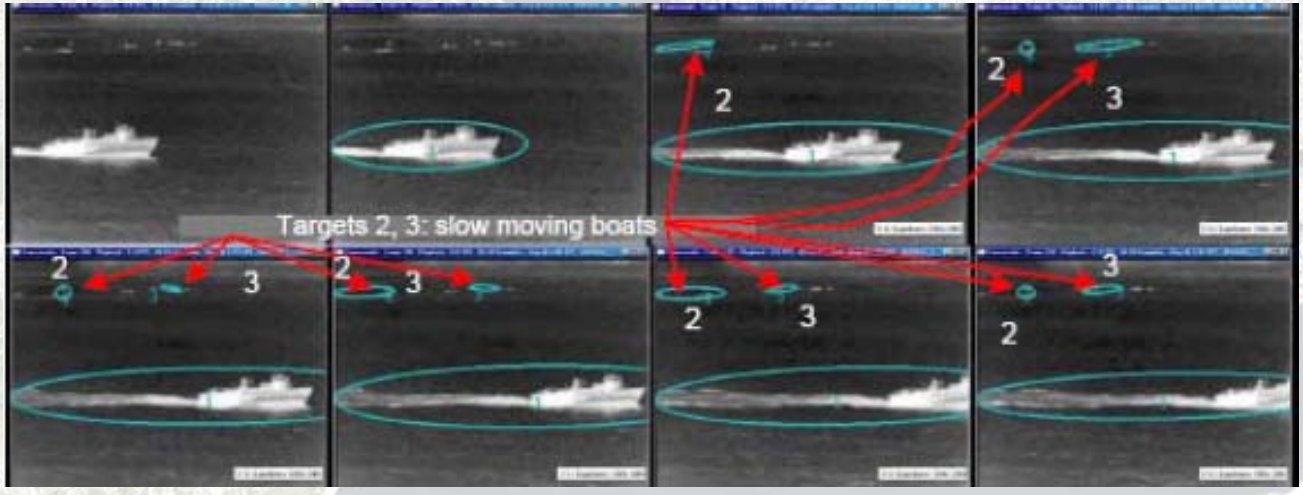
Four Night Images in New York Harbor

Maritime Security Laboratory (MSL)

Object Cast Overboard – MWIR – August 28, 2007

Maritime Security Laboratory (MSL)



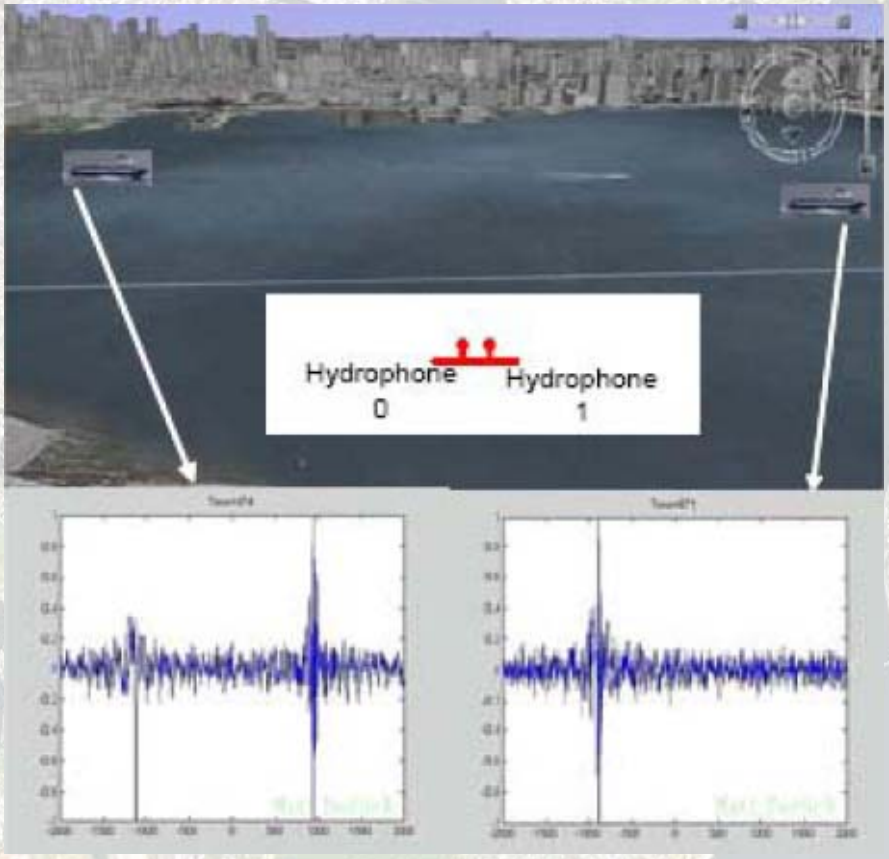


Automated Target Detection and Tracking

Maritime Security Laboratory (MSL)

Geo-referenced vessel tracks based on Field of View measurements

Maritime Security Laboratory (MSL)



Combined underwater acoustic and surface video tracking

Questions?