

A Study of Small Vessel Threats using Acoustic and Electro-optic Technologies

Results received at Summer Research Institute of Stevens
Institute of Technology supported by DHS

Wojciech
Czerwonk

a

Talmor
Meir

Andreas
Graber

Saiyam
Shah

Qing Li

Walter
Seme

Ariel
Marrero



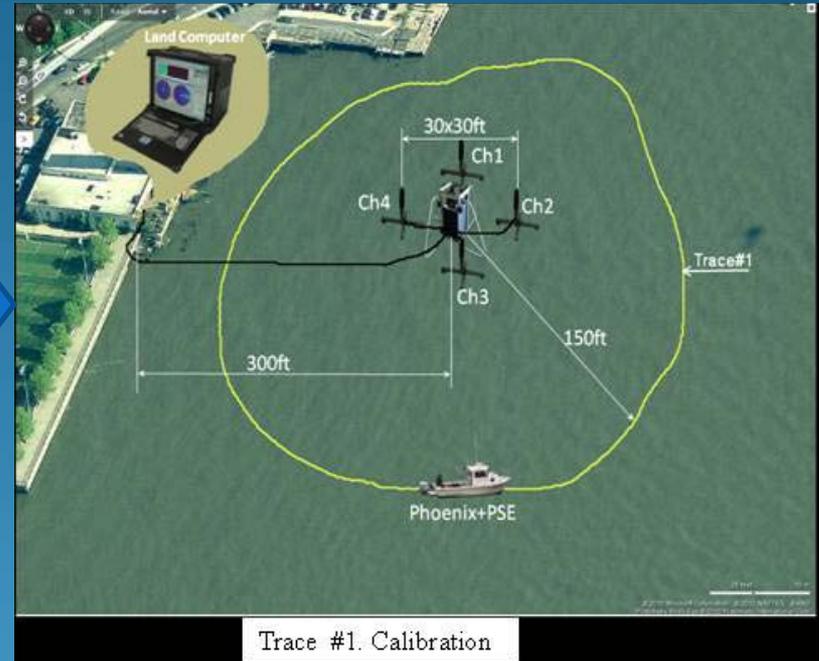
Outline

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- **Methodology**
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 - Infrared (IR)
- **Results**
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 - IR Results
- **Discussion**
 - Acoustic and IR applicability
 - Data fusion
 - Ship classification
 - Acoustic and IR limitations
 - **Conclusion/Questions?**

Objectives

- ▣ To determine the applicability of acoustics and electro-optic technologies in *detecting, classifying* and *tracking* small vessels in the Hudson Estuary.
- ▣ Conduct research supporting development of passive acoustic detection, classification and tracking method:
 - Acoustic reconnaissance of estuary
 - Collection of acoustic signatures from different boats
- ▣ Fusion of satellite acoustic and electro-optic data
- ▣ Describe the limitations of acoustics and electro-optic technologies in the maritime security domain.

Acoustic Methodology – System Deployment



July 12th, 2010 14:36GMT

- Underwater computer --approximately 300 ft away from Griffith building
- Four omni-directional hydrophones were released from the Savitsky and positioned near the underwater computer area.
- Exact locations were acquired with a special calibration procedure presented at the next slide

Infrared Equipment

LWIR Camera

- Indigo System's Merlin Uncooled Microbolometer
- 7000 - 14000 nm wavelength
- Long wave is generated by thermal radiation



NIR/SWIR Camera

- SU320KTSX-1.7RT
- 900 - 1700 nm wavelength
- Does not detect thermal radiation
- Detects infrared light in specified wavelength



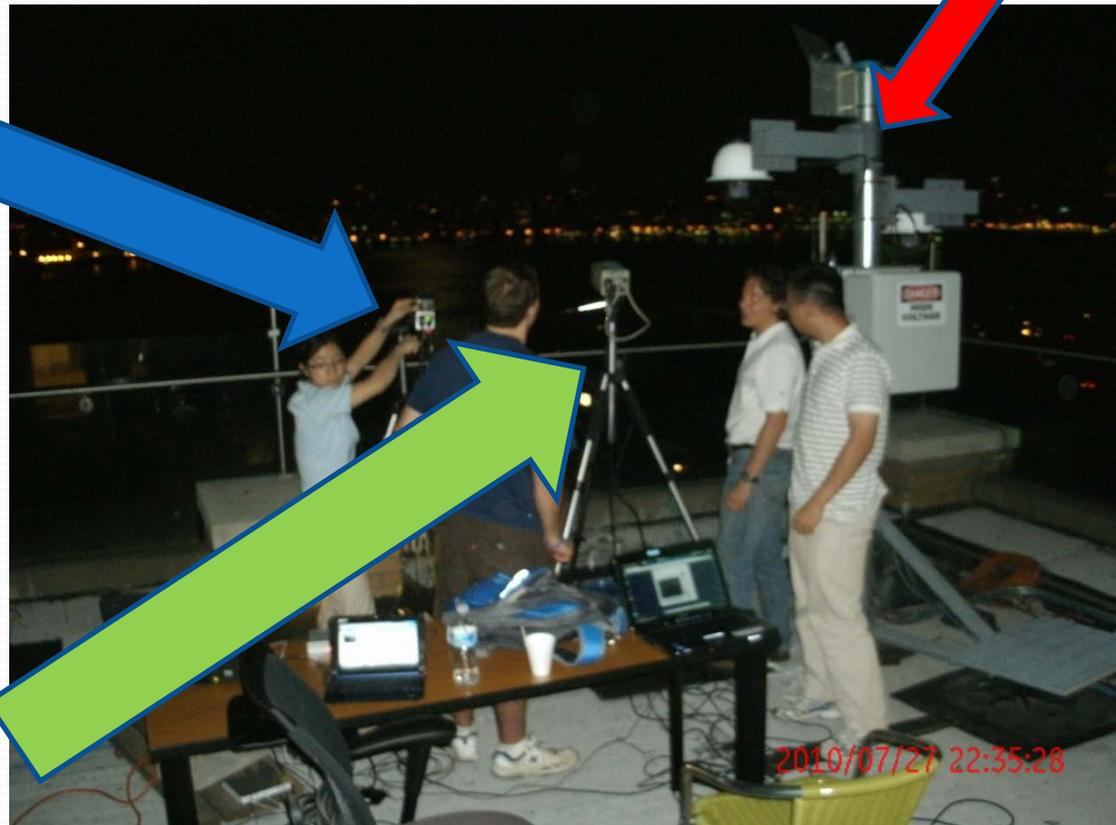
Set up

- 6th floor Babbio Center patio

CCTV

NIR/SWIR

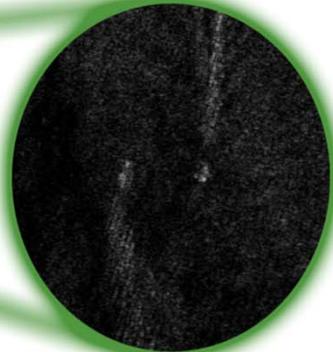
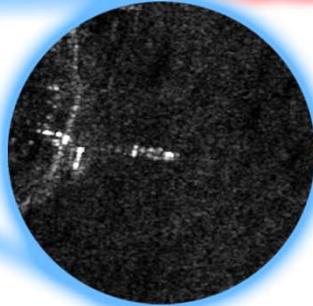
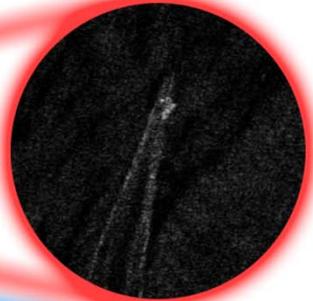
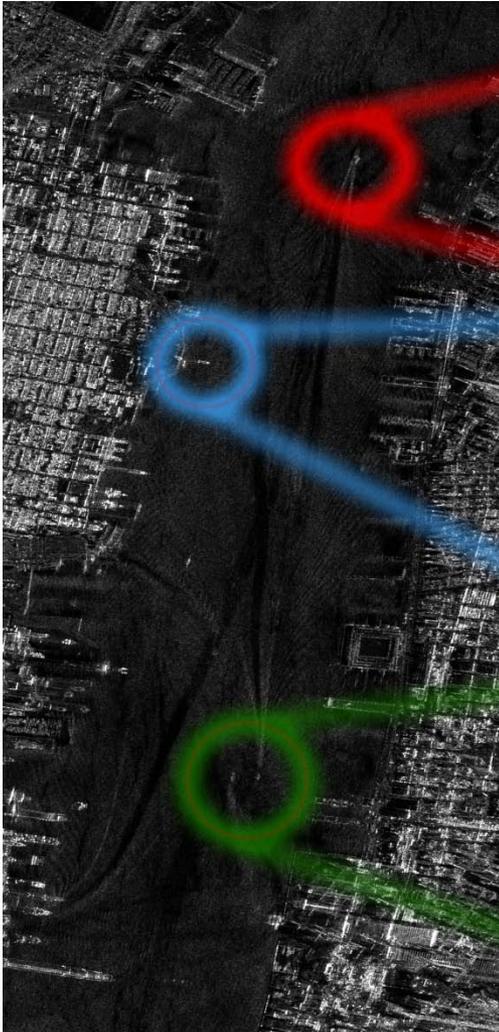
LWIR



Results

Satellite Imaging

TerraSAR-X Pass on 7/13/2010 11:13:21 (GMT)



Data Log: TerraSAR-X

July 13th, 2010, 11:06-11:13 GMT

Date	Time(GMT)	Time(ET)	Weather Conditions	System Action Taking	Visible Description	Observation on Display
7/13/2010	11:08:31	7:08:31	Salinity: 13.24 psu; Water Temp: 74.32K; Wind Velocity: 5.65 kn Wind Direction: 136.1		Ferry N to S	
7/13/2010	11:10:02	7:10:02		Sav is turning to North to fix its location (current drift)	Ferry moving from S to N	
7/13/2010	11:10:10	7:10:10				strong noise from Sav
7/13/2010	11:10:54	7:10:54			Ferry from N to S	
7/13/2010	11:13:06	7:13:06			Satellite PASS. Sav drifting near array	

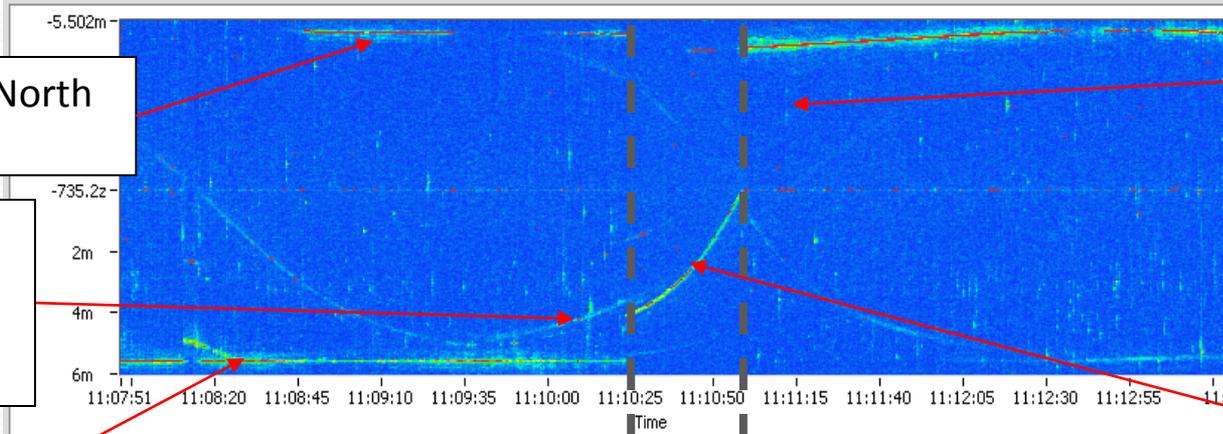


Ferry moving North to South.
 Ferry moving South to North.

Savitsky shifting its position to North.

Acoustic Reconnaissance: TerraSAR-X

Linear Cross Correlation



Ferry from North to South

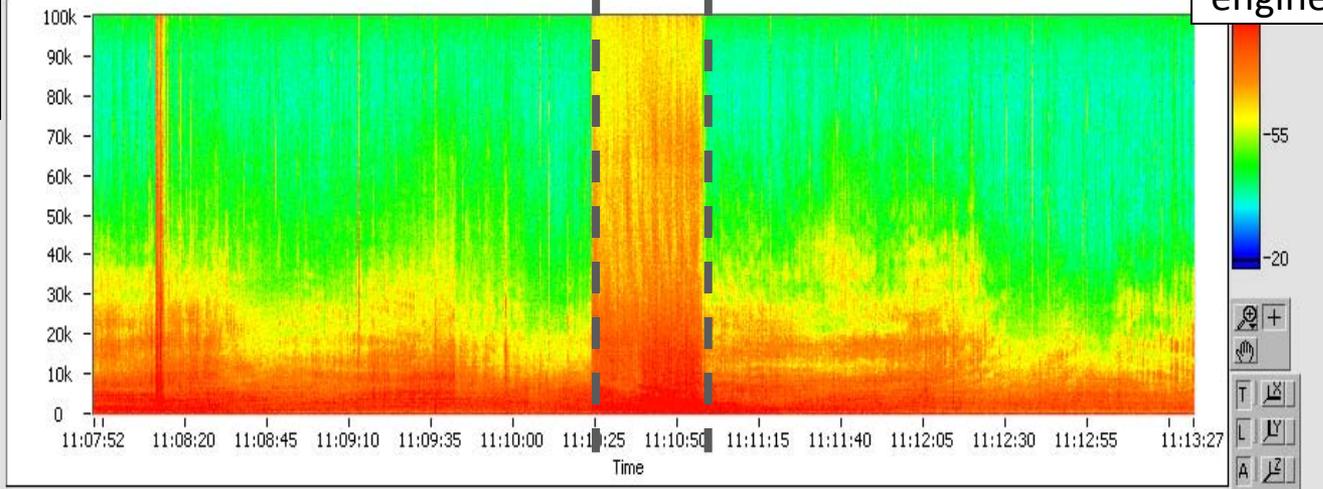
Ferry from South to North

Additional noise from South (entry to Harbor)

Savitsky is Dead-In-the-Water and then begins its testing moving in SE direction.

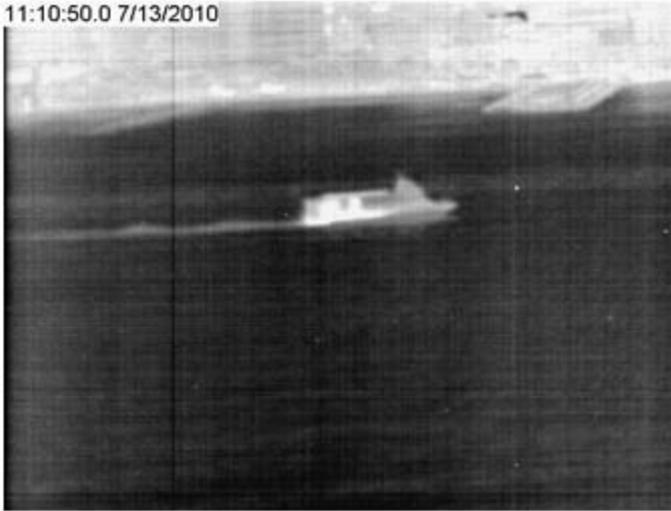
Savitsky moving north to readjust its location. High Intensity coming from the boat's engine

Spectrogram



Infrared Images During Satellite Pass 11:13:21 (GMT)

11:10:50.0 7/13/2010



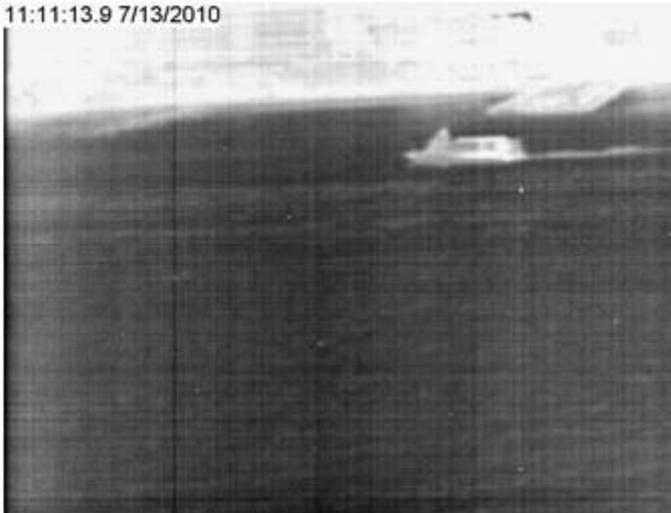
a) LWIR image of Ferry North to South.

11:10:50.5 7/13/2010



b) NIR/SWIR image of ferry North to South.

11:11:13.9 7/13/2010



a) LWIR image of Ferry South to North.

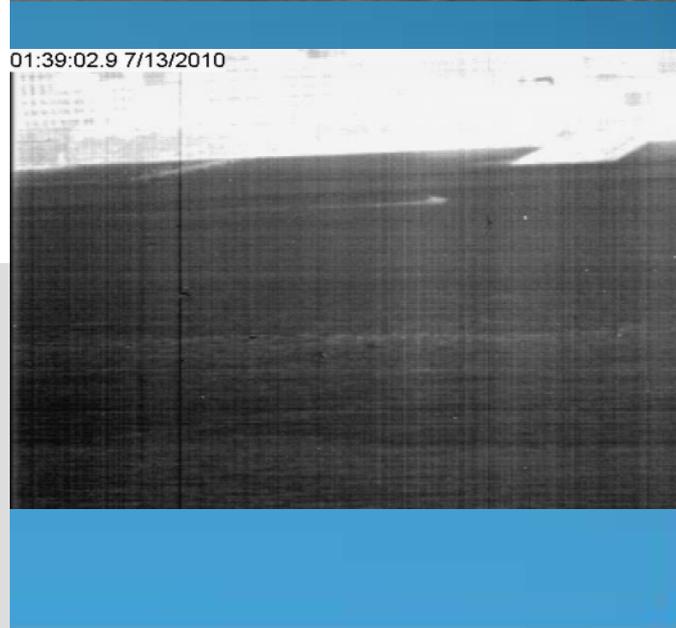
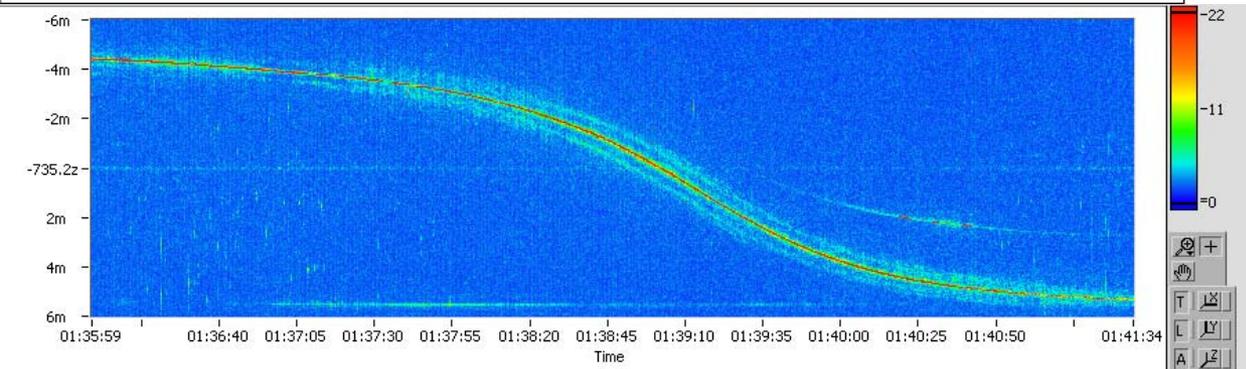
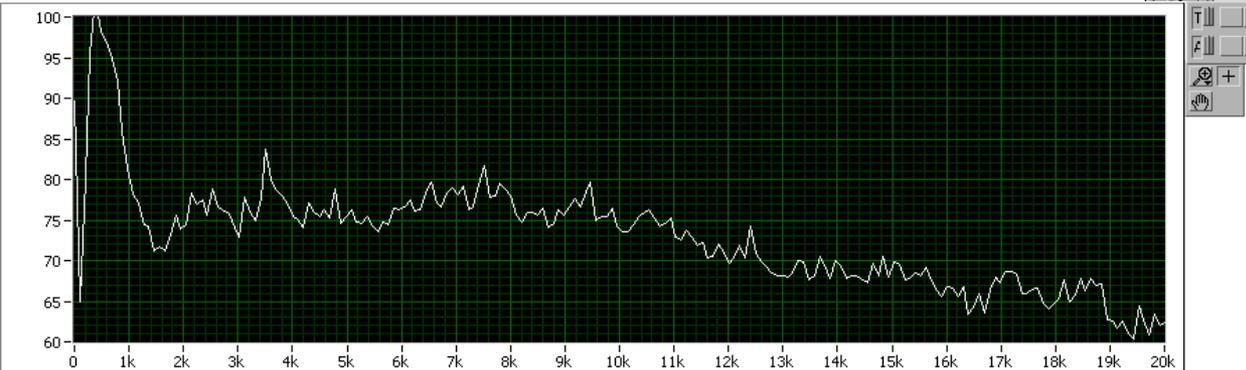
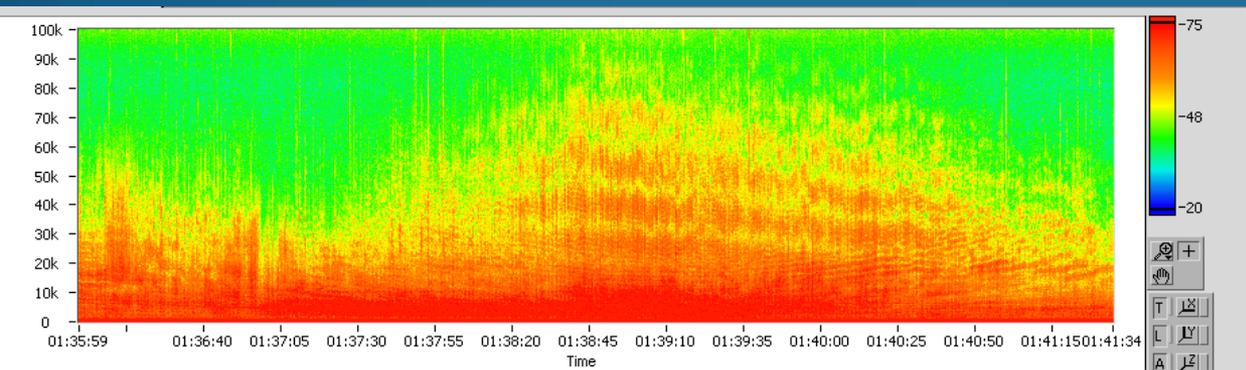
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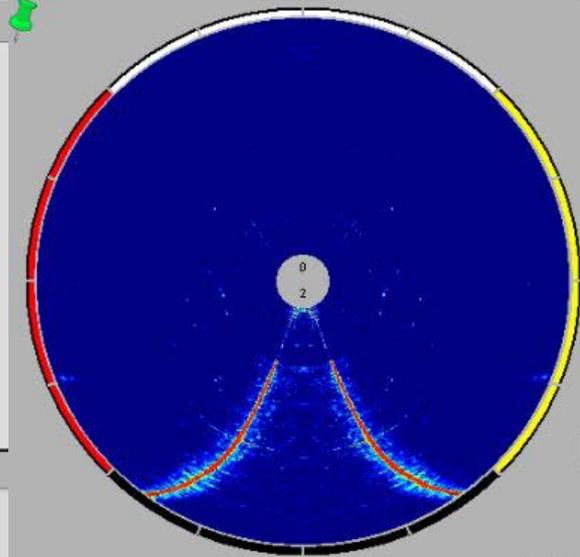
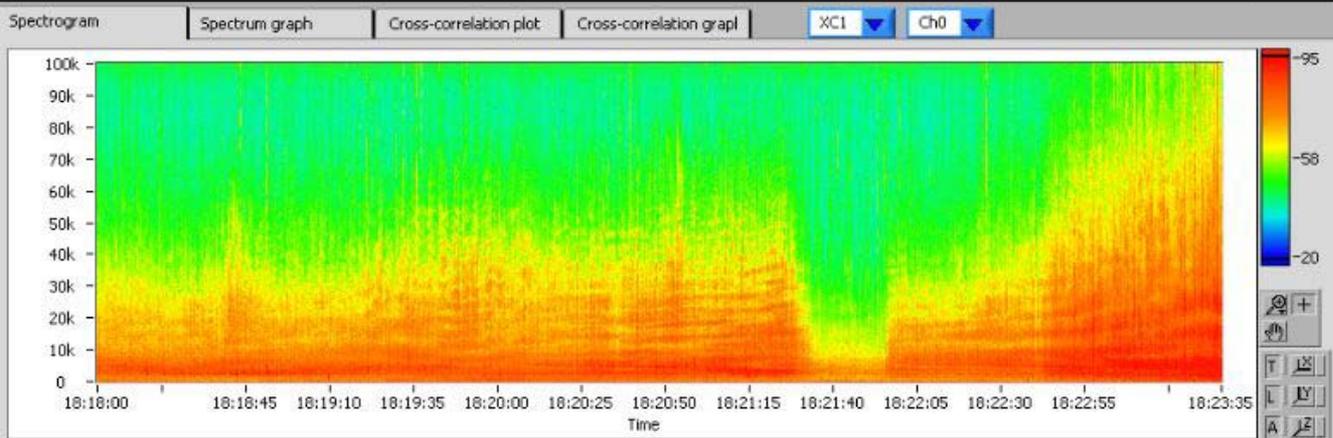
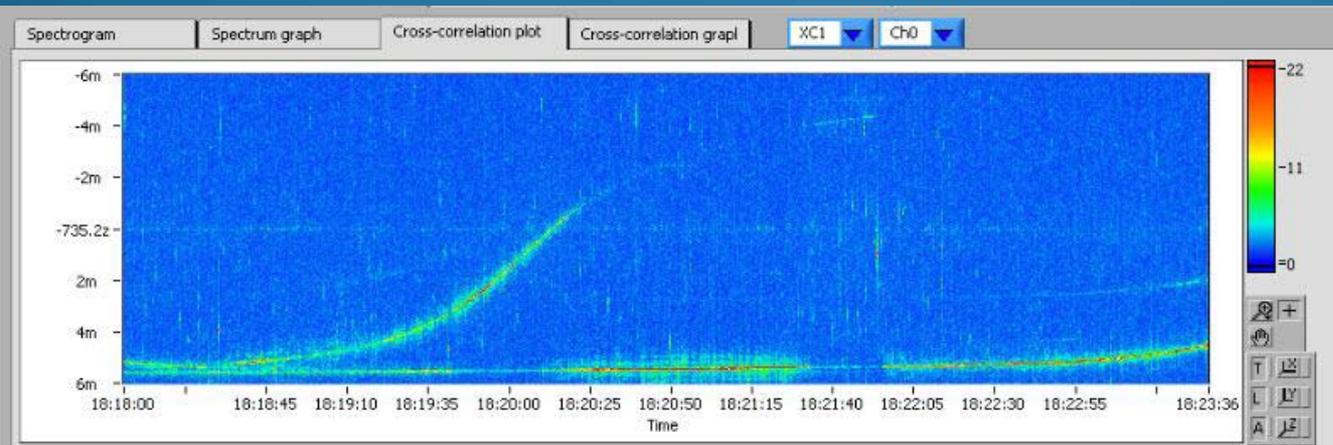
b) NIR/SWIR image of ferry South to North.

Acoustic and IR of Small Boat

Small Boat 7/13/2010 01:39:02 GMT

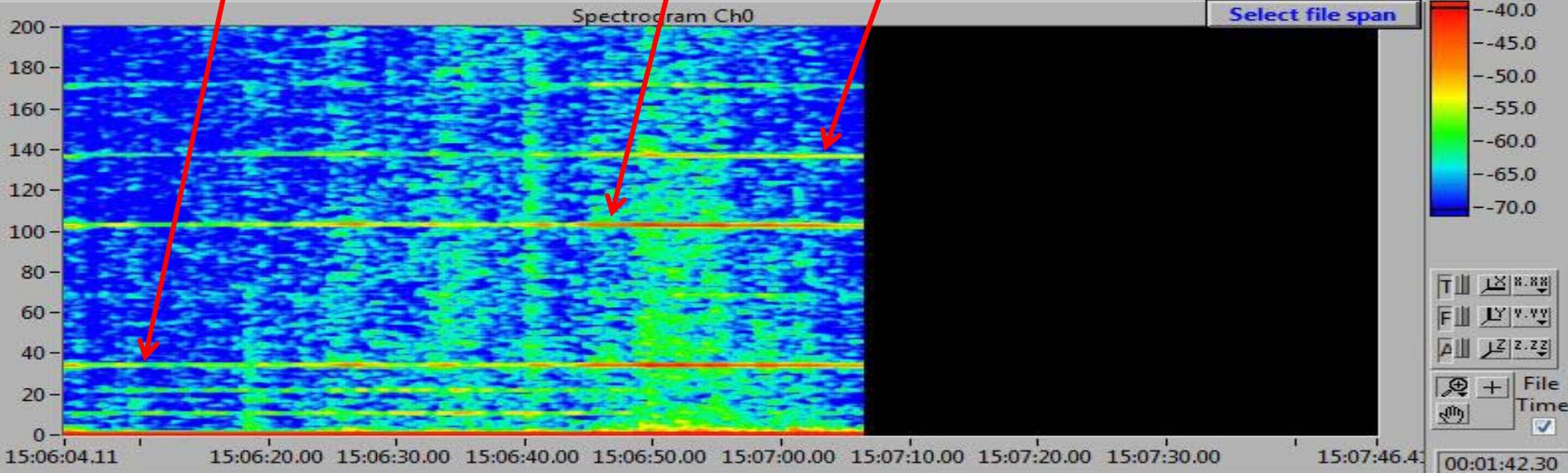
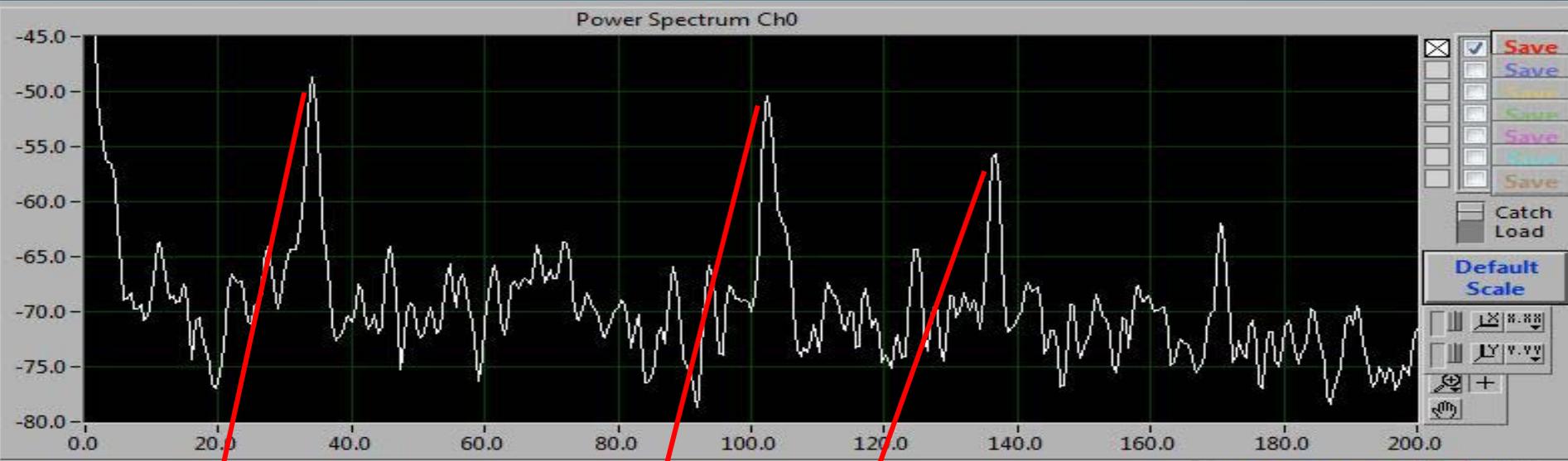


Speed Boat 07/13/2010 18:19:35 GMT

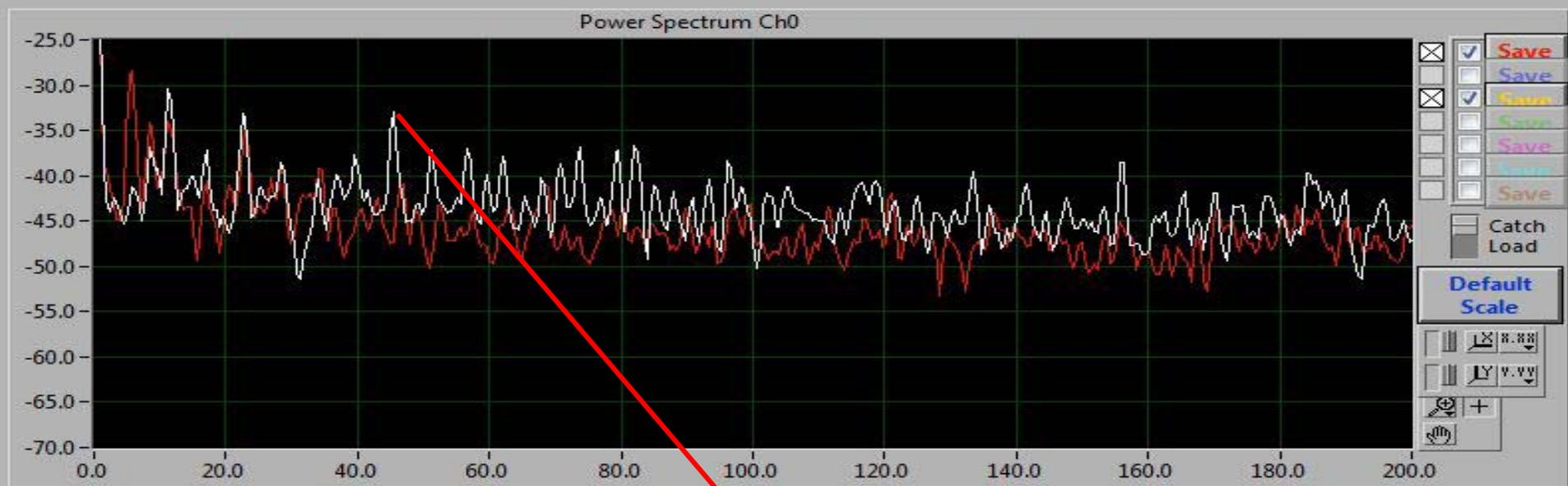


Demon (Detection of Modulation on Noise) signature of speed boat

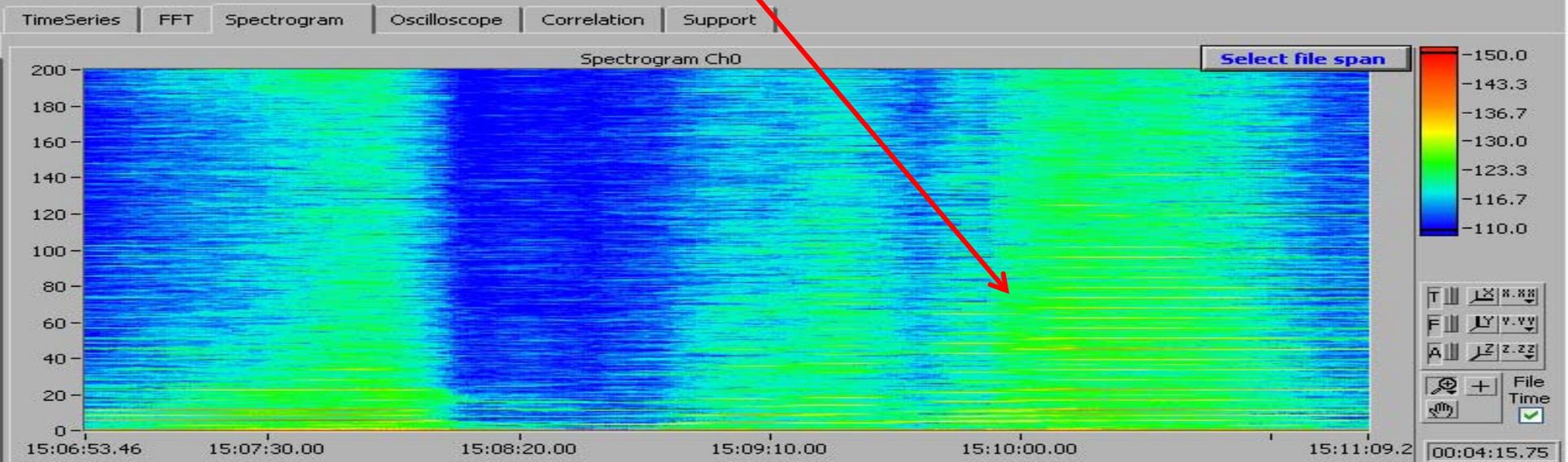
Speed Boat 07/13/2010 18:19:35 GMT



DEP 07/13/2010 15:07:20 GMT



DEMON – (Detection of Modulation on Noise) signature of DEP barge



Infrared Results

- Good detection tool for day and night
- Not useful for underwater imaging
- Possible to determine features of vessels
 - Ex: engine, sails, hot surfaces, and wakes
- LWIR + lens = estimated \$50k
- Applications
 - Surveillance
 - remote detection
 - Track vessels by wake
 - Search and rescue
 - Check for defective equipment



Conclusion

- Joined testing illustrated that fusion of data from satellite, IR and acoustics indeed produces a more complete reconnaissance of the maritime domain.
- Satellite images provide the control room with the bigger figure of the area of interest but are limited on its time domain.
- Infrared cameras are extremely useful during night hours and bad weather conditions where sight capabilities become narrow.
- Passive acoustic system excelled in vessel classification and tracking.
- Having all three technologies incorporated into the production of maritime security reconnaissance has shown a more complete network of information.

Any Questions?

Acknowledgements

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