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# Tactical Networking and Collaboration on Maritime-Sourced Nuclear Radiation Threat: Tracking, Detection, and Interdiction

Bordetsky, Alex

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# **Tactical Networking and Collaboration on Maritime-Sourced Nuclear Radiation Threat: Tracking, Detection, and Interdiction**

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**In cooperation with Dr. Arden Dougan, Dr. Bill Dunlop, and Dave Trombino  
Lawrence Livermore National Laboratory, LLNL-PRES-424149**

Performed under the auspices of the U.S. Department of Energy  
by LLNL under the Contract DE-AC52-07NA27344.

**MIO Planning Workshop, NPS, March 29-30, 2011**



# Background



- Beginning in 2002, a team of Naval Postgraduate School researchers together with sponsors from USSOCOM, and later joined by the OSD and DHS S&T Programs, started a new campaign of discovery and constraints analysis experiments, which is now collectively known as Tactical Network Topology (TNT) Experiments.
- The first one involves quarterly field experiments with USSOCOM, in which NPS researchers and students as well as participants from other universities, government organizations, and industry investigate various topics related to tactical networking with sensors and unmanned aerial systems (UAS) as well collaboration between geographically distributed units with focus on high value target (HVT) tracking and surveillance missions.
- The second direction involves Maritime Interdiction Operation (MIO) experiments with Lawrence Livermore National Laboratory, USCG, First Responders (San Francisco Bay, New York/New Jersey) supported by HLD and HLS S&T Programs and DoE agencies. These experiments are conducted twice a year and are also supported by the overseas partners from Sweden, Germany, Denmark, Greece, and Singapore.



# NPS-LLNL MIO Experimentation Partners

## NPS Team

Networks: ship-to-ship, ship-to-shore  
Collaborative Technology  
Operations & Command Center  
VPN reachback  
Unmanned vehicles  
Biometrics

## LLNL Team

HOPS  
Export Control  
Radiation Reachback  
Plume Modeling  
Radiation Sources  
Radiation Detection  
Ultra-wide band Communication  
Explosives Detection

## Participating DoD and U.S. Gov't.:

- USSOCOM
- OSD/HD
- Biometric Fusion Center
- NIST
- MARAD
- USCG/D-11
- US Marine Corps
- DOE Radiological Assistance Program
- OFT
- DTRA

## Foreign Partners:

National University of Singapore/DSTA  
Swedish National Defense College/Swedish Naval Warfare Center  
Salzburg Research  
University of Bundeswehr at Munich

## State and Local Government

Alameda County Sheriff  
Oakland Police Dept.  
San Francisco Police Dept.  
California Office of Emergency Services



## Partners TNT-MIO Experiment 2010

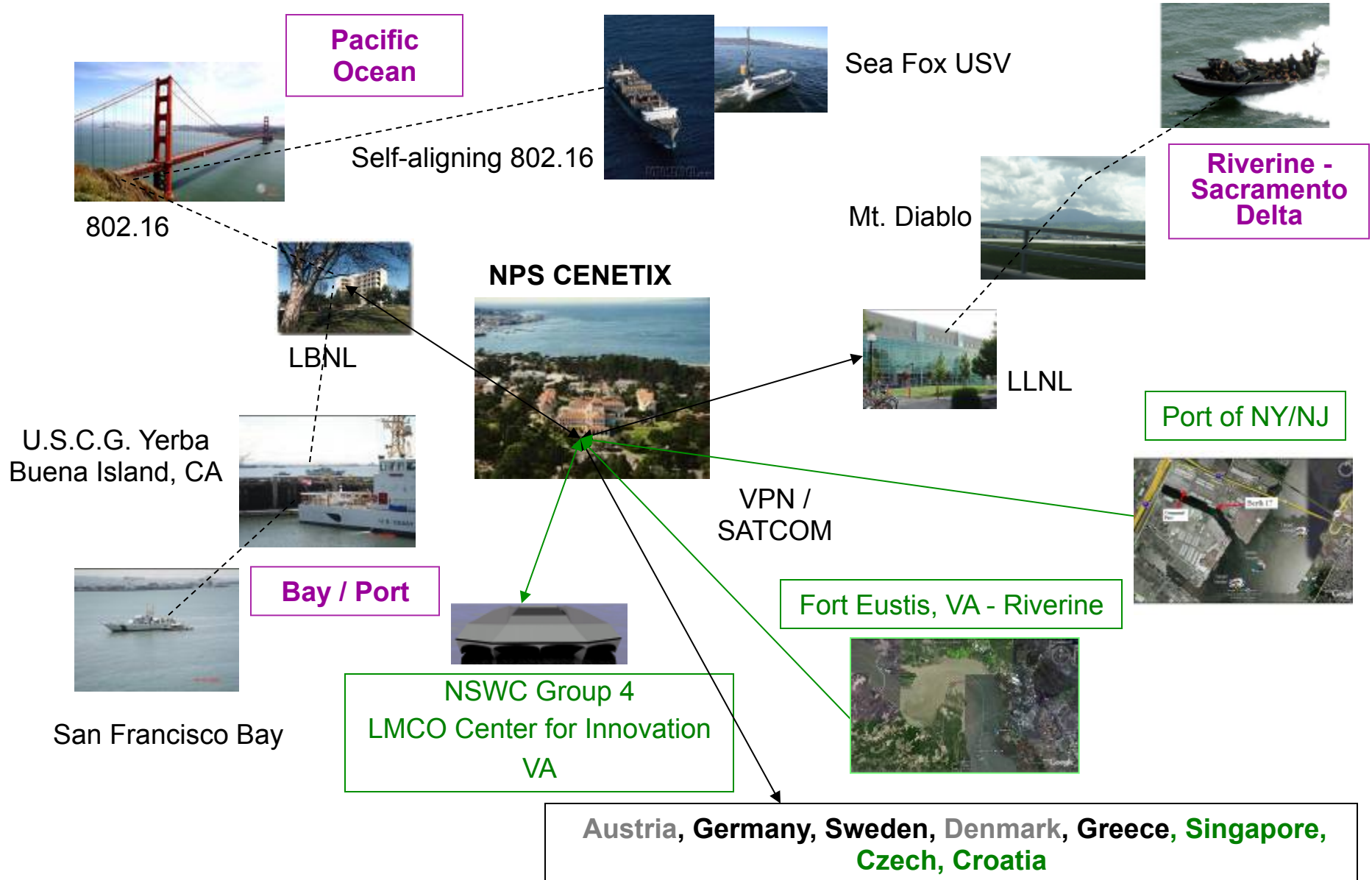
- NPS
- FOI-Sweden
- NATO MIOTC
- LLNL
- ARDEC
- BAE-JSAS
- University of Bundeswehr
- Lockheed Martin Co

### Sponsors:

- USSOCOM
- DHS MDSP
- OSD/HD



# MIO Testbed Segment: SF Bay, East Coast and Overseas





## Functional Focus of the MIO Testbed Geographically Distributed Teams

- **San Francisco:** *All new sensor, unmanned systems, and networking technology; data sharing and collaboration with USCG and marine police units, multiple small boat interdiction, DoE reachback*
- **Ft. Eustis:** *Riverine operations, data sharing and collaboration with NSW, USSOCOM, Army Divers*
- **PANYNJ:** *Data sharing and collaboration with NY-NJ area Police and FD first responders, interoperability with DHS JSAS*
- **Swedish Defense Research Agency:** *Data collection, modeling and simulation*
- **University of Bundeswehr:** *Check points in the smuggling routes, tagging and monitoring*
- **NMIOTC:** *Expert Center for Small Boat interdictions in Mediterranean and Black Sea*
- **Singapore, Prague, Salzburg, : ???**

# NPS-LLNL Network-Controlled Sensors: Searching Cargo Ships and Multiple Small Craft Possessing Nuclear Radiation Threat



## Network Controlled Nuclear Radiation Detection

- Small craft drive-by detection at high speed
- ARAM – Adaptable Radiation Area Monitor used for Drive-by detection
- Choke point (portal) detection operational model
- Stand-off mesh network-controlled detection
- Multiple small craft search and interdiction
- Network-controlled unmanned surface vessels
- Tactical broadband wireless, cellular, satellite, and UWB network

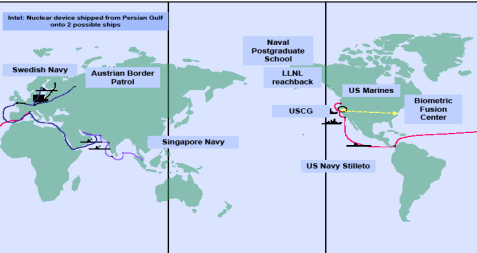
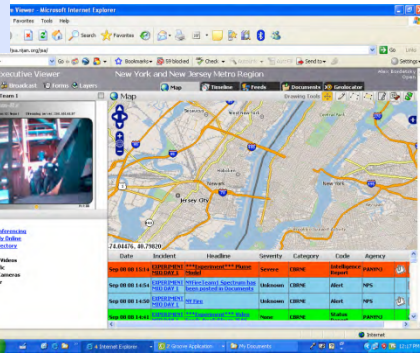
## Globally Distributed Tagging, Tracking, and Search

## Experimentation Goals

Evaluate the use of networks, advanced sensors, and collaborative technology for rapid Maritime Interdiction Operations (MIO), Port Security, and Riverine Operations;

Evaluate ability for a Boarding Party to rapidly set-up ship-to-ship communications that permit them to search for radiation and explosive sources and collect biometrics while maintaining network connectivity with C2 organizations

Learn how to collaborate with remotely located sensor experts, coalition partners, and first responders.







# ARAM – Adaptable Radiation Area Monitor used for Drive-by detection of Nuclear Materials

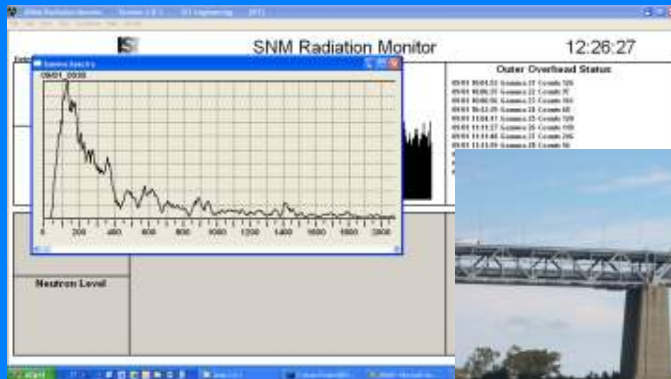


- Real time radiation monitoring system
- Spectral data analyzed to quickly provide actionable information
  - flow of commerce not impeded
  - secondary search possibly not necessary
  - Spectra transmitted to reachback



**R&D  
100**

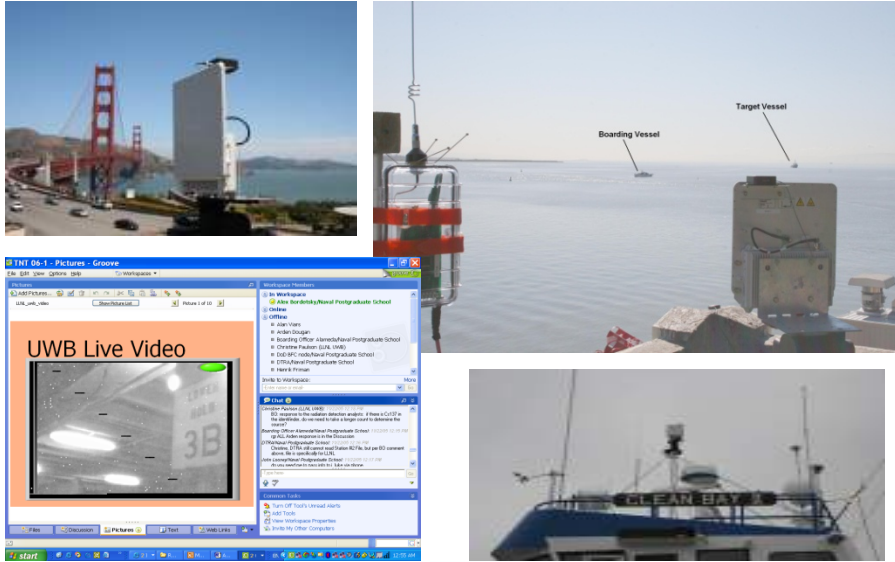
2005



Drive-by detection of radiation sources in small boats; With Reachback 6/6 sources correctly identified



# NPS Self-forming agile adaptive ship-to-ship/ship-to-shore networks



## Major Approach

### Self-Organizing Mesh Wireless Networks

**Network and SA controlled UAVs, USVs, UGVs:** Unmanned vehicle is controlled by submitting the way points via tactical N-LOS mesh network.

**Network-on-Target:** Peer-to-peer links configured from the top of Common Operational Picture interface, self-aligning directional antennas

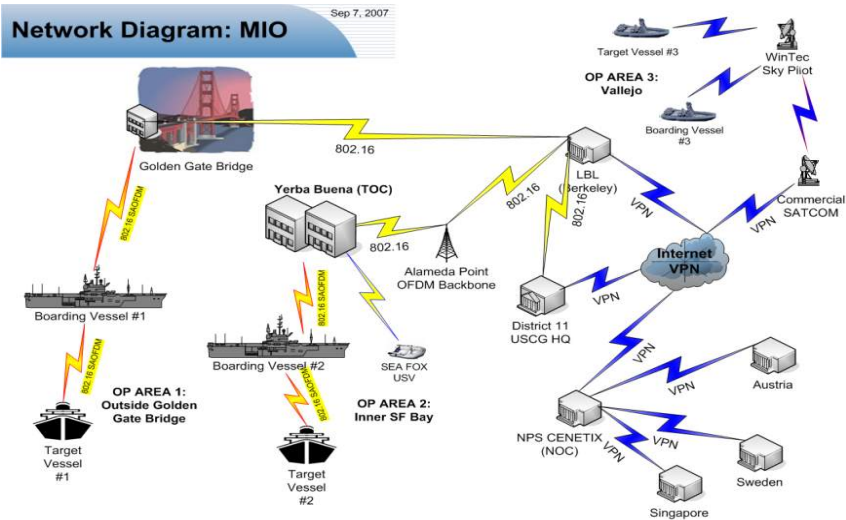
## Unconventional Solutions

**Ultra Wideband (UWB) Mesh networking:** Integrating the UWB link into the peer-to-peer wireless mesh network.

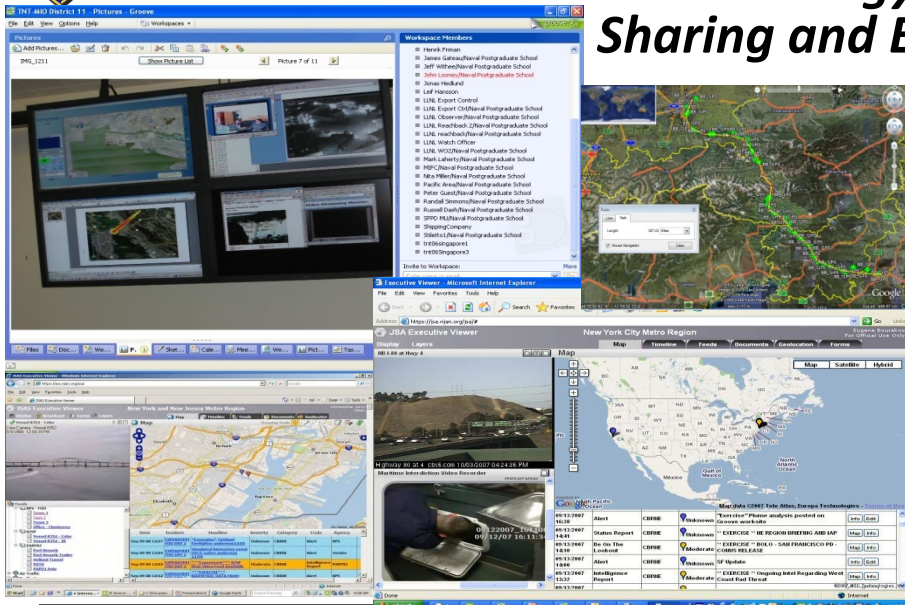
**Projectile-based Networking Hyper-Nodes with 8<sup>th</sup> Layer:** Tactical Self-Forming nodes as miniature network operations centers

**Networking-by-touch:** Transmitting data via highly adaptive human network by using physical or electronic touch.

## Sensor Search and Interdiction Network



# Collaborative Technology for MIO Interagency Data Sharing and Expert Response



## Network Controlled Nuclear Radiation Detection

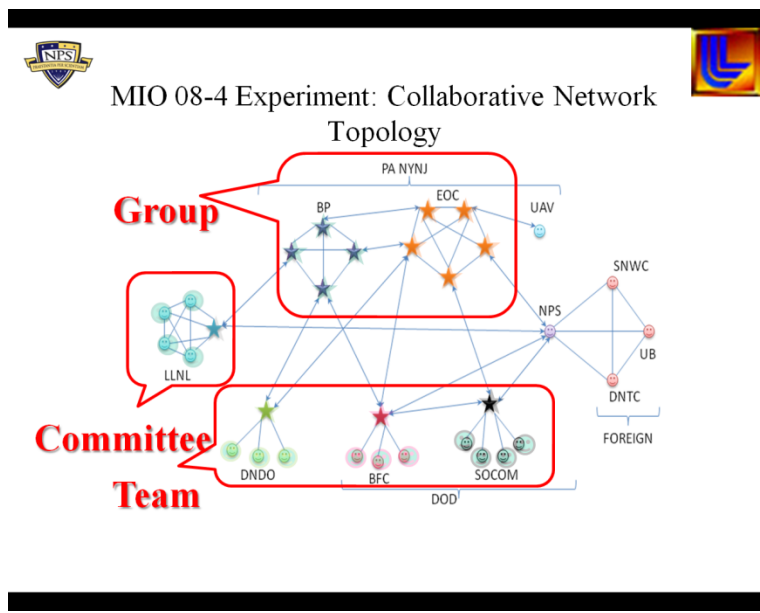
Collaborative networks for rapid interagency data sharing and expert response:

Synergy of social and information networking :

Flattening the emergency response hierarchies in the virtual space

MIO SA and Collaborative platforms interoperability

## Synergy and Patterns of Collaboration



## Cargo Ship Search & Interagency Collaboration

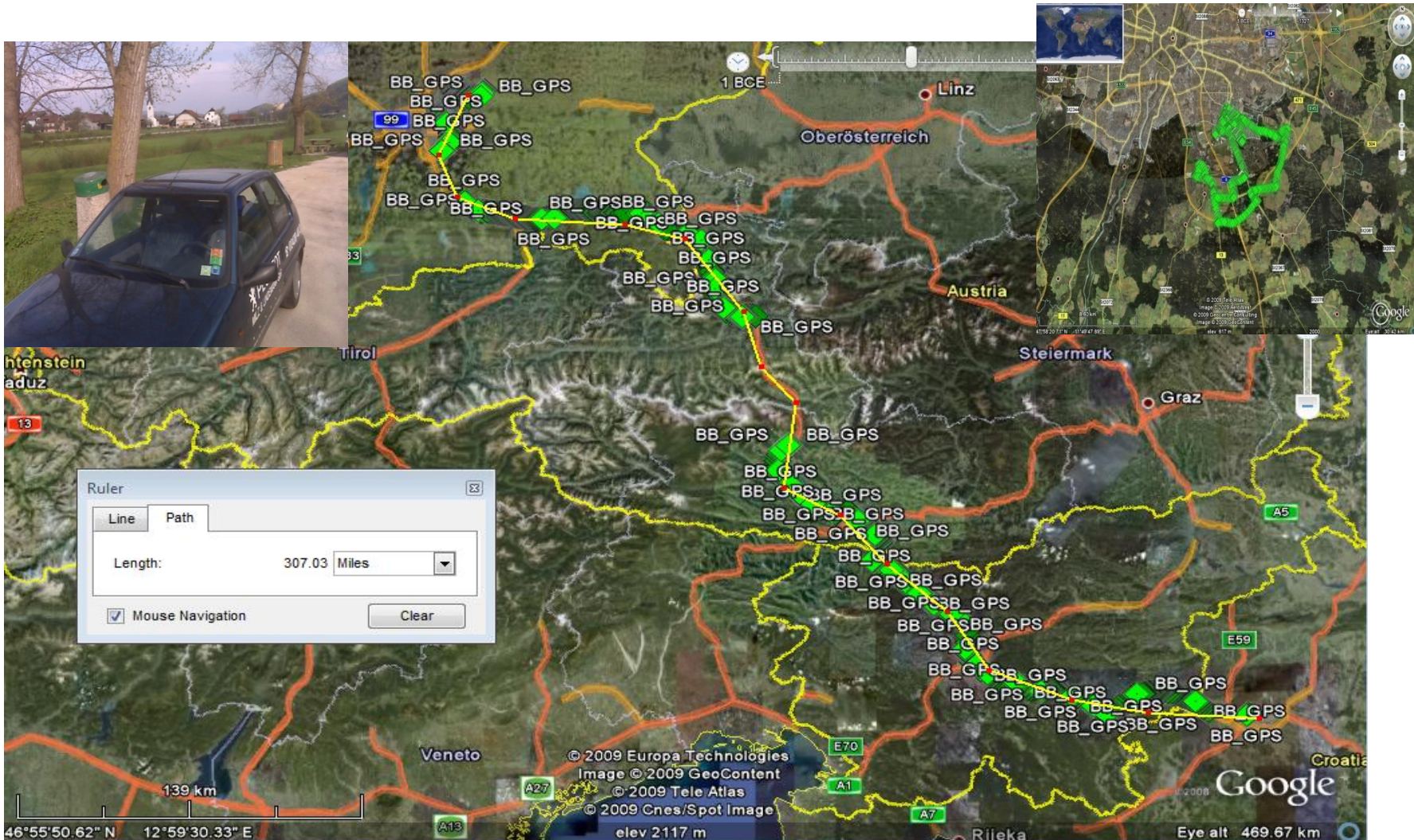


**TNT MIO 2008-2009:  
NETWORKING AND INTERAGENCY  
COLLABORATION ON MARITIME-SOURCED  
NUCLEAR RADIATION THREAT AND SMALL  
CRAFT INTERDICTION**





# Monitoring suspect vehicle smuggling material from Slovenia: tagged by SOF unit





# Monitoring Phase: Detection, Tagging, and Tracking (March , 2008: NPS-LLNL-UoB team)

## Goals

- Real time situational awareness and collaboration
- Tagging, tracking and locating a vehicle

## Timeline

- Checkpoint in Bavarian Alps: Vehicle Detection, Biometrics Identification, and Tracking
- Vehicle Tracking in Germany-Poland
- Vehicle Search in Sweden



Figure 3. ARAM Sensor (white box in the trunk) is set up for action



Figure 8. Fingerprints taken at the Bavarian checkpoint.



Figure 9. Monitoring vehicle going up North Germany



Figure 20. Swedish vessel with suspect crew onboard.



# New York: Cargo Vessel Search

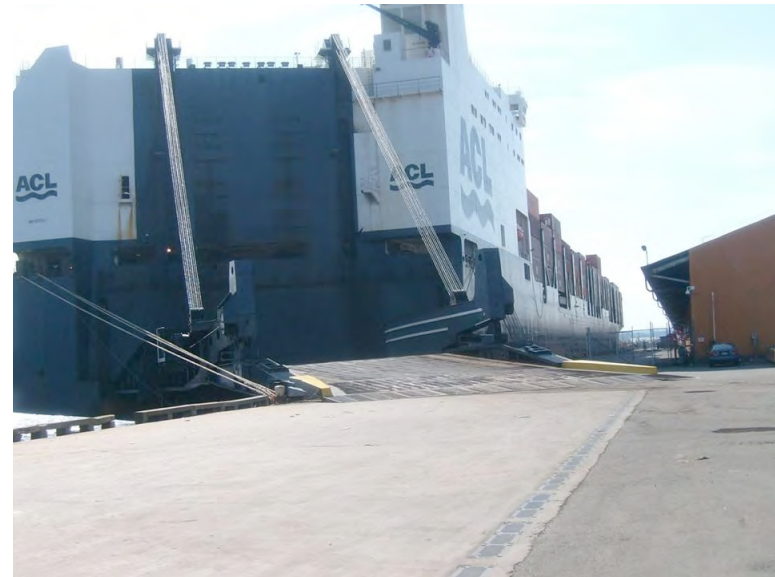
PANYJ Mobile and Jersey City Command Centers, FDNY, Karlskrona TOC (Sweden), Aarhus Port Security TOC (Denmark), NPS C2 Center

AXIS 241QA Video Server [Live View](#) | [Setup](#) | [Help](#)

View size:  X0  X1  X2  X4  
Video format: Motion JPEG  
Source: Video 1

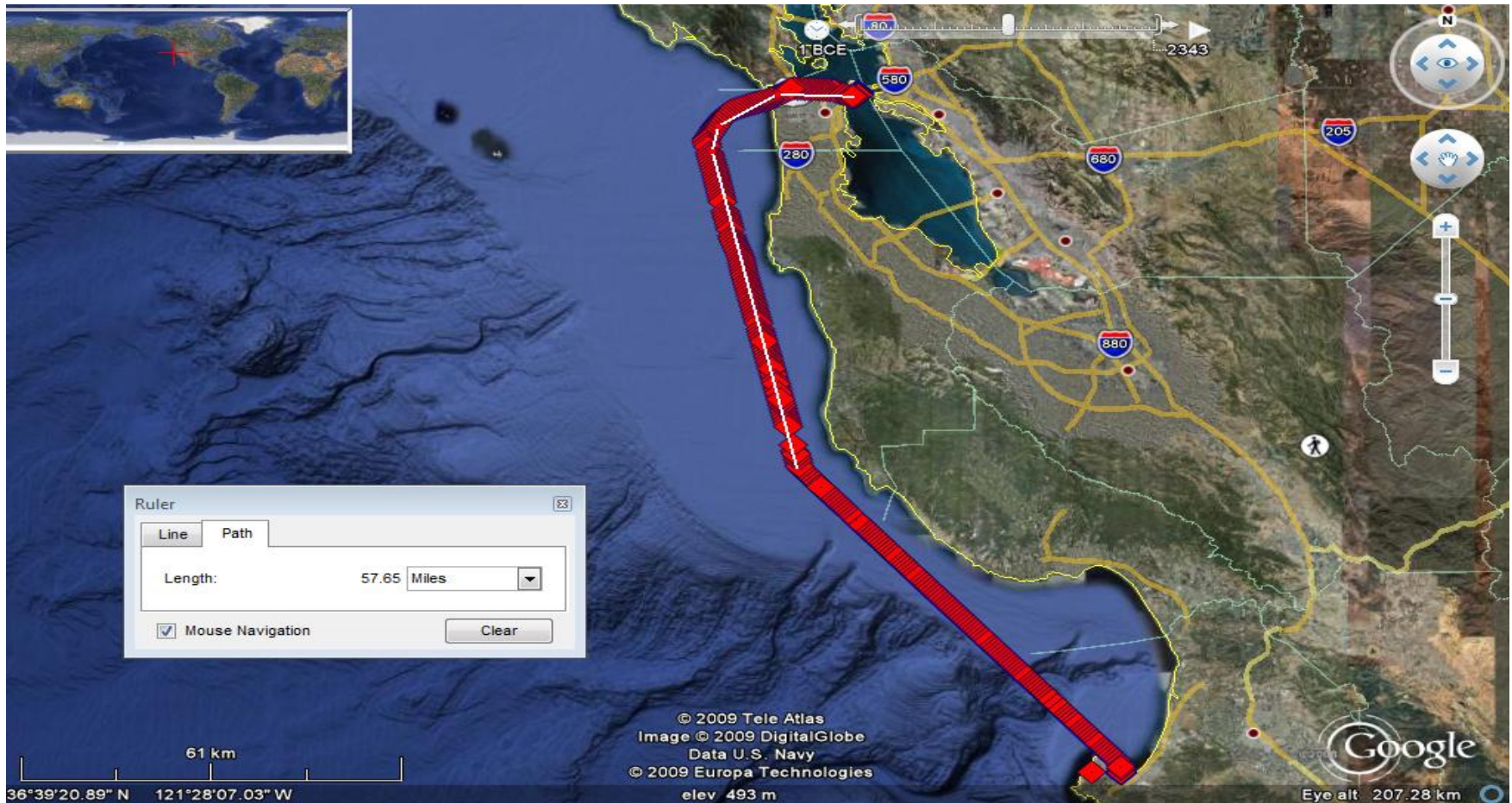


Playing Motion JPEG





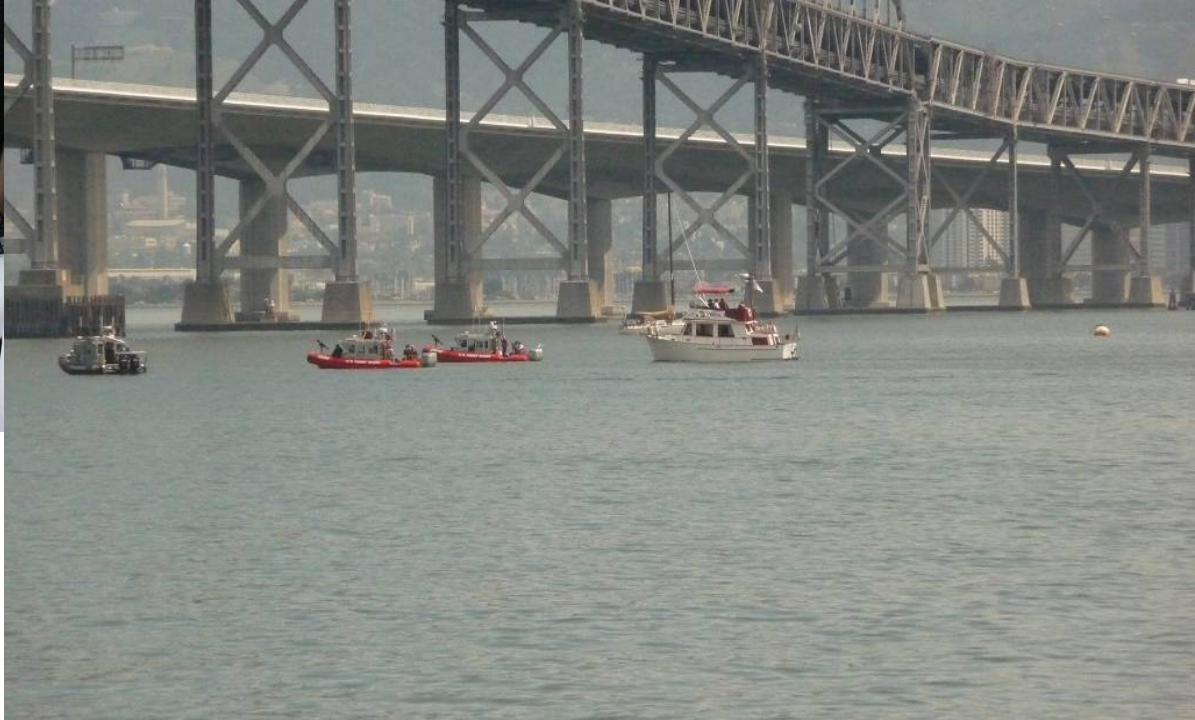
# Source transferred to the boats: Small craft long distance monitoring by SOF unit





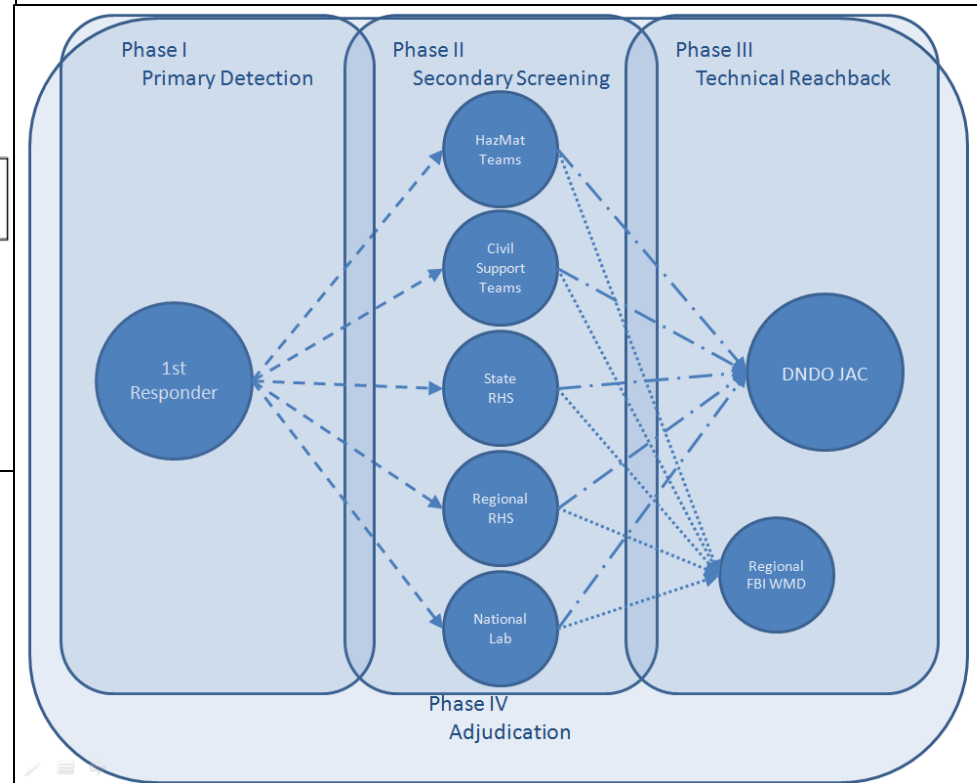
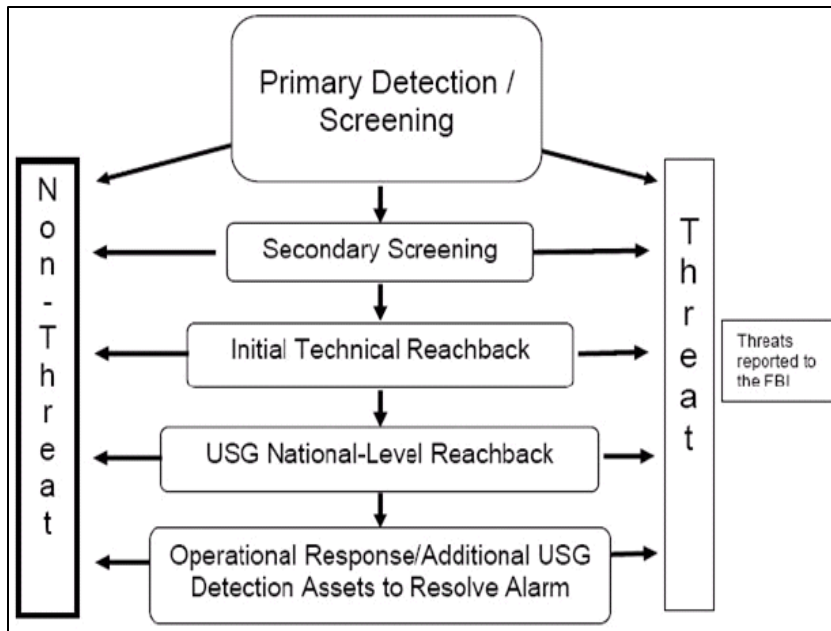


# Cargo Vessel Search by Multiple Boarding Parties in SF Bay Area and Seven Small Craft Drive-by Search



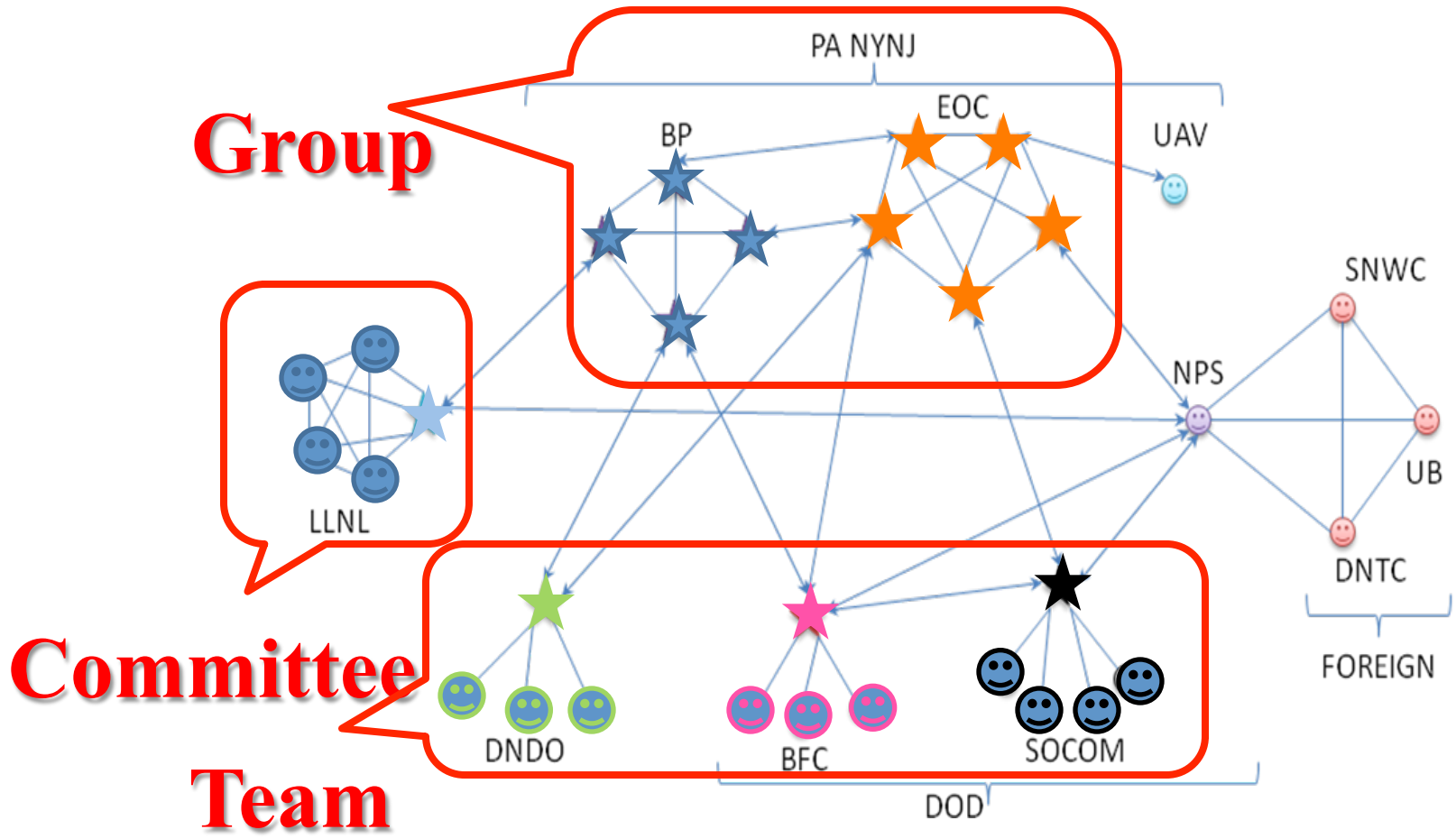


# Interagency Collaboration in Cargo Vessel Search: Sharing Reporting of Hazmat, CBP, RHS (Regional and Local), Civil Support, and Lab





# MIO 08-4 Experiment: Collaborative Network Topology



**Group**

**Committee**

**Team**



# MIO 08-4 Experiment: Adopted Collaborative Technology Features

		DOD			PORT AUTHORITY NY-NJ				LLNL	DNDO	FOREIGN		
		NPS	SOCOM	BFC	BP1	BP2	UAV	PA EOC		JAC	SNWC	UB	DNTC
DOD	NPS		C,M,F,S	F,M	F,M	F,M		F,M,S	F,M	F,M	C,M,F,S	C,M,F,S	C,M,F,S
	SOCOM	C,M,F,S		F,M	F,M	F,M		F,M	F,M	F,M			
	BFC	F,M	F,M		F,M	F,M		F,M					
PA NY-NJ	BP1	F,M	F,M	F,M		C,M,F,V		C,M,F,V	C,F,M,V	C,F,M,V			
	BP2	F,M	F,M	F,M	C,M,F,V			C,M,F,V	C,F,M,V	C,F,M,V			
	UAV							F					
	PA EOC	F,M,S	F,M,S	F,M	C,M,F	C,M,F				F,M			
LLNL		F,M	F,M										
DNDO	JAC				F,M	F,M		F,M					
FOREIGN	SNWC	C,M,F,S										C,M,F,S	C,M,F,S
	UB	C,M,F,S											C,M,F,S
	DNTC	C,M,F,S											

C: CHAT

V: VIDEO STREAM

M: MESSAGE

F: FILE SHARING

S: SITUATIONAL AWARENESS

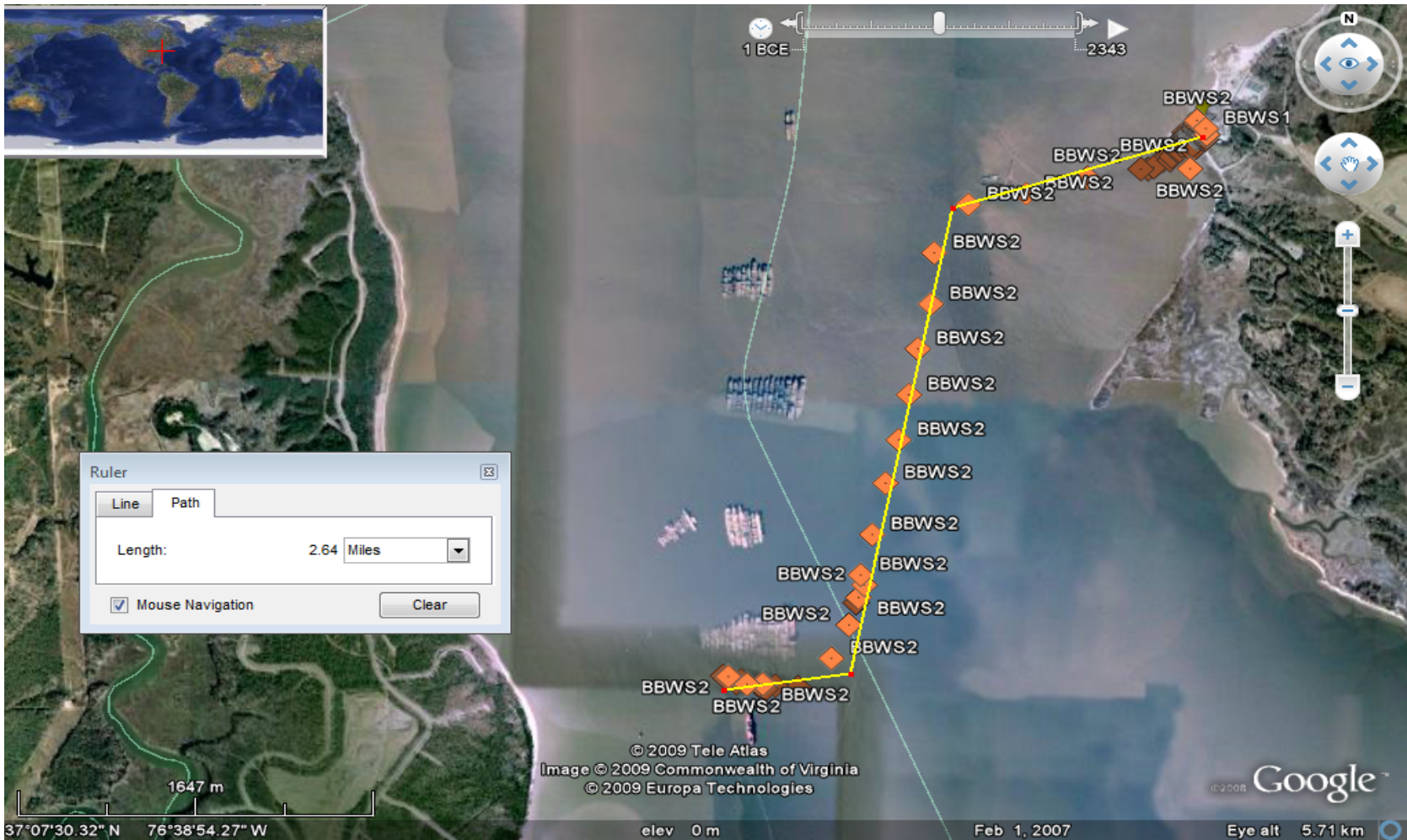


# Extending Self-forming Tactical Network to Swimmers: Small Craft Tagging and Tracking



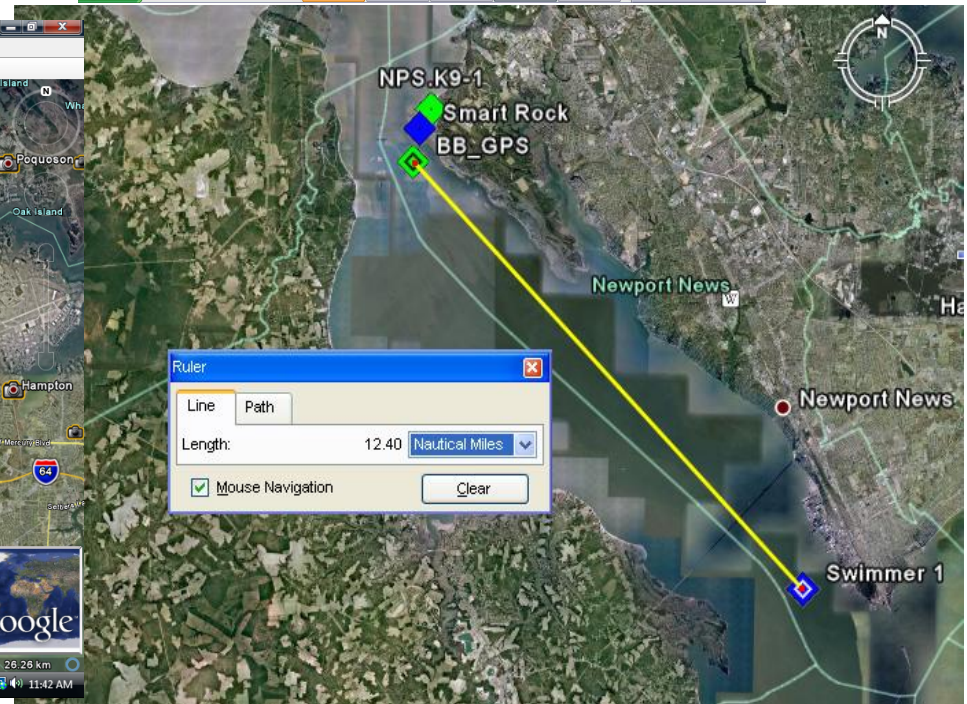
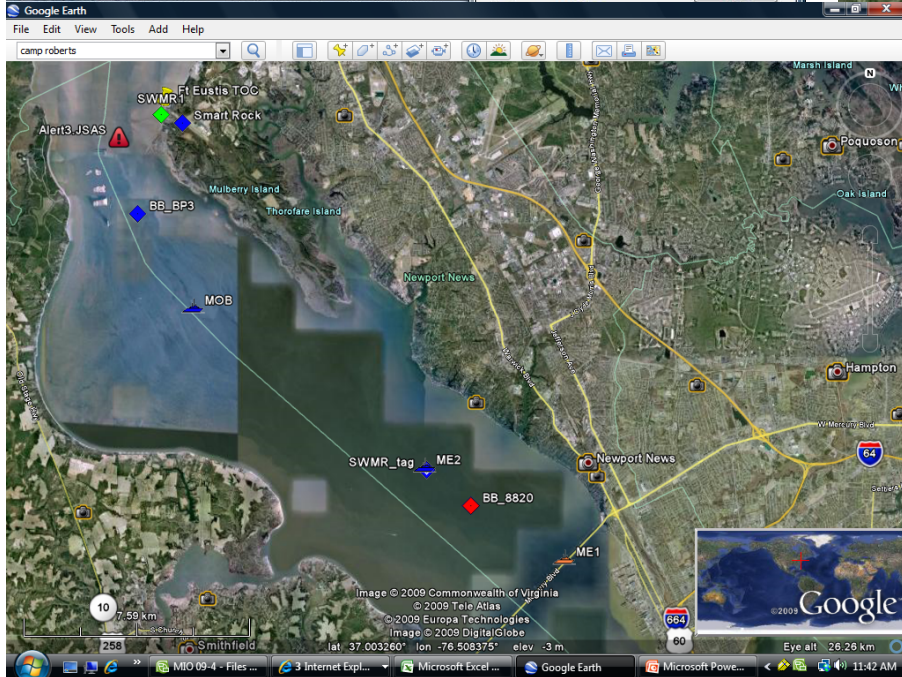
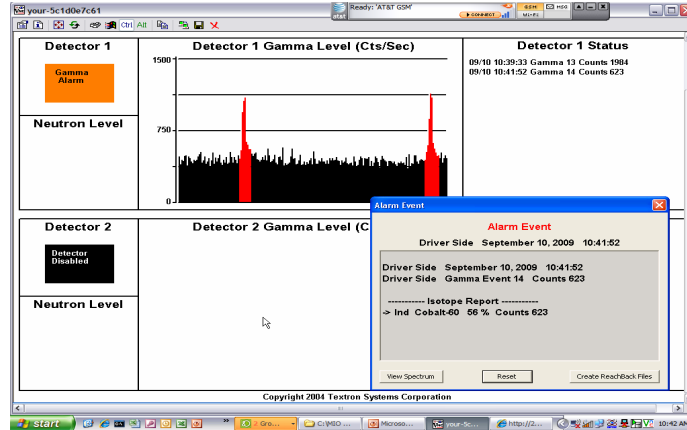


# Monitoring the Tagged Small Craft with Network-Controlled Sensor at 25nm/h



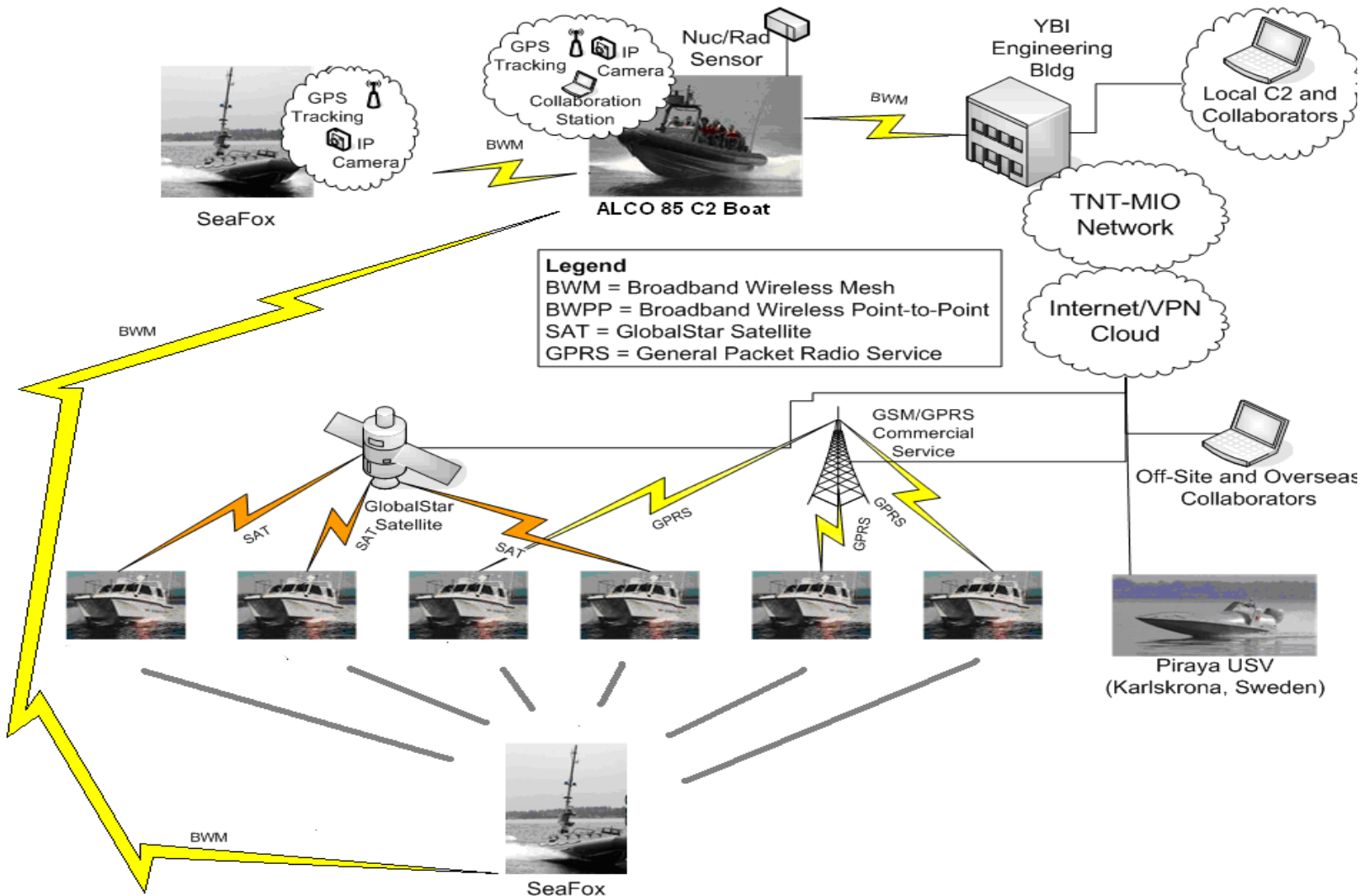


# ARAM Portal and stand-off detection at high speed: Feasible at 75ft, speed up 58nm/h





# Multiple Small Craft Portal and Drive-by Detection Network: Augmented by USVs





## USV, UAV Relay to the Fast Boat, UGV in the Tunnel



USV provided radiation detection in small-boat drive-by with real-time expert reachback; network-controlled USV & UGV

## Small Craft Drive-by Detection: Placing the ARAM Sensor to Sea Fox USV (Brian Agrawal, Ben Wring)



# Adding Unmanned Systems to MIO Network: Drive-by Search by Sea Fox USV





# Receiving shared USV drive-by search results in PANYNJ and NPS TOCs: Network controlled USV Piraya in action at Karlskrona, Sweden



# View of shared PANYNJ JSAS small vessel interdiction event COP at the TOC in Karlskrona, Sweden



# Cooperative Multiple Small Craft Search:

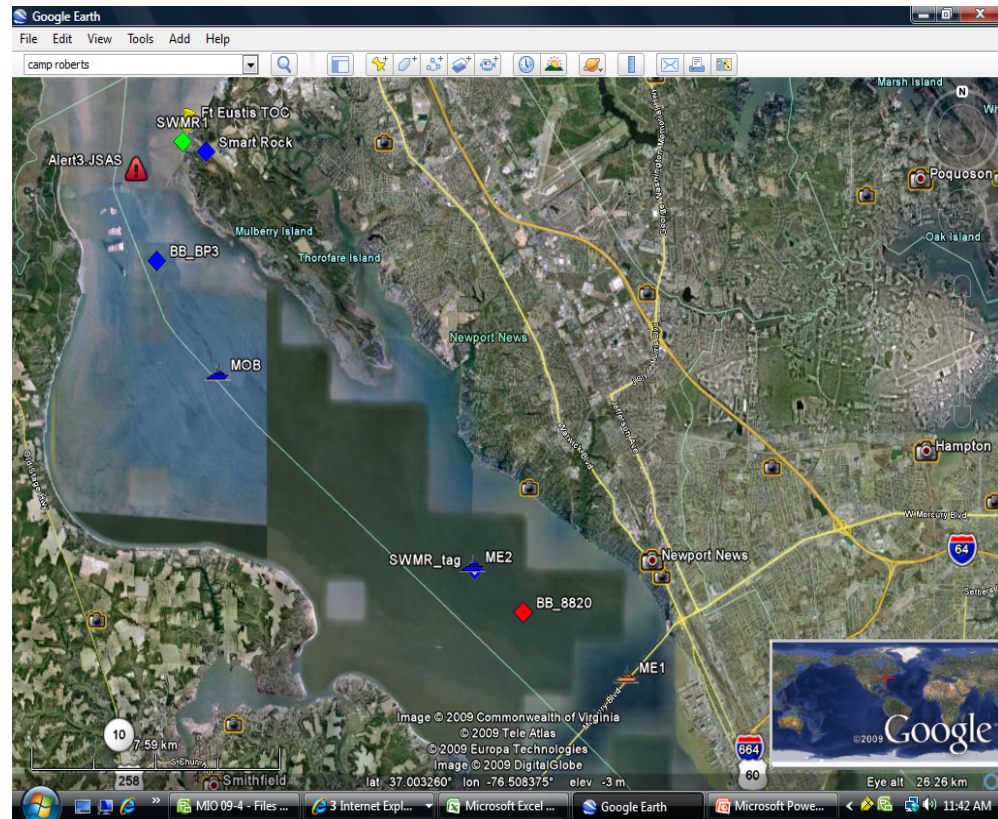
- Ft. Eustis TOC View of Video from Piraya USV in Sweden,
- NSWG4 Sea Fox USV as a mesh relay node in Riverine chase

Piraya Pi14 CAM

Pi1 4 KOCKUMS SNWC 2009-09-10 18:09:48



Playing, MPEG-4 using RTP over RTSP over HTTP





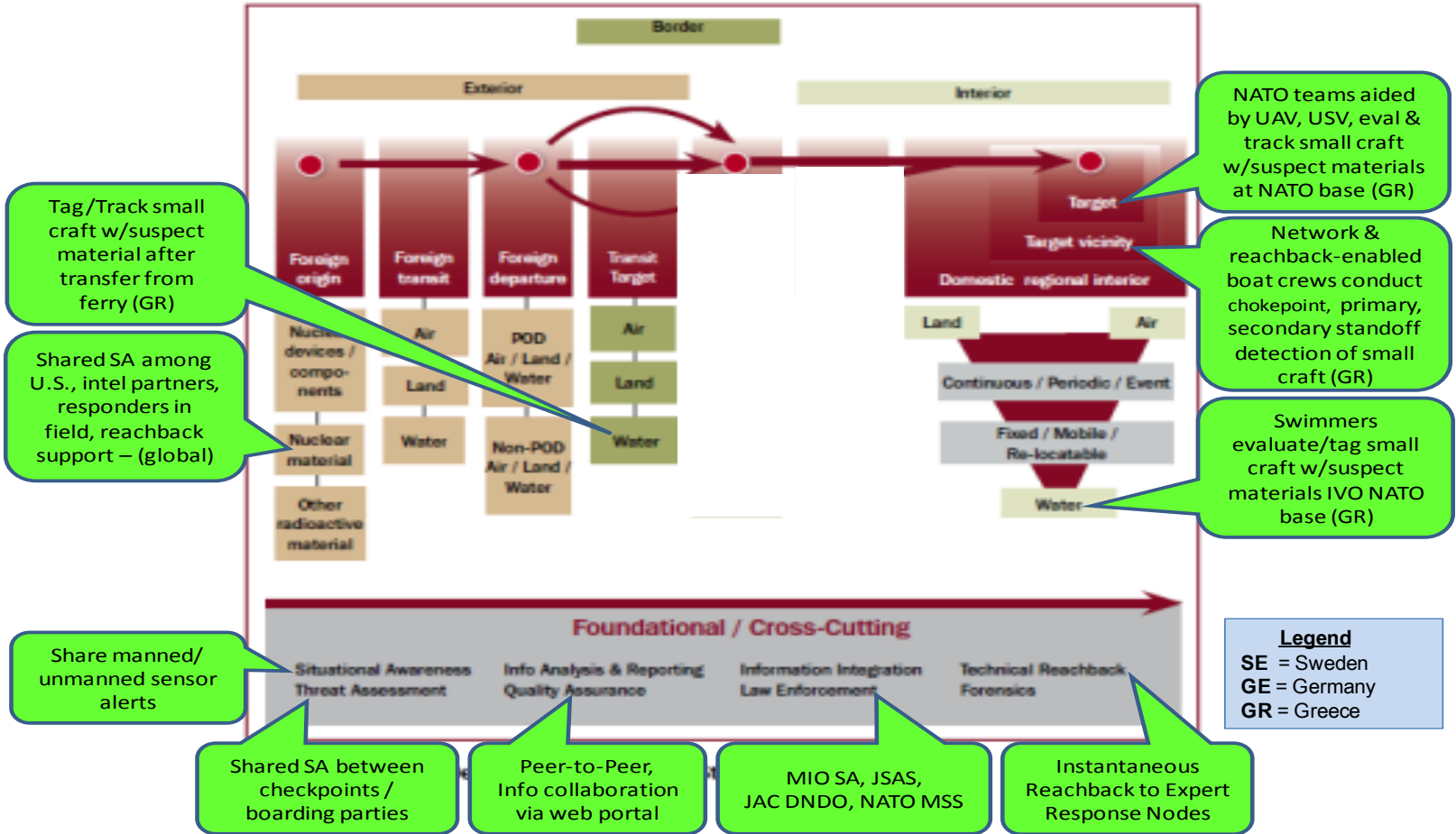
## **TNT MIO 2010:**

- **Extending MIO detection networking and expert reachback to joint operational models with NATO crews, German NSW team, and EUCOM SOF Units**
- **Detection and interdiction of small craft threat to US installation abroad**
- **Integrating swimmer in network-enabled detection with reachback to remote expert**
- **Tagging and tracking target on foot**
- **Aerial network-enabled UAV based small boat detection**



# The elements of Layered Global Detection Architecture (DNDO) addressed with NMIOTC team

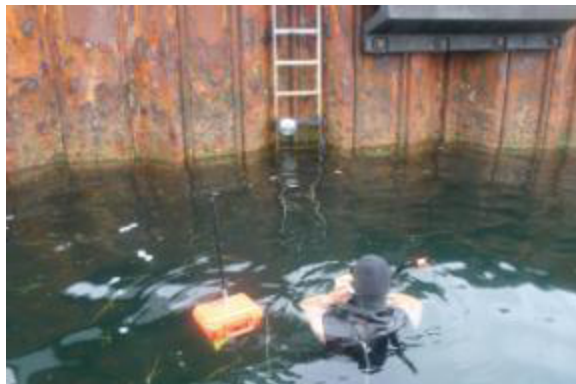
## Phase II - Greece







# Integrating Swimmer in Network Controlled Detection



The screenshot displays a Windows XP desktop environment. The taskbar at the bottom shows several open applications, including Internet Explorer, Google, and a video conference room. The desktop background is a blue-themed website for CENETIX, featuring a sidebar menu with categories like 'EXPERIMENTATION SNAPSHOTS', 'PUBLICATIONS', 'CENETIX PARTNERS', 'ORGANIZATION STRUCTURE', 'KNOWLEDGE REPOSITORY', 'EVENTS AND NEWS', 'USSOCOM WEB PORTAL', and 'CENETIX LOCATION'. The main content area includes sections for 'TNT Host IP Configuration', 'Google Earth SA Viewer', 'SA Replay Control', 'SA Agent Web Control', 'Frequency Manager', and 'Streaming Video Browser'. A video conference window is open in the foreground, showing a grid of video feeds. A red circle highlights a specific video feed in the bottom-left corner of the grid. The system tray at the bottom right shows the date as 6/9/2009 and the time as 12:34 AM.



# Experimenting with German NSW Unit on Small Craft Detection and Interdiction

The screenshot displays a Windows desktop environment with several active windows:

- Google Earth:** Shows a satellite view of a coastal area with labels for 'MOB-Eck', 'SRC1', and 'SRC2'. The interface includes search and places panels.
- Internet Explorer:** Displays a data plot titled 'http://cenetix.nps.edu/SA1/ObserverNotepad/ObserverPictures/4078\_G2.jpg'. The plot shows a series of red and black vertical bars representing data points over an energy range from 0.00 to 1536.00 keV.
- Web Application:** A page with a 'CENETIX' header and a form for adding comments. The form includes a text area, a 'Submit' button, and a 'Currently active:' list containing 'FOI', 'FOI 2', 'LLNL', 'LLNLa', and 'TOC-Eck'. A 'Chapter:' field is set to 'MIO 10-2'. A timestamp at the bottom reads '6/9/2010 1:47:31 AM ALERT on sensor SRC1'.
- Video Conference:** A window showing a multi-camera view of a meeting. One camera shows a man in a white shirt, and another shows a man in a dark shirt. A 'Send Audio/Video' button is visible at the bottom.

The Windows taskbar at the bottom shows the system clock as 1:56 AM on 6/9/2010.



# Ground Tracking and Interdicting Source Smuggling Target with 1<sup>st</sup> Br 10<sup>th</sup> Group Airborne

The screenshot displays a Windows desktop environment with several open applications:

- Microsoft Word:** Open in the top left, showing a document with the font set to Calibri (Body) size 11.
- Windows Internet Explorer:** Open in the top middle, displaying a "Video Conference Room" page. The address bar shows <http://cenetix.r>.
- Google Earth:** Open in the top right, showing an aerial view of a residential area. Two blue markers labeled "Trg2" and "Trg1" are visible on the map. The "Places" list on the left includes "My Places", "Sightseeing Tour", and several "TNT" folders.
- Windows Internet Explorer (Log Window):** Open in the bottom right, displaying a log of events. The address bar shows <http://cenetix.nps.edu/SA1/ObserverNotepad/default.asp?CachePreventer=85474537037037>.

The log window contains the following entries:

- 6/11/2010 2:03:05 AM NPS NOC 1: Delayed Entry: 0145: MOB is currently awaiting further guidance once analyzing is complete. LLNL still trying to download from the repository but unable due to latency issues. NPS NOC 2 states it is file specific.
- 6/11/2010 2:02:49 AM LLNLa: With the background information the alarm DOES look like Cs-137. Please provide video of the vehicle and possibly contents, if it is safe to do so.
- 6/11/2010 2:02:19 AM UoB-Christian: The MOB will provide more information for the LLNL and will soon start a video conference.
- 6/11/2010 1:52:58 AM UoB-Christian: The LLNL expert experienced some problems downloading the detection file. he now got it.

The system tray at the bottom right shows the date and time as 2:27 AM on 6/11/2010.



# Ground Tracking and Interdicting Source Smuggling Target with 1<sup>st</sup> Br 10<sup>th</sup> Group Airborne

The screenshot displays a Windows desktop environment with several open applications:

- Microsoft Word:** Open in the top left, showing a blank document with the Calibri font and size 11.
- Windows Internet Explorer:** Open in the top middle, displaying a "Video Conference Room" page. The address bar shows <http://cenetix.r>.
- Google Earth:** Open in the top right, showing an aerial view of a residential area. Two blue markers labeled "Trg2" and "Trg1" are visible on the map. The search bar contains "Fly to e.g., Reservoir Rd. Clayville, NY".
- Windows Notepad:** Open in the bottom right, displaying a log of events from 6/11/2010. The log entries are:
  - 6/11/2010 2:03:05 AM NPS NOC 1: Delayed Entry: 0145: MOB is currently awaiting further guidance once analyzing is complete. LLNL still trying to download from the repository but unable due to latency issues. NPS NOC 2 states it is file specific.
  - 6/11/2010 2:02:49 AM LLNL: With the background information the alarm DOES look like Cs-137. Please provide video of the vehicle and possibly contents, if it is safe to do so.
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  - 6/11/2010 1:52:58 AM UoB-Christian: The LLNL expert experienced some problems downloading the detection file. he now got it.
- Video Conference Room:** A window showing a video conference with participants "LLNL%20Dave" and "MOB-Stg". A car with license plate "AS-VW 504" is visible in the bottom right video feed.

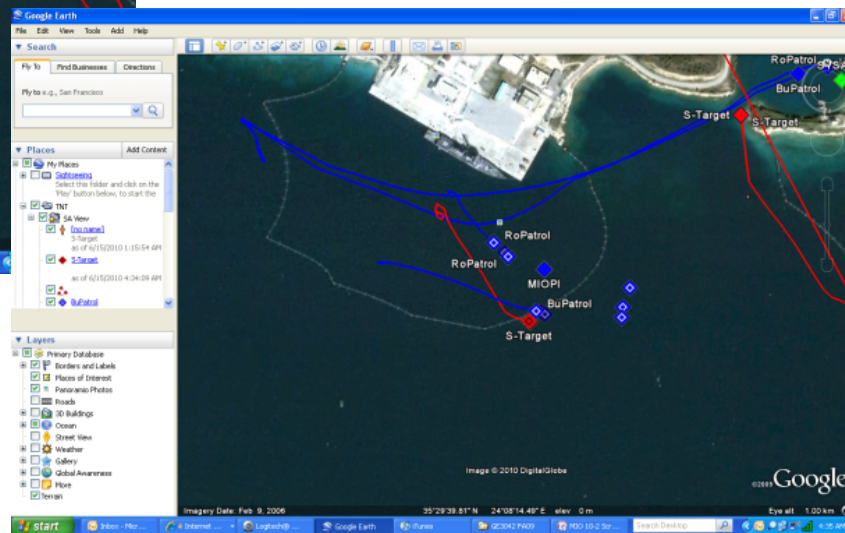
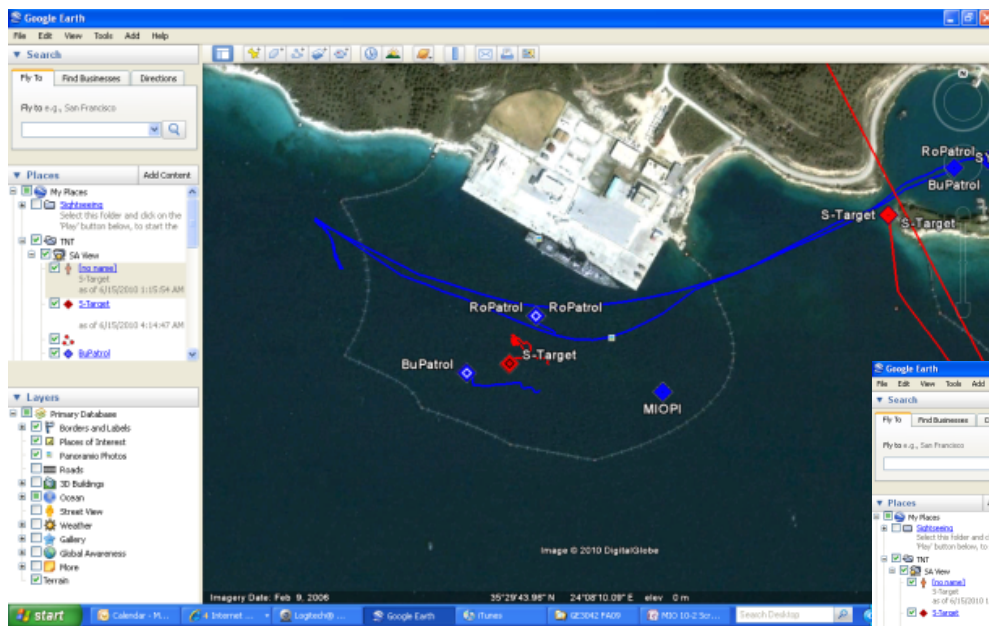
The system tray at the bottom right shows the date and time as 2:27 AM on 6/11/2010.

# US and Hellenic Swimmers Collaborative Networking On-the-Move: Identification, Tagging, and Tracking



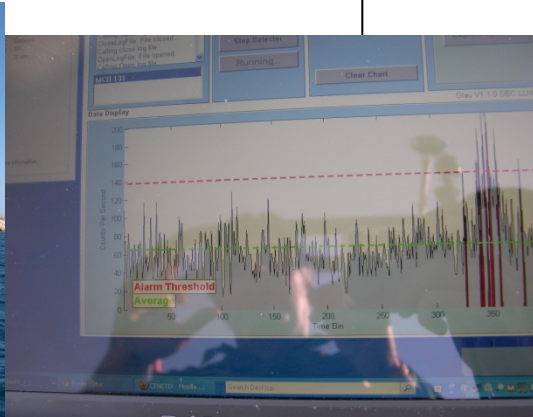


# Remotely Controlled Choke Point with NATO Interdiction Crews (Hellenic SEALs in Lead)



# *Collaborative Technology for International MIO Crews Data Sharing and Mutual Expert Support*

## **Collaborative Network Controlled Large Vessel Search for Nuc/Rad Source**



**Czech, Romanian, Bulgarian, and Turkish Boarding Officers Deciding on Data Sharing**

**Portal Detection & SA Sharing Between International Patrol Crews**



# Unmanned Rotorcraft augmented cargo vessel and small craft detection with NATO partners

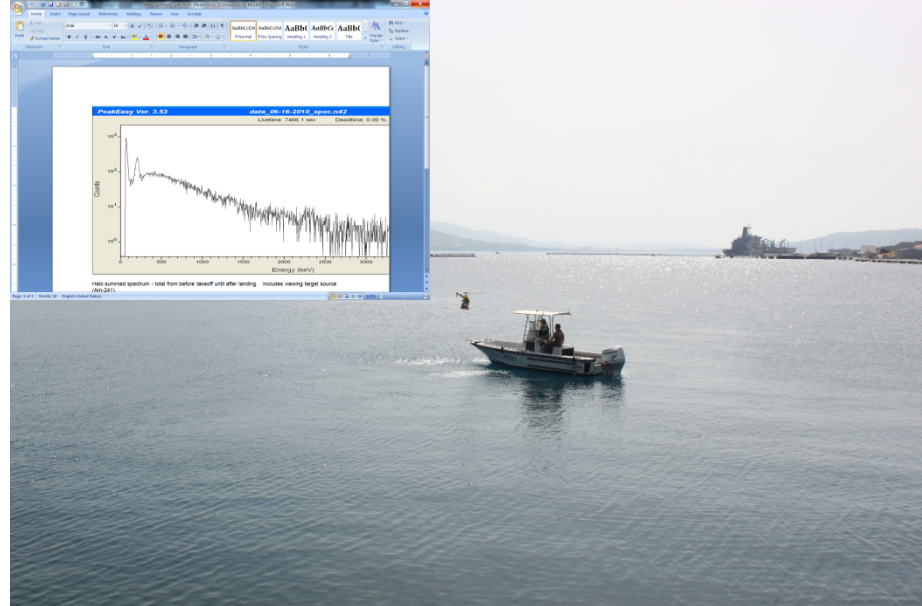


Putting Network and Nuc/Rad Detector On Board Unmanned Rotorcraft

## Assisting Large Vessel Search



## Small Craft Stand-Off Detection On-the-Move







# Way Ahead: TNT MIO 2011

- **Extending MIO experiment to long-term daily boat patrol based detection in SF Bay: Data capture and modeling of network-controlled detection**
- **Extending MIO detection networking and expert reachback to joint operational models with NATO WMD Class, European Reachback Center in Czech, Singapore, Croatia**
- **Integrating Nuc/Rad detector with ad hoc mobile network and different SA interfaces (NPS, MFK, SLATE, etc)**
- **Low visibility detector networking (UWB), integrating LVN with tactical radios**
- **Automated detection by network-enabled swimmer**
- **Multiple swimmer/casualty tagging and tracking**
- **Tagging and tracking reachback based on integrated satellite/cellular link**
- **Cooperative Aerial and Surface Unmanned System based (UAV, USV) small boat threat detection; UGV-based large vessel search**



# SFPD Boat Networked for Daily Patrol Based Data Capture





# SF Bay Daily Patrol Based Detection and Interdiction Model



## Patrol crews learn:

- How to visually share situational awareness on the patrol and target location together with detection alert information,*
- How to communicate with Radiological Health Department experts, support them by video feed and detection maneuvering (choke point, stand-off pursuit, etc) to assist in threat adjudication,*
- How to assist each other in maintaining connectivity, if target vessel stand-off/drive-by detection requires to operate on the edge of detection mesh network coverage*



# SF Bay Daily Patrol Based Detection and Interdiction Model

- **NPS, LLNL, and Testbed Centers** capture into computerized models :
  - Daily observations on patrol boat tracks,
  - Alerts generated,
  - Spectrum received
- **Operational variables** associated with stand-off detection include:
  - Detector measurements with the source in various locations on the boat,
  - Measurements of wave action and boat rocking and the corresponding detector response,
  - GPS data of patrol boat and source boat movement during the stop/interview inspection and during the approach and departure from the stop/interview inspection to assess speeds, delays, paths, etc.