TNT Maritime Interdiction Operation Experiments: Enabling Radiation Awareness and Geographically Distributed Collaboration for Network-Centric MIO

Dr. Alex Bordetsky
Naval Postgraduate School

Dr. Arden Dougan
Lawrence Livermore National Laboratory

Dr. Foo Yu Chiann
DSTA, Singapore

Col. Andres Kilberg
Swedish Naval Warfare Center

Objectives

- Evaluate the use of networks, advanced sensors, and collaborative technology for rapid Maritime Interdiction Operations (MIO); specifically, the ability for a Boarding Party to rapidly set-up ship-to-ship communications that permit them to search for radiation and explosive sources while maintaining network connectivity with C2 organizations, and collaborating with remotely located sensor experts.
- Extend the set of participating organizations to coalition partners (currently includes international teams in Sweden, Singapore and Austria) and first responders (currently includes San Francisco, Oakland Police, and Alameda County Marine Units)
- Provide the recommendations for transforming advanced networking and collaborative technology capabilities into new operational procedures for emerging network-centric MIOs

TNT MIO Testbed: System of Networks and Collaborative Technology for Supporting Globally Distributed MIOs

Plug-and-Play Sensor-Unmanned Vehicle-Decision Maker Networking Testbed with Global Reachback

- Plug-and-play wide area adaptive network with global reach back capabilities and rapidly deployable self-forming wireless clusters (including student network operation services 24/7)
- Local networking clusters: ship-to-shore, ship-to-ship, ship-UAV-ship, ship-USV-ship, ship-AUV, sensor mesh mobile networks
- Operational focus: Boarding Parties support, MIO connectivity and collaboration for radiation awareness, biometrics identification, non-proliferation machinery parts search , and explosive materials detection on the board of the target vessel during the boarding party search phase
- Testbed backbone: NPS (Monterey), USCG (Coast Guard and Yerba Buena Island in SF Bay Area, Camp Roberts (Central California),

  -New sites: Golden Gate Bridge, Mt. Diablo, Sacramento River delta
- Global VPN reach back :

  -East Coast (BFC, DTRA)

  - Sweden (Navy site in Southern Sweden),

  -Austria (GATE site in Bavarian Alps-Salzburg Research)

  -Singapore (DSTA), and

  -Australia (DSTO), Cana-new member, first collaborative experiment in November, 2006)

Background MIO Studies: Rapidly Deployable Self-Forming Network for Maritime Interdiction Operations

SOCOM - NPS
Field Experimentation Cooperative (Dr. Dave Netzer in Lead)

UNCLASSIFIED

Large Interdisciplinary NPS Team

NPS: - FY06: 28 Thesis Students

32 Faculty

Includes 21 PhD, 4 PhD Students

- Course Projects: IS, OR, DA

10 Departments and Institutes

Affiliated Programs

DARPA HURT ACTD

DARPA MAV ACTD

USSOCOM Global Reach ACTD

AFRL JASMAD

MCWL Distributed Operations

OSD/OFT Stiletto

OSD/HD MDA

Participating Universities

Virginia Tech
University of Florida
Case
MIIS

Broad DoD and Gov't. Participation and Support

- **USSOCOM**
- **USASOC**
- **AFSOC**
- **NAVSPECWARCOM**
- **JSOC**

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

AFRL	BFC
DARPA	DTRA
LLNL	MARAD
NSA NTIO	NRL
ONR	ONR 113
SPAWAR	USCG
USN/VC-6	OSD/OFT
NASA/ARC	STL
USASMDC	JHU APL

UNCLASSIFIED

Industrial Support

WinTec

Inter-4

Redline Communications

Flarion

Northrop Grumman

Lockheed Martin

ITT

AeroVironments

Space Data Corporation

Brandes Associates, Inc

Chang Industries

L-3 Communications

AGI

Mitre

Mission Technologies

State and Local Government

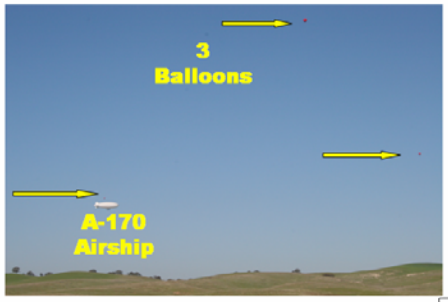
Alameda County Sheriff

Oakland Police Dept.

San Francisco Police Dept.

TNT 05-1, Nov 2004

MESH Topology



Ft. Bragg

Tampa

HHMWV Cameral Control

Reach-back

Internet

NOC NPS

7 Videos + SA

TOC CR

Network aware air mesh nodes

Network camera, Rajant Breadcrumb and 802.11b

A-170 Airship

Video

Camera GPS Tracker SA

Self forming/ healing

802.11b MESH

Tethered Balloons: Network camera,Pelco, small laptop, Freewave, GPS, 6 hr batteries

TNT 05-2 Feb 05

Improved Camp Roberts TOC

Cypress Sea Approaching USCGC HAWKSBILL – Radiation Detection

Surrogate Light Reconnaissance Vehicle

VC-6 with TERN UAVs

TERN Network Payload

Balloon Payload

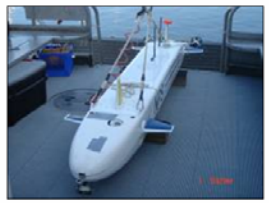
NA Sea Nodes TNT 05-2 Feb 05

Cypress Sea Support Boat

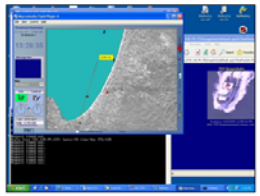
Cypress Sea NOC

Pelican 802.16/ OFDM Payload

ARIES AUV



SA for Cypress Sea, Pelican, Pelican Video



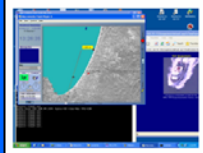
Resolution Target for EO Performance Prediction

NAVBOARD

TNT 05-2 Feb 05

Above and Below Water Situational Awareness for Combat Diver

NPS NOC

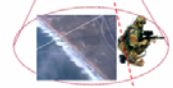


802.16/OFDM VoIP

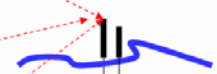
Surrogate UAV

GPS

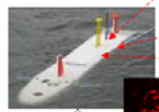
NA enables seamless SA

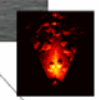


Shore Image

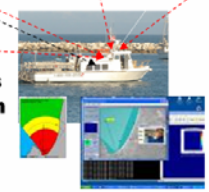


802.11b or Mesh



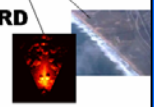


ARIES AUV



Cypress Sea with SA

NAVBOARD



Mine Location and Image

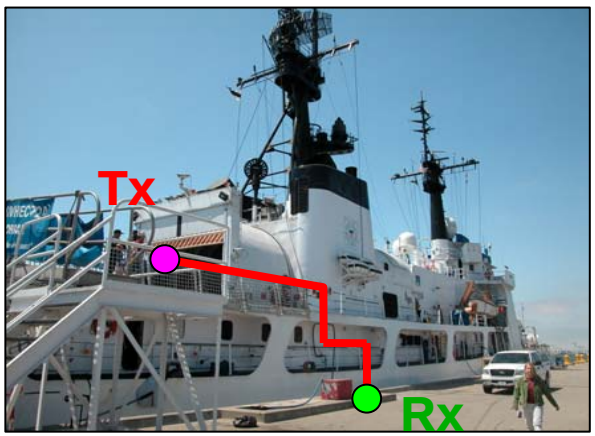
Stretching OFDM Man-Pack Boarding Party Network to Target Ship (15min)

Background: Prior NPS-LLNL experiments focused sending data and video in real time within a boarded ship to external networks

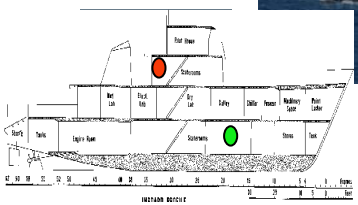
Feb 05 TNT: 802.11B affected by radar

May, August 05 TNT UWB comms demonstrated within Cutter

Suisun Bay: UWB able to transmit between holds of a container ship with holds closed!



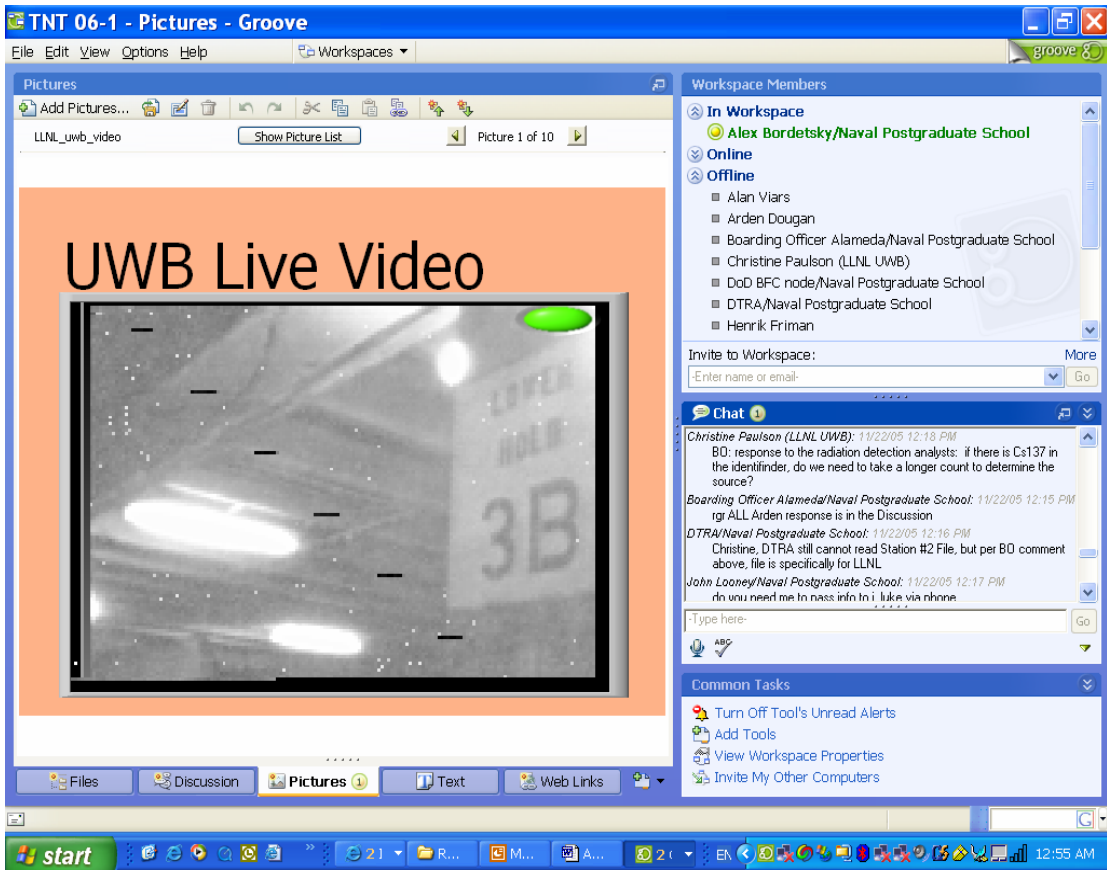
UWB on board USCGC Munro (multi-deck, no radar)



Collected system performance data on operational ship (Point Sur) UWB WORKED in difficult high multipath environment

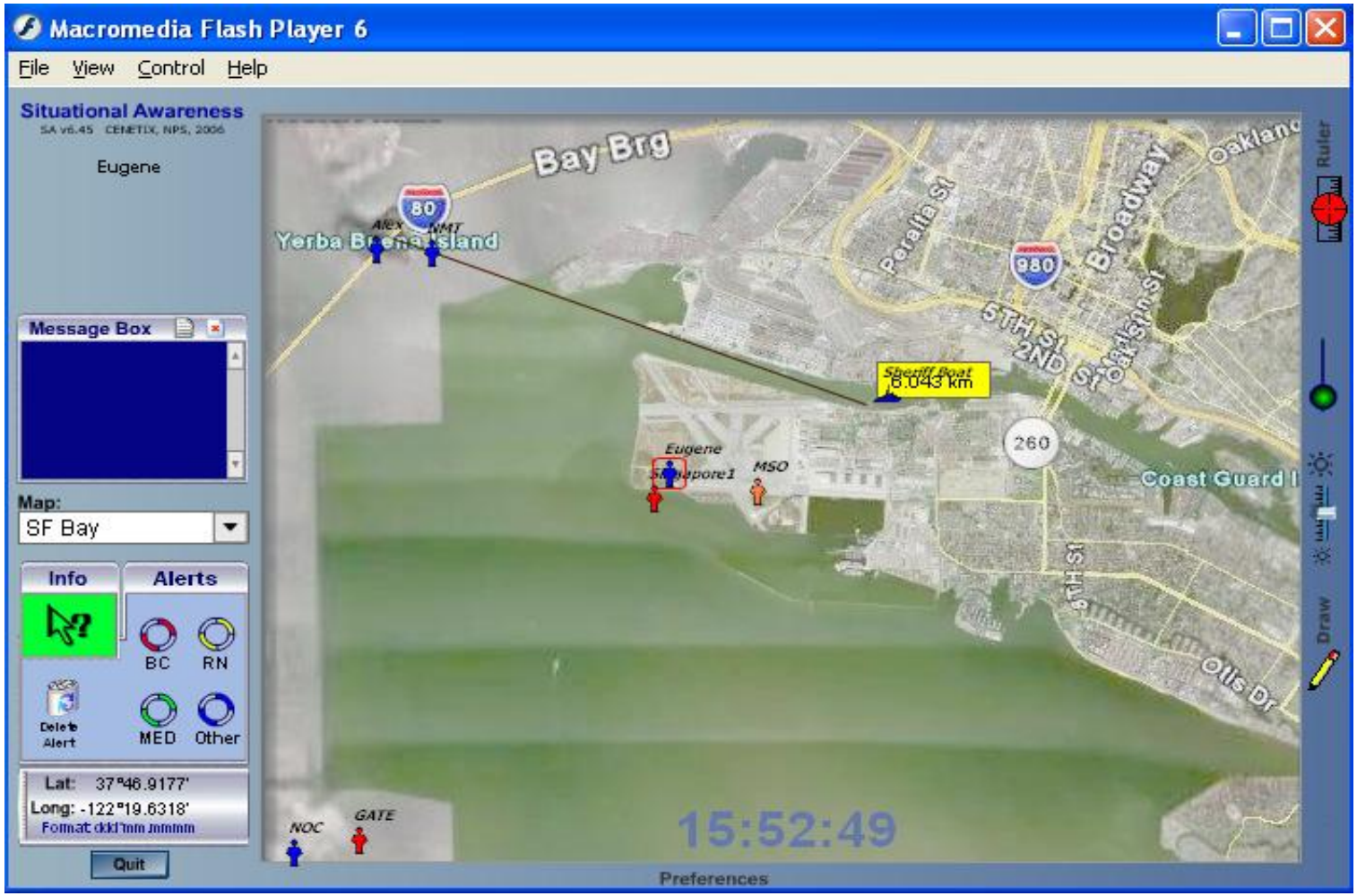
Polar Star – Planned experiment w/ USCG R&D Center

Sharing UWB Video with DTRA via Groove



TNT 06-1 MIO Network Topology: Forming the Boarding Party network to the target ship

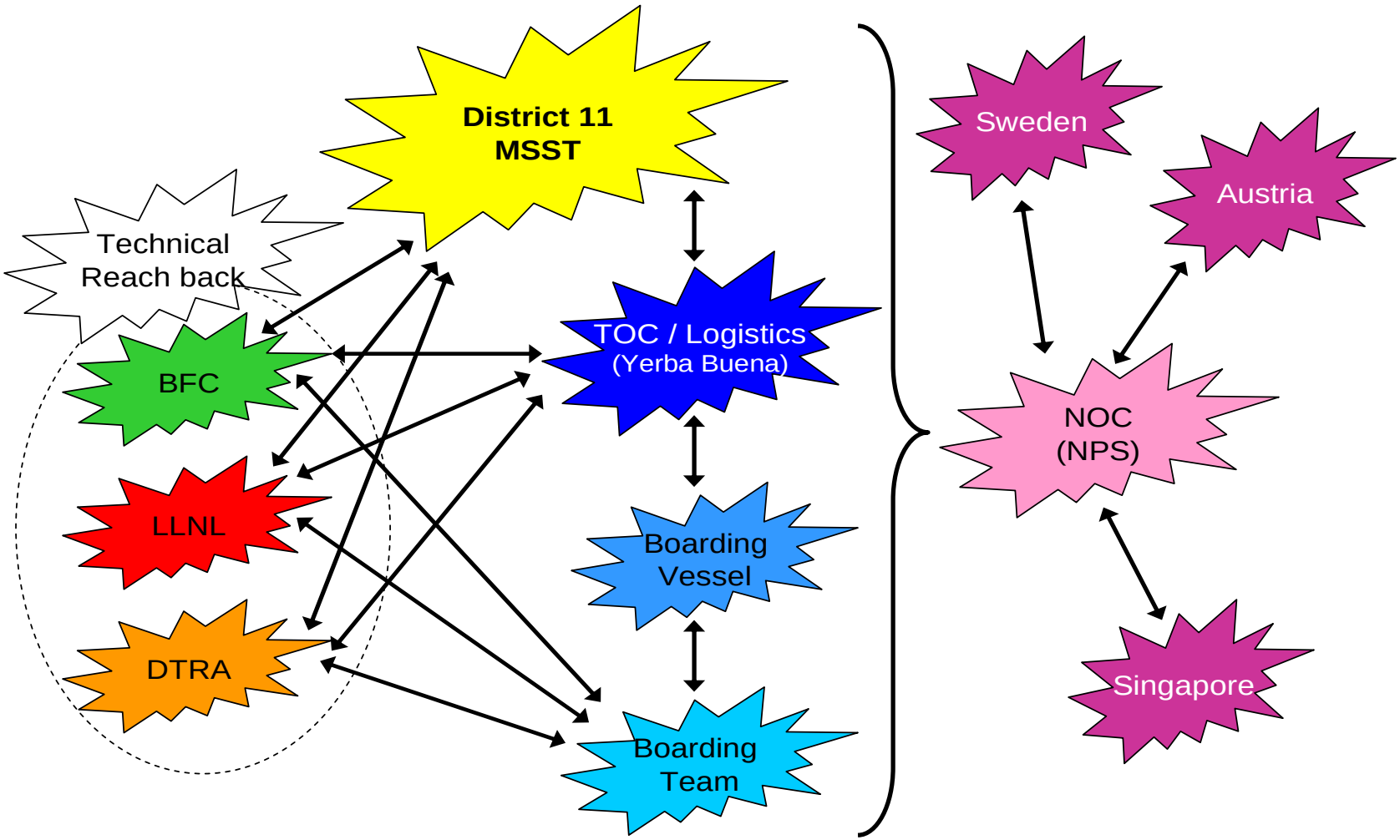
Adaptive Ship-to-Shore link with Boarding Vessel operational behind port structures in the Oakland Channel



Sending Target Crew Biometrics via Boarding Party Wireless Mesh network to the BFC (4 min)

Stretching the UWB link below the deck to the Radiation Detection officers

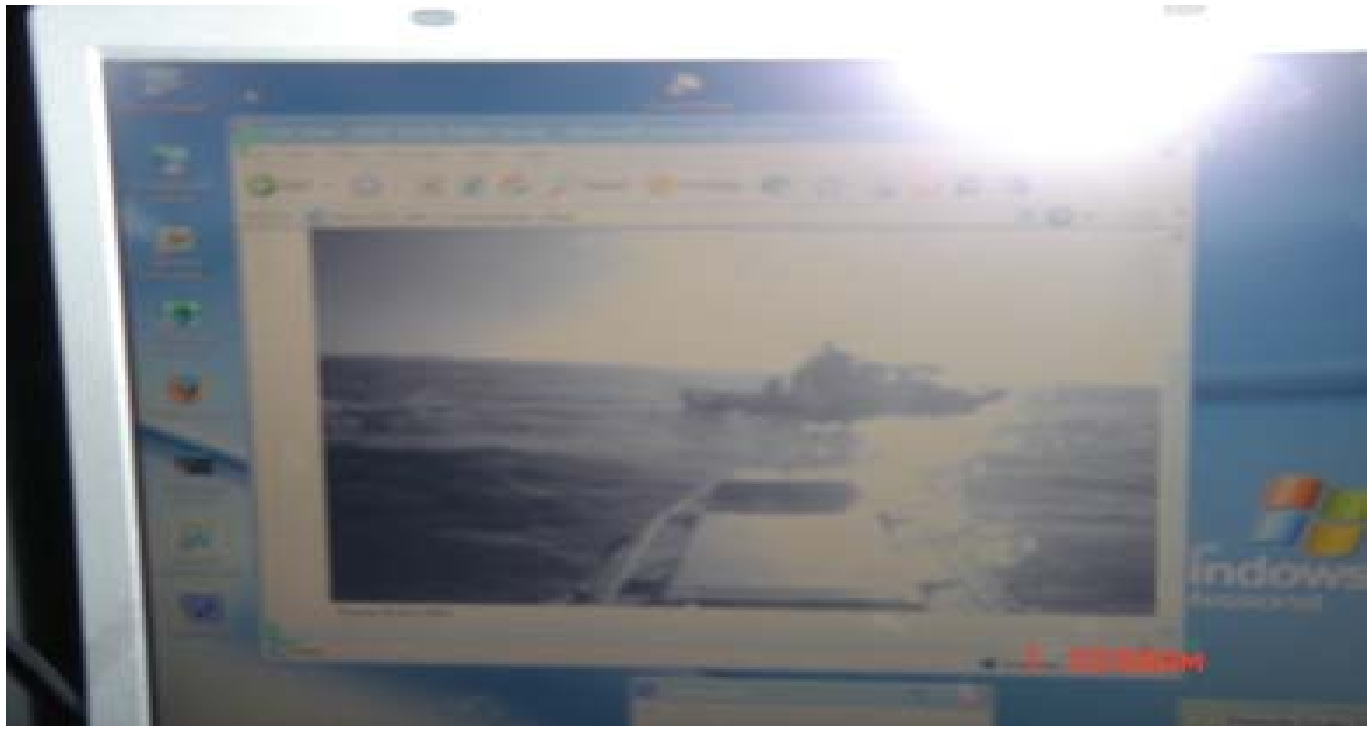
MIO 06-4 Collaborative Network



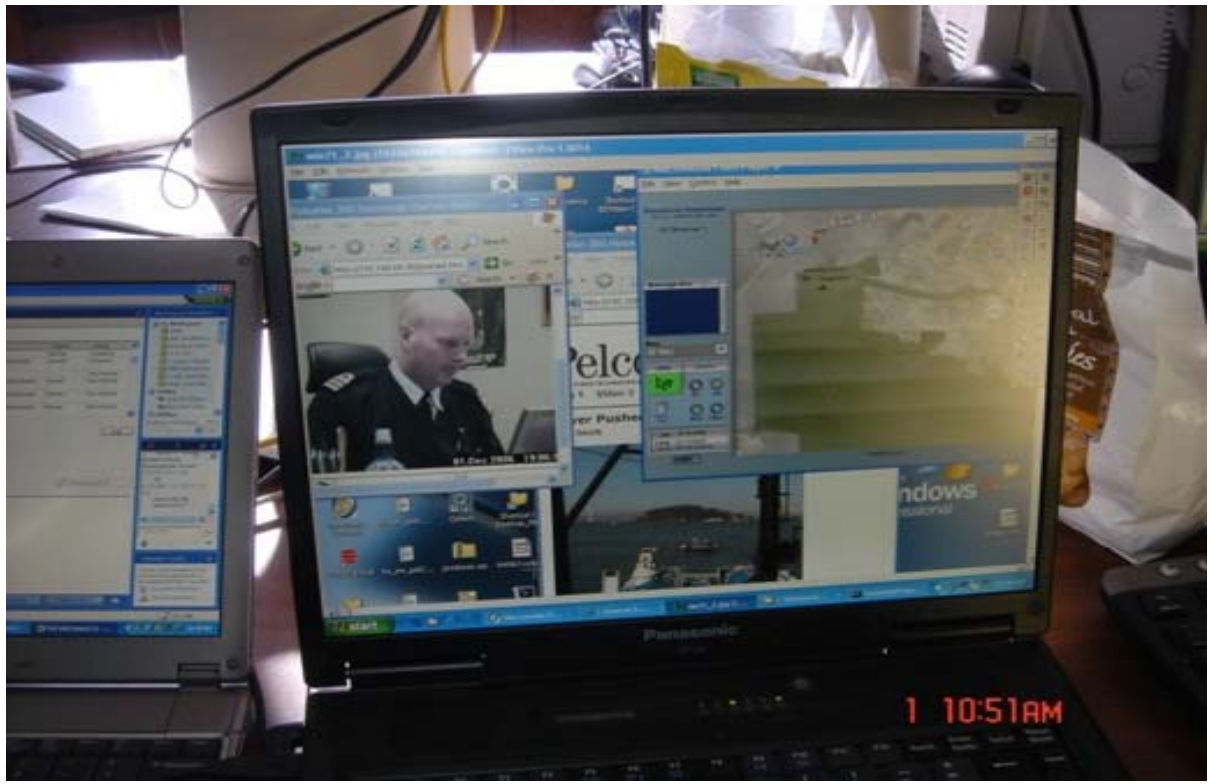
MIO Adaptive Ship-to-Ship and Ship-to-Shore Networking On-the-Move: First SAOFDM node

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

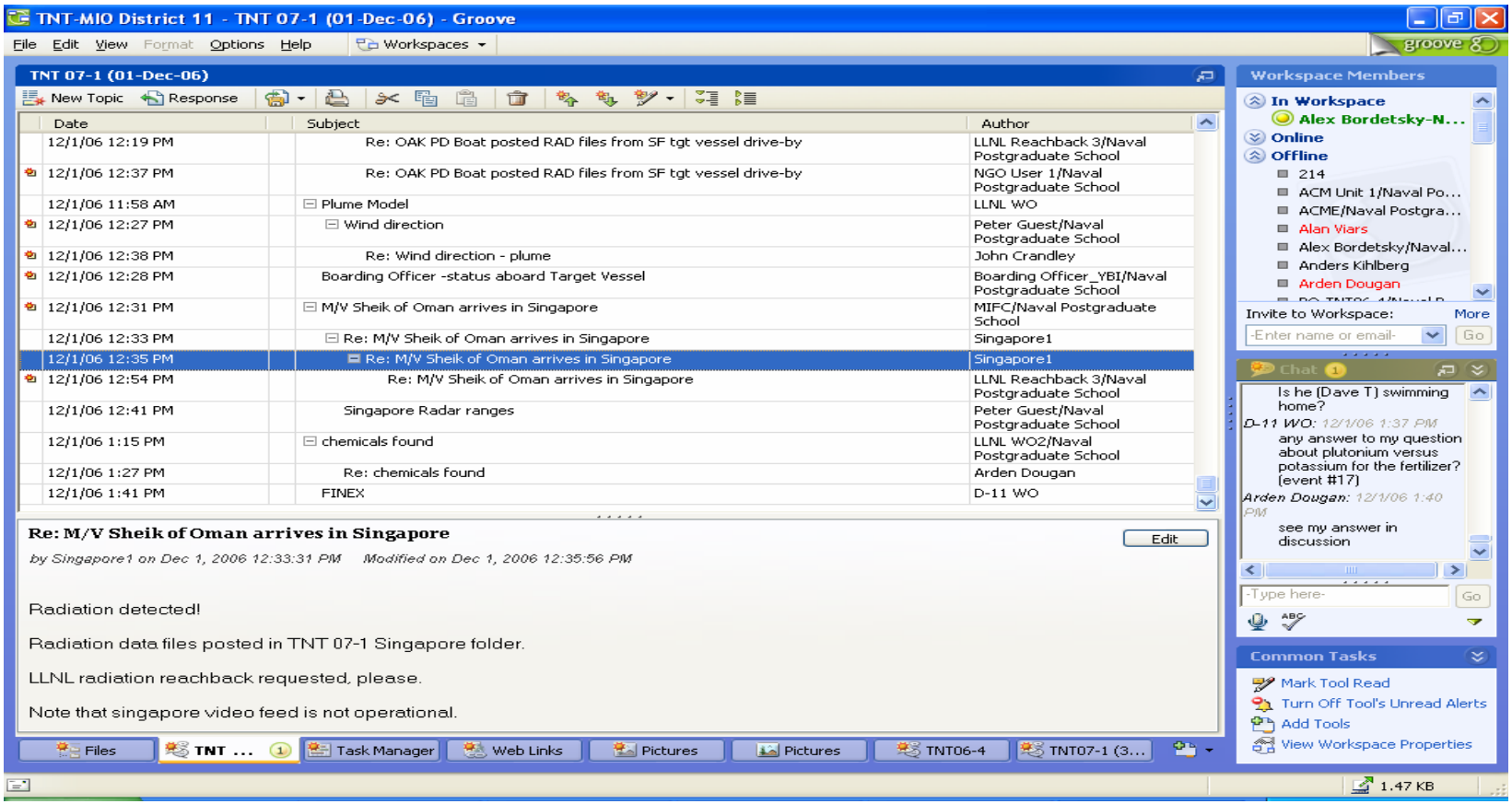
Video Feed on the Target Vessel Provided by Unmanned Surface Vessel



Getting Drive-by Search Feedback from Sweden

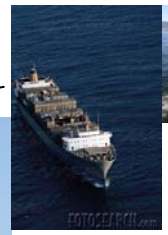


Source Detection Feedback from Singapore



TNT MIO Testbed: Self-Forming Broad Band Wireless Backbone

DARPA MAV



Pacific Ocean

Sea Fox UGV

Mt. Tamalpais

802.16

LBNL

LLNL

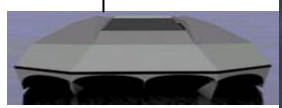
NPS CENETIX

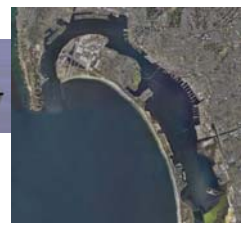
VPN/GIG

Mt. Diablo

U.S.C.G. Yerba Buena Island, CA

San Francisco Bay





OSD/OFT Stiletto,MSC Coronado

Riverine - Sacramento Delta

May 07

In Progress

Sweden, Austria, Singapore, Australia, Canada, Germany, Israel

Role for MIO-07

- Simulated the boarding & search of a vessel that may have a nuclear device
  - Radiation profile and photo of the suspicious item sent via collaborative environment for reachback analysis at LLNL

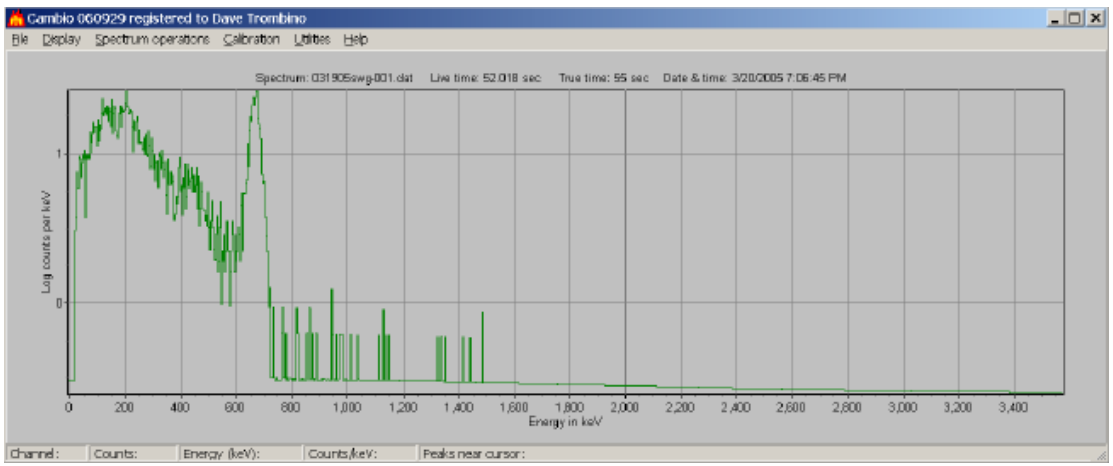


Figure 9-9. Moisture Gauge

Questions?

SOCOM - NPS
Field Experimentation Cooperative
Tactical Network Topology Testbed

NPS CIRPAS UAVs and Manned Aircraft

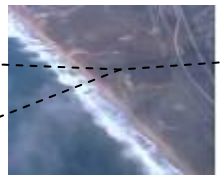
Local Access Ft. Ord MOUT

MIO Extension

U.S. Army SATCOMSTA

MOA with Ft. Hunter Liggett, USAR (1-07)

VPN/GIG



NPS Beach Lab

NPS CENETIX

802.16

~100 mi

MOA with Camp Roberts ANG

ITT Mesh

Monterey Bay,

Pacific Ocean

NPS Experimentation East Dahlgren/Norfolk

2-07

NPS/CIRPAS McMillan Field UAV Flight Facility

Unlimited Use of Restricted Air Space

In Progress

Cooperative and Coordinated Field Experimentation

CENETIX

OSD/OFT
WolfPAC – Stiletto Experiments

OSD/OFT
HA/DR Project

NJ Health
Emergency Medical Response Network

OSD/HD
NPS Maritime Security Program

USMC Field Experiments

- Modeling and Simulation
- Biometrics
- Airspace Management/Deconfliction
- Data analysis and mining
- Image Enhancement, Mosaics, Stitching

SOCOM - NPS
Field Experimentation Cooperative

- Agile, Adaptive Tactical Networks with Long-Haul Reach-back; Ground, Airborne, Ship, Underwater
- Collaboration Technologies
- Integration with GIG-EF via DREN (CONUS), GIG-BE (theater locations, satellite links), and Abilene (Internet 2 backbone) (overseas clusters)
- Shared Situational Awareness
- Unmanned/Autonomous Vehicles
- Network Controlled UASs
- Networked Sensors
- Dual-use Technologies for Post-Conflict Reconstruction, Stabilization, HA/DR

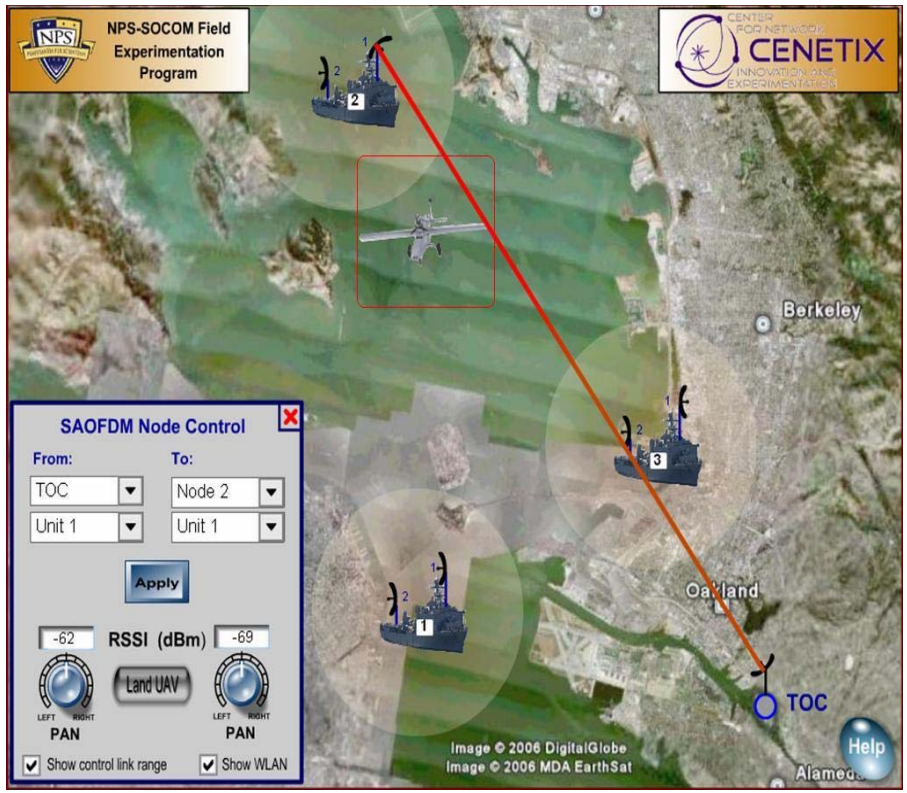
Sites:

- **Camp Roberts**
- **Ft. Hunter Liggett**
- **Monterey Bay**
- **San Francisco Bay**
- **Avon Park, FL**
- **etc**

- IED Detection and Jamming
- Smart Antennae
- Precision Tracking and Targeting
- Network Vulnerability Assessment
- Red Team Intent
- Human Systems Integration (Warfighters as Users and Evaluators)
- CONOPS
- Individual Identity Friend or Foe
- NGO-Warfighter Combined Operations

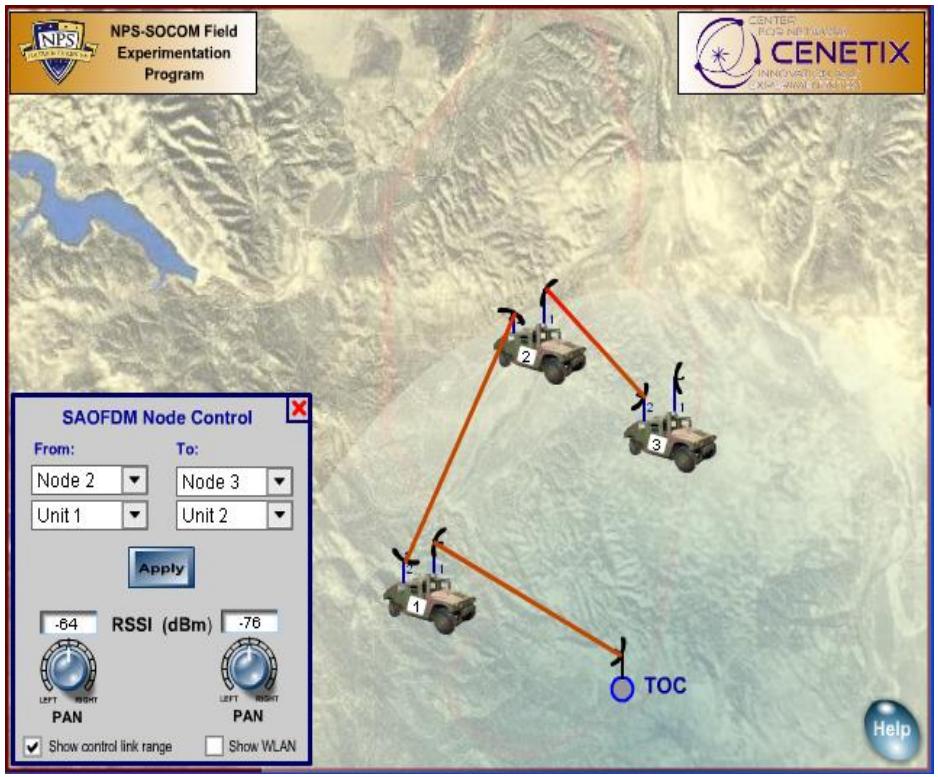
Adaptive Networking at the Situational Awareness Interface Level: Network-on-Target

- The NoT process starts at the level of Situational Awareness Interface used by the local or higher echelon commander, to point onto the Target, which in this case is the site to be reached by the self-configuring network
- In response the mobile networking node, i.e. small boat, light reconnaissance vehicle, or operator are moved to the area to extend the tactical mesh
- If the site is too far, or the preceding links are about to break down, the UAV is deployed to stretch the network further to the remote most node , or to heal the overstretched intermediate link



NoT at Work : Remote and Self-Alignment of Broadband Point-to-Point Antennas

- This in turn would require rapid and frequent re-alignment, of the antenna assets including panel switching and tune-up decisions made right at the level of local commander situational awareness view
- More so, the commander's remote advisers, located thousands miles away of surveillance and targeting area would be able to see the effects of the healing assets deployment in the Situational Awareness view and assist the commander in re-aligning and stretching the mobile network to the target area



NoT (SAOFDM Solution) at Work

SAOFDM_MIO.swf

Collaborative Technology

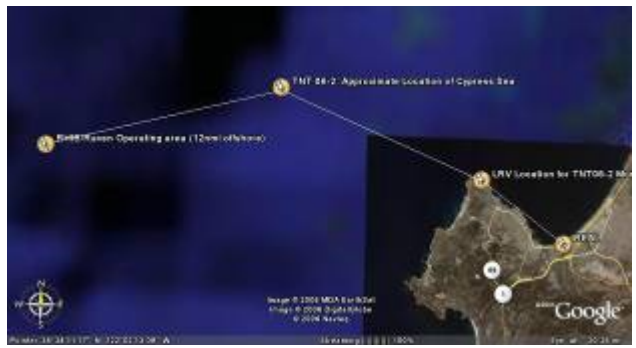
TNT 06-2 Monterey Bay

Aqua Puma UAS Launch and Recovery from RHIB with Comms and Video Relay Ashore

ROVER III – Video Scout with 900 MHz Radio Link to Shore

Boat Launched and Sea Recovered Aqua Puma UAS

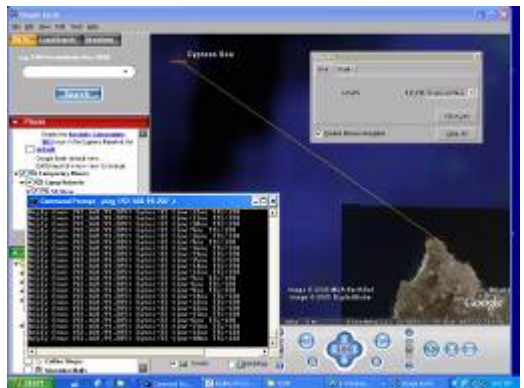
LRV Mobile TOC for Comms Relay: Ship-TOC



Cypress Sea: Comms Realy from UAV to Shore

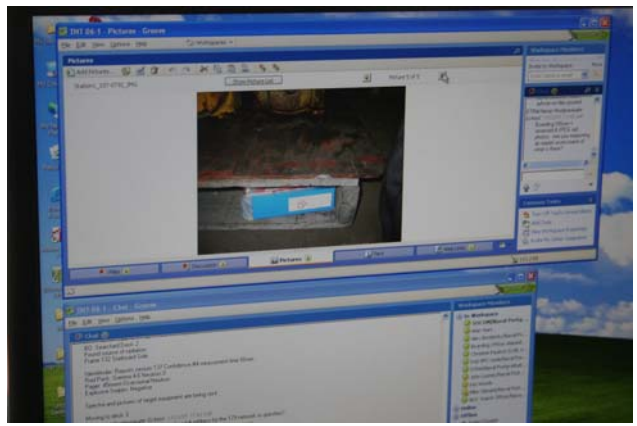
NSW RHIBs with Coast Guard Target Boat

(Day and Night Operations)

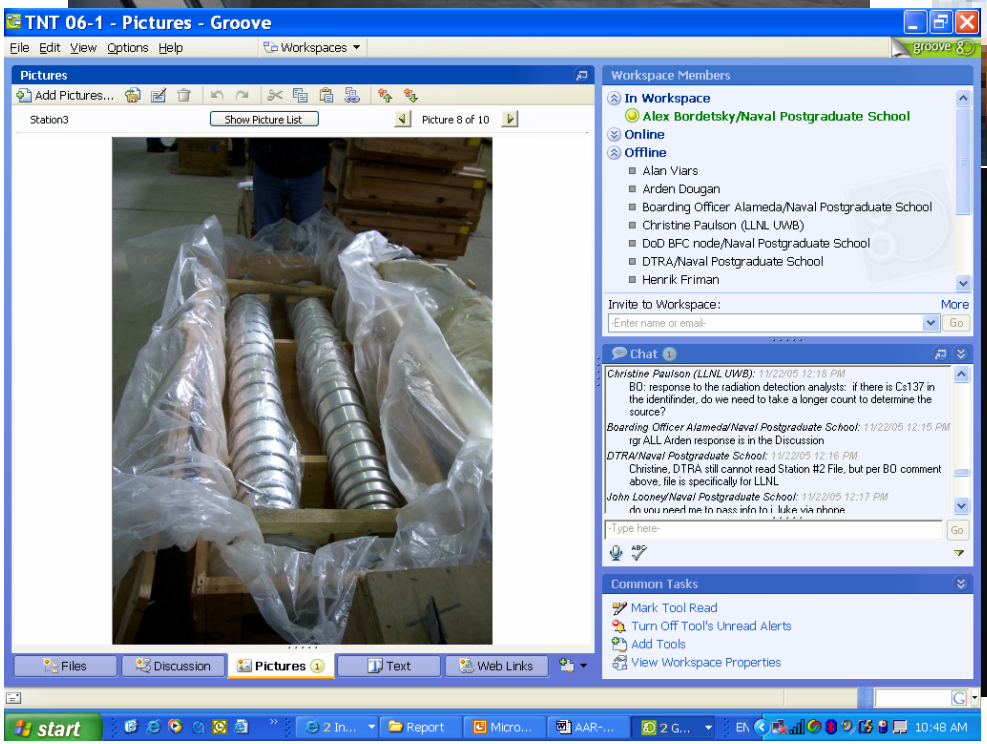


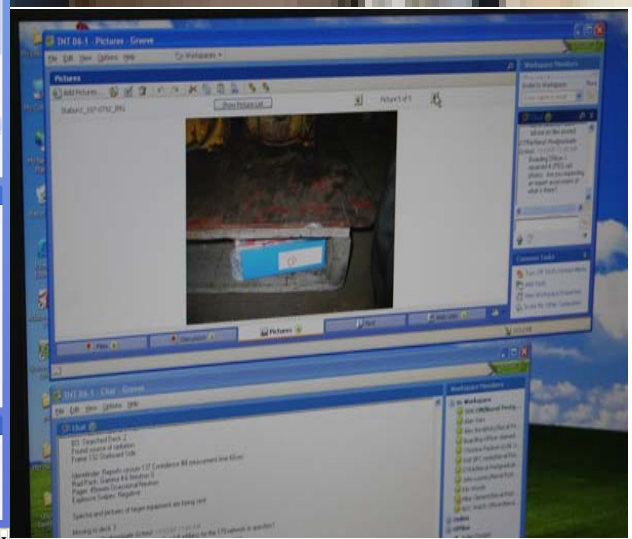
Geographically Distributed Collaborative C2 and Data Fusion Environment

Distributed team of Experts and Command Officers: Mobile Command Post (C2 input), DTRA (machinery smuggling), LLNL (radiation detection), SOCOM (ops advice)



Boarding Party Self-Synchronization with TOC and DTRA in Groove





MIO Networking Accomplishments

TNT MIO 06-4 : Feasibility of using innovative self-aligning broad band wireless solutions to support boarding and target vessels on-the-move, boarding party real time collaboration with coalition partners and first responders

(August 30-September 1, 2006)

Participating Units

NPS
Class on Collaborative Technologies
Network Operations Center and Data Collection site via groove
Network Support team and Experiment Control (act as back up to make all necessary inject should network connectivity problems exclude certain players).

Swedish Team
Maritime Security Office of the Port of Oakland
observing and supporting experiment control by scenario injects made via groove, SA, and by video feed (with CDR Leif Hansson in Lead)

Austrian Team
Port of Hong Kong (where the containers were loaded)
observing and supporting experiment control by scenario injects made via Groove, SA, and by video feed (with Dr. Ulrich Hofmann in Lead, Ulrich Wagner as Technical POC)

Team in Singapore
Shipper of the cargo containers
observing and supporting experiment control by scenario injects made via Groove, SA, and by video feed (with Dr. Yu Chiann in Lead)

DHS Science & Technologies CounterMeasures Test Beds
Office of Emergency Services
Assists CalOES and DOE RAP

Participating Units

Alameda County Sheriff's Office Marine Patrol Unit Boat and RHIB– Boarding vessel, deploys boarding party and does drive by (carries IST detector)

Oakland Police Boat 35 the target vessel

OFT Stiletto Ship-remote early warning command post en route to San Diego area

USCG

District 11 Watch Officer

PAC Area Watch Officer

MSST Level Two capable boarding team with radiation detection equipment?

Participating Units

LLNL

Providing source, source security, and data files for detection teams (if necessary)

Providing remote analysis cell from Livermore via Groove

Provide mapping facility of bay showing critical facilities (HOPS), radiation detection reachback and atmospheric modeling reachback

LLNL Watch Officer – remote cell (operating from NPS)

2 members of Boarding Party (with radiation detectors)

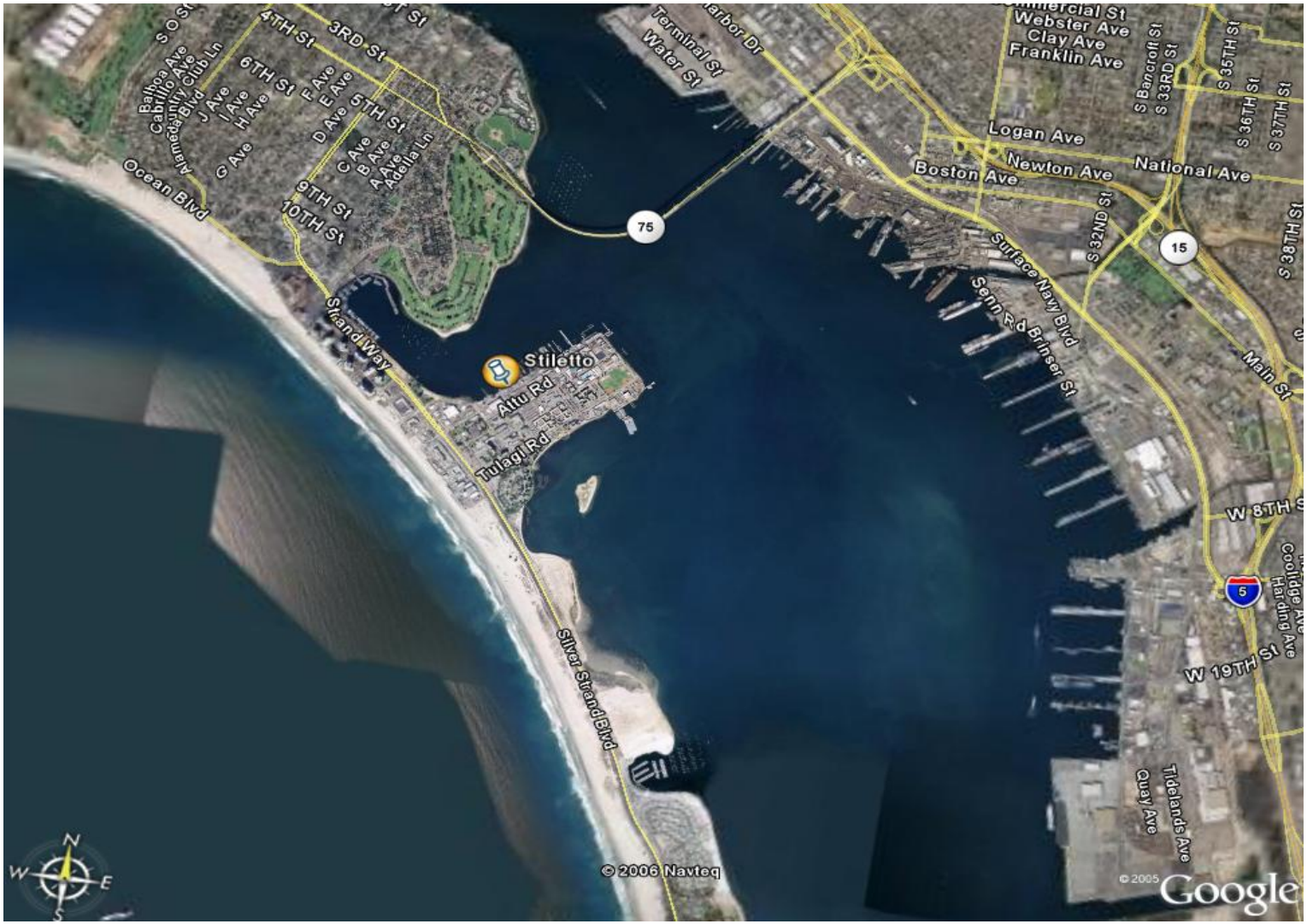
BFC (Biometrics Fusion Center)

Providing data files for detection teams,

Providing remote support for exercise database search and results reporting via Groove collaborative software

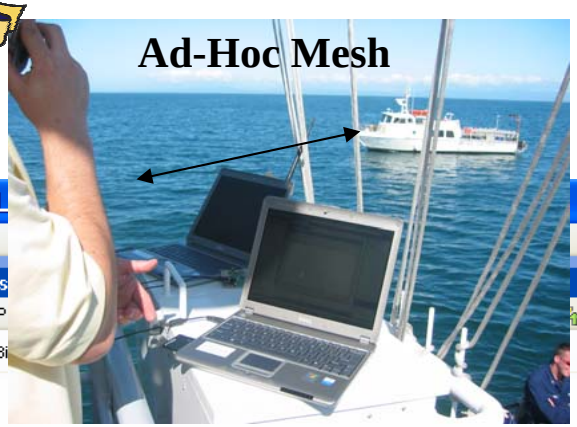
SOCOM Observers

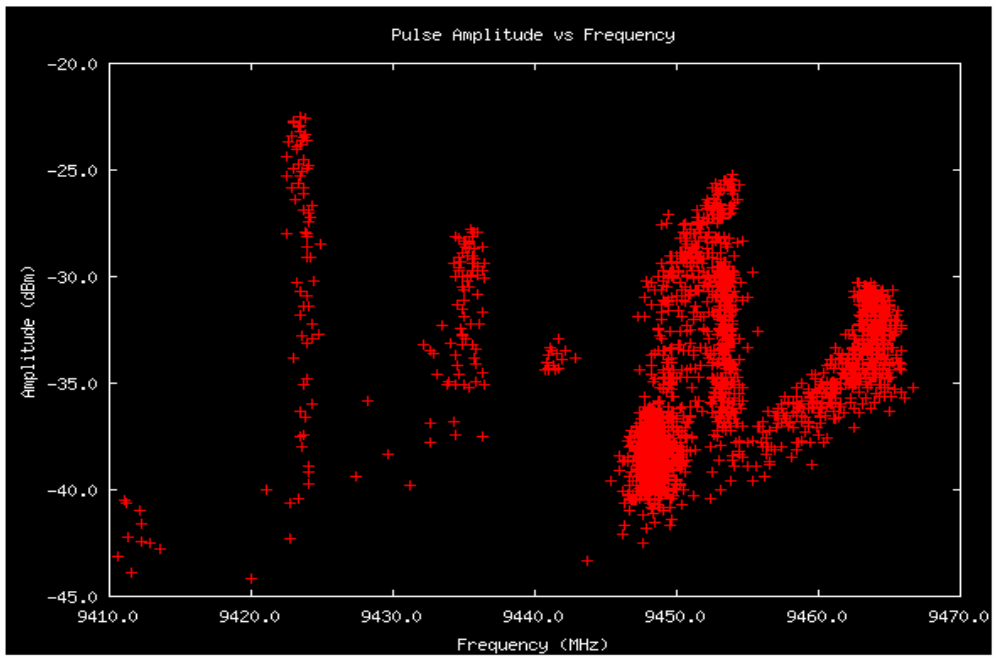
Remote Navy Asset: OFT Stiletto Ship in San Diego



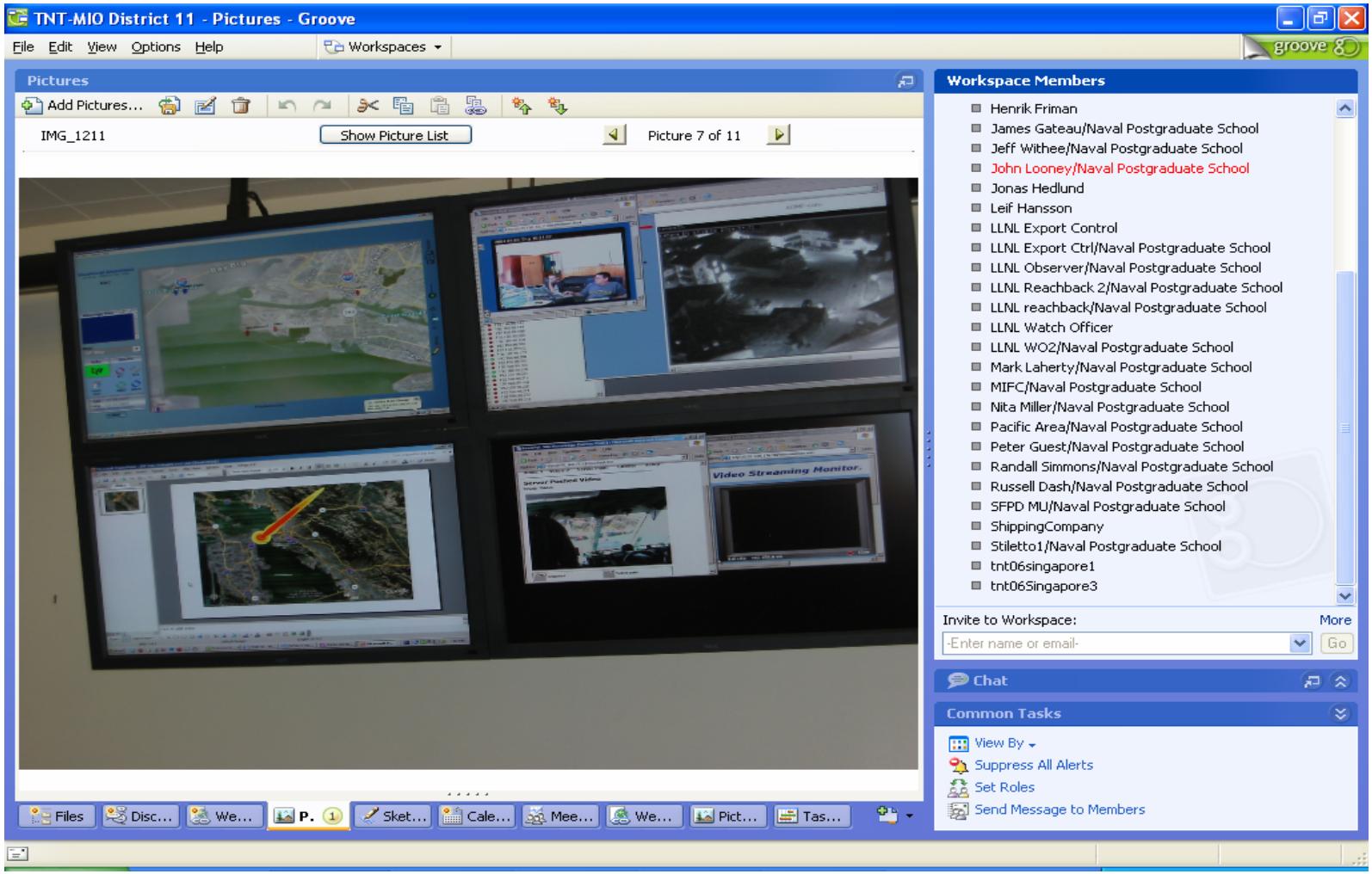
Target Ship Enters Monterey Bay; Collaboration with TACSAT for Ship ID

Ship-to-Ship

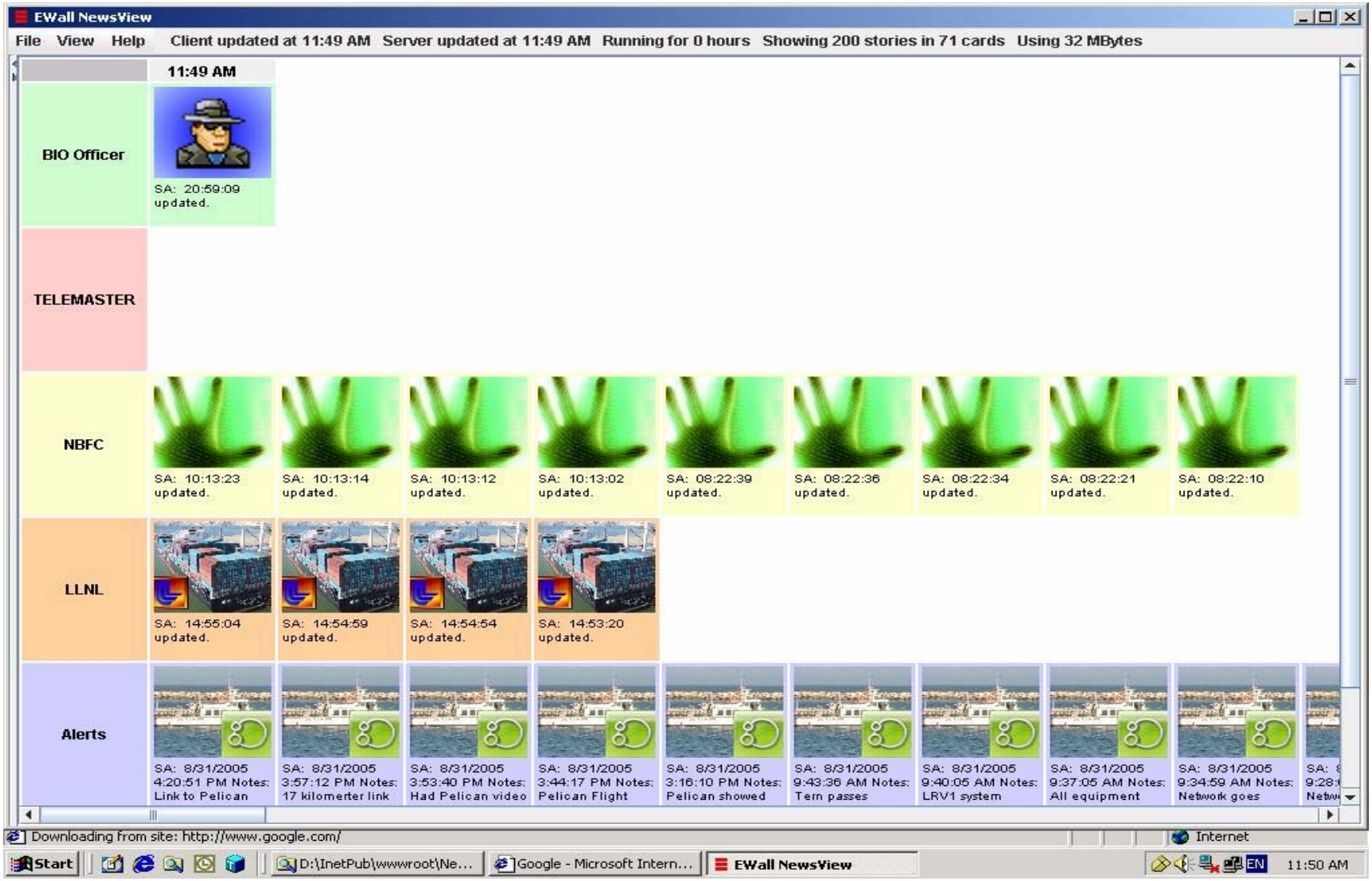




Boarding Party Situational Understanding Development via Collaboration with Expert and Command Remote Sites



EWall Integration with Groove: Combining Biometrics Identification (NBFC row), Radiation Detection (LLNL row) and Groove events at the distributed locations (Alerts row)



MIO 06-4 Findings

- SAOFDM-based experimental adaptive on-demand ship-to-shore network provide expected connectivity and level of bandwidth capable of carrying on several video streams and data sharing situational awareness applications. While on the move at speeds 3-5 nm/hour and zigzag maneuvering of the Boarding Vessel trying to chase the Target, the SAOFDM node by using designed self-aligning algorithm applied via the control channel enabled to keep ship-to-shore directional link intact, providing transmission rates up to 5 Mbps.
- Collaborative technology (shared workspaces, SA, video tools) performed well, enabling simultaneous radiation detection and analysis taking place in different geographically distributed locations.
- We observed successful SA integration with early drive-by detection of radioactive source on board of truck in Bavarian Alps (upper right view), by the first time in action Stiletto ship in San Diego (lower right view) and plum detection of the boat in SF Bay (lower left view). For the first time three surface nodes and three overseas command posts (Swedish Navy, Singapore DTSA, and Austria (Salzburg Research) acted together with District 11 (CG), YBI TOC and NPS NOC.

UCRL-PRES-226372

Tactical Network Topology Maritime Interdiction Operation Experiments: Enabling Radiation Awareness and Geographical Distributed Collaboration for Network-Centric Maritime Interdiction Operations

December 5-8, 2006

Arden Dougan

International Maritime Domain Security Symposium

This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

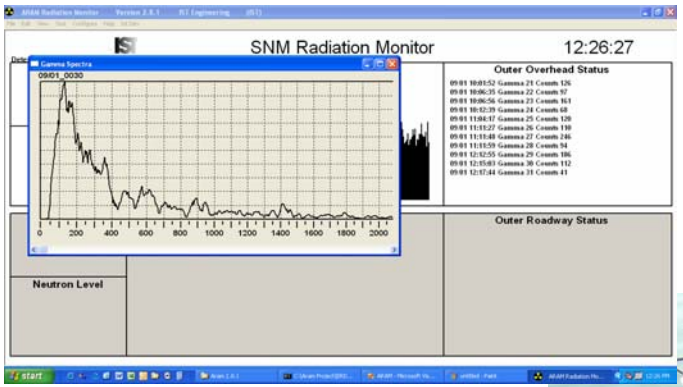
TNT Maritime Interdiction Operation Test Bed

- **Tests cutting edge technology for WMD detection and communications in maritime environment**
  - — Communications in harsh environments, between moving ships at sea
  - — Netcentric collaboration with global partners
  - — Situational Awareness
  - — Scenario-based

Drive-By Radiation Detector: ARAM – Adaptable Radiation Area Monitor

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

R&D 100 2005



Radiation Sources used in TNT

- **Naturally occurring radioactive materials (NORM)**
  - — Radium smoke detector
  - — Thorium lantern mantles
  - — Calibration Sources
  - — Moisture gauge
- **Surrogates**
  - — Fiestaware
  - — Uranium-238
  - — Plutonium surrogate

Surrogate Radiation Sources used to simulate special nuclear materials

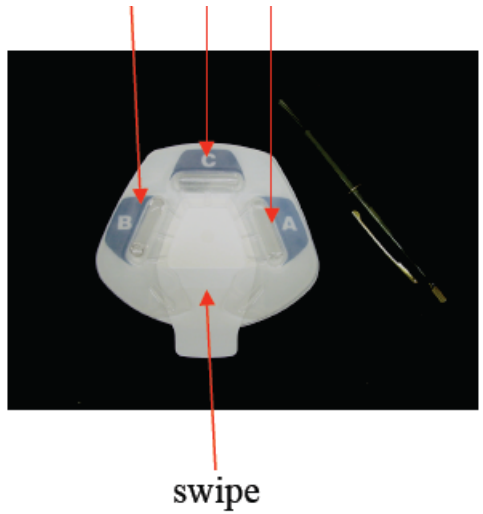
- **Plutonium surrogate**
  - Mimics Pu for 1st response detectors
  - DOT Limited and Excepted Quantity for easy transport
  - Field life 2-3 months (renewable)

Explosives detection kit - ELITE

- Colorimetric explosives detection system
- Simple to use swipe test, immediate results, requires little training
- Detects over 25 explosives and their precursors
- Low nanogram detection limits
- Swipes and tests potentially contaminated areas
- Enables easy detection of color change

'LITE detects:

- *nitro aromatics (including TATB)*
- *nitrate-esters*
- *nitramines*
- *picric acid*
- *inorganic nitrate compounds*



- Small, disposable, one use system
- Easy to use, no training required
- Minimized heating requirements
- Uses a swipe material for improved sampling
- Inexpensive to manufacture
- Detects aromatic, aliphatic, and nitrate explosives
- Utilizes three types of chemical reactions
  - Meisenheimer complex
  - Griess Reagent
  - Zinc reduction of nitrates

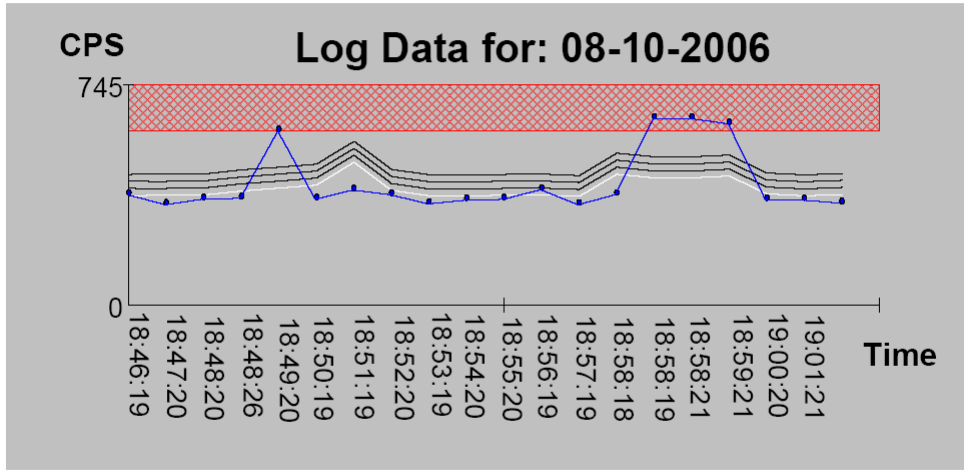
Reachback

- **Radiation Experts**
  - — Analyze radiation spectra
  - — Determine quality of data
  - — Ask for additional information (background spectra, photos)
- **Consequence Analysts**
  - — Plume modeling
  - — Access to maps, atmospheric modeling, hazardous chemicals database
- **Export Control Experts**
  - — Analyze photos of items
- **Emergency Response Coordinators**
  - — Advanced planning (direct movement of ships, area vulnerabilities, etc.)

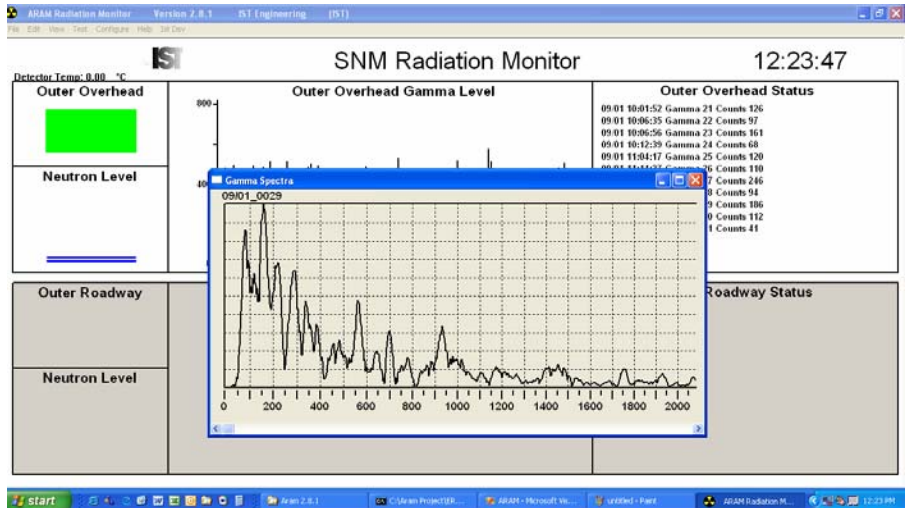
Examples of Radiation Reachback

- **Who: unknown**
- **What: A truck loaded with an cargo container**
- **When: A time ago (exact time unknown)**
- **Where: Entrance into the Hong Kong seaport**
- **How: Portal monitor**
- **Specials: No neutrons observed, just gamma radiation**

Radiation Alarm



Hong Kong Border



There is one item that was added to CalMart's shipment, not normally part of their shipment. This item is sent by George Koncher to the "Citizens Against Nuclear Things."

Plume Modeling

The TNT MIO Node in Singapore

Dr Foo Yu Chiann
Project Manager
Defence Science and Technology Agency

Experiment Set-up

- 3 wireless laptops connected via 802.11g to the Internet
- Location:

DSTA
Defence Science & Technology Agency

- The Singapore node is connected to the MIO collaborative environment through a Virtual Private Network (VPN) established between DSTA and NPS.

Video Feeds

Stiletto

Boarding Vessel

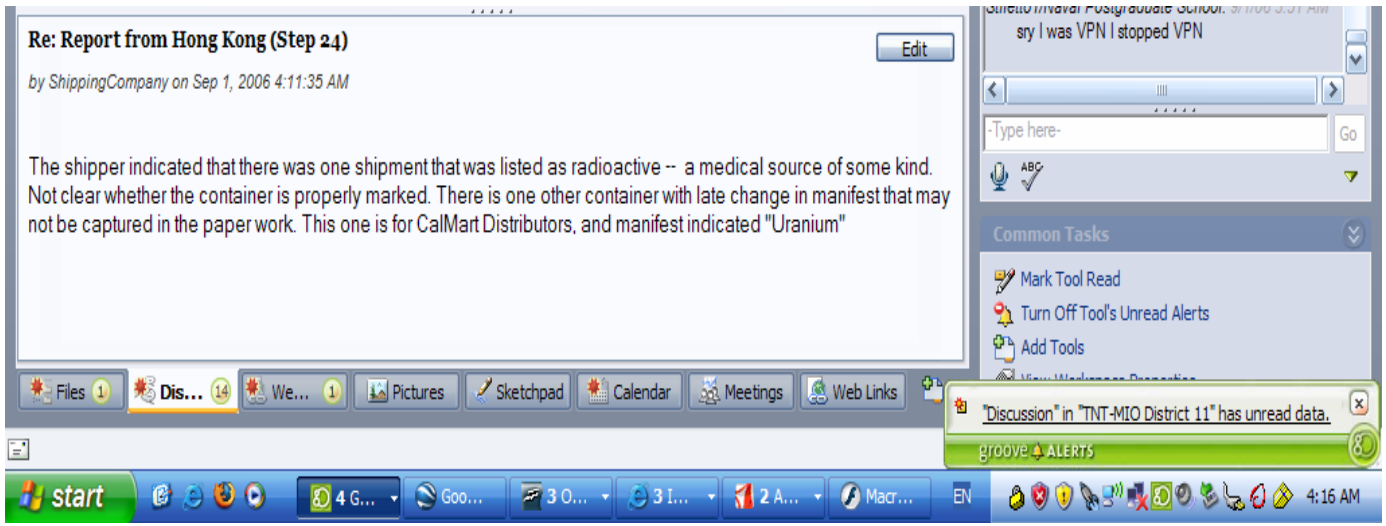
TOC

Sweden

Austria

Role for MIO-06

- Singapore played the role of the shipping company that had unknowingly transported the radioactive cargo (via Port of Hong Kong) as part of its shipment
- Provided the shipping manifest of the cargo containers to Port of Hong Kong and MIFC to aid investigations



Observations

- The Experiments have provided insights on the possible new operational capabilities that could be achieved with collaborative networking
  - Allow boarding team immediate access to remote expertise during boarding operations
  - Shorten decision-making processes
- Way ahead
  - Explore how such collaborative technologies could be applied for our own operations

Thank you

Swedish Naval Warfare Centre

Wireless Broadband supporting Maritime Security in Littoral Waters

TNT 07-1

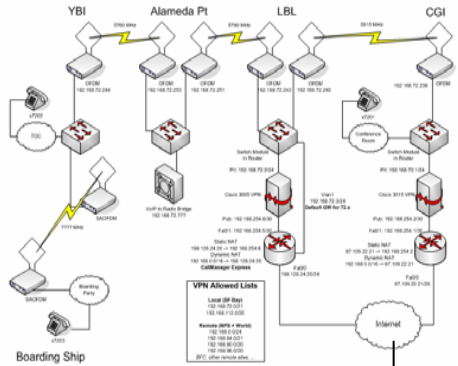
Sweden acted as a counterpart MIO agency, conducted the same operations and exchanged real time information that was analysed by the reachback organisation.

Radiation data (provided by the CBRN centre)
Calculated radiation spread (provided of the CBRN centre)
Live video feed
Observer at SF Bay

TOC

TNT 07-1

Result:
Connectivity with all participants
Posted files where analysed
Video feed to/from all participants
VPN connection LAN-to-LAN



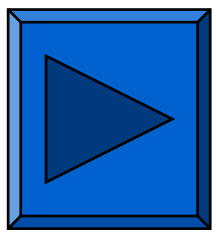
SNWC

CBRN centre

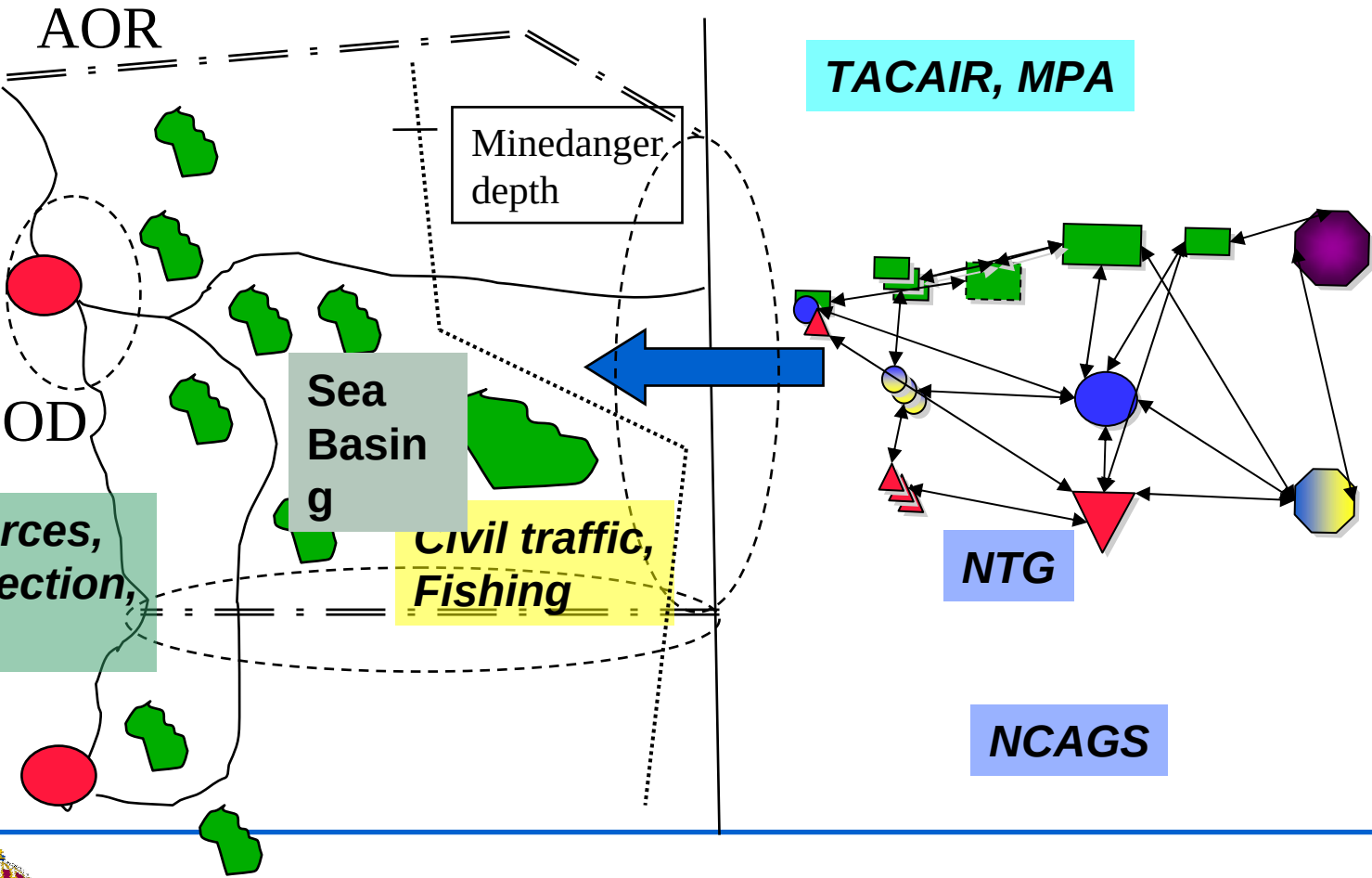
BP

The Swedish goal for participating in the TNT experiments

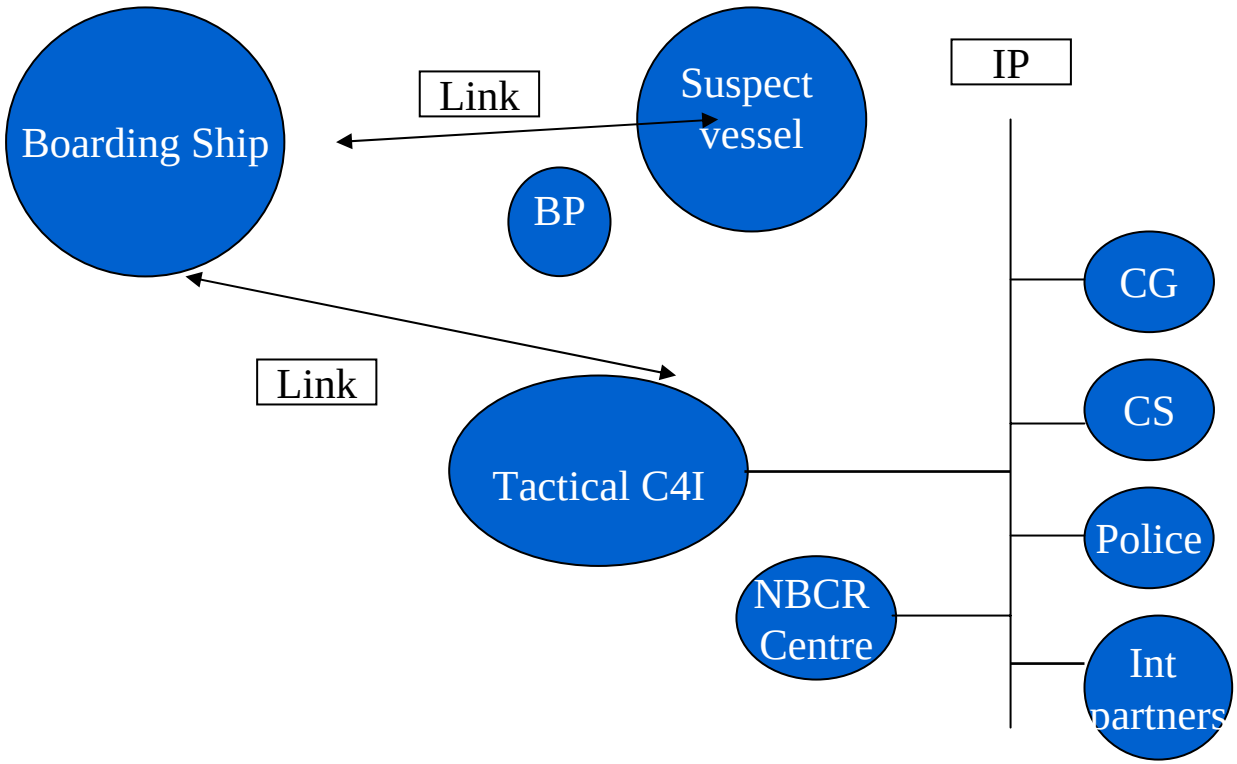
- **Use the experiments as stepstones to be able to conduct the Swedish TNT experiment fall 2008**



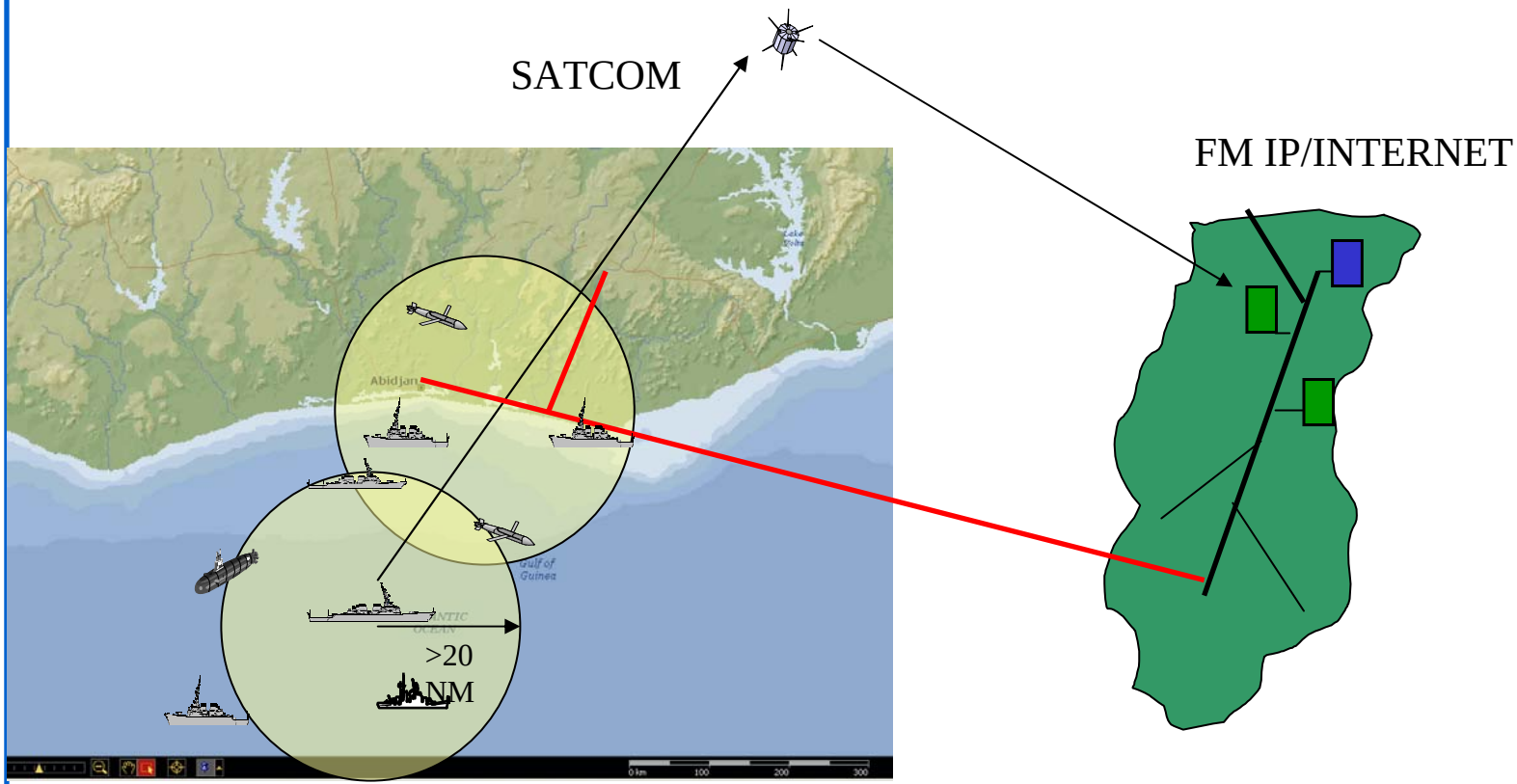
Swedish Operational Concept - Maritime Security



Vision for Swedish TNT experiment fall 2008



Wireless Broadband supporting Maritime Security in Littoral Waters



TNT 07-2

Live radiation detection
Boarding party

Integrated sensor
systems for soldiers

Sensor and communication jacket

Demonstration vest developed in collaboration with Combitech and the University of Umeå

Sensor and communication jacket

Key features:

- Real time communication of voice, data and sensorinformation
- Integrated in the combat suit (jacket)
- Adapt sensors to the specific mission/task
- Possibility to supervice physiological status and position of the soldier
- Presentation of alarm and data to the solider (MMI)

Sensor and communication jacket

Camera

Explosives detector

CW/TIC detector

Radiological detectror

MMI

Display

Control panel

Microphone

Earpiece

Vibrator

LED Bar

RDO

CPU

PAT

Inertial nav

GPS

Body temp

Heart