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Alex Bordetsky
David Netzer

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Testbed for Tactical Networking and Collaboration

Dr. Alex Bordetsky and Dr. David Netzer
(Naval Postgraduate School, USA)

Abstract

Beginning in 2002, a team of Naval Postgraduate School researchers together with sponsors from the United States Special Operations Command (USSOCOM), and later joined by the Office of the Secretary of Defense (OSD) and the Department of Homeland Security (DHS) S&T Programs, started a new interagency experimentation program, which is now collectively known as the Tactical Network Testbed (TNT) Experiments. An observed general lack of synergy between military operators, government labs, industry, and the academic community in resolving increasingly complex problems of integrating and operating emerging technologies motivated the project.

In the core of TNT experimentation is a unique testbed, which enables sustainability and evolution of the experimentation process. It provides for the adaptation and integration processes between people, networks, sensors, and unmanned systems. It enables plug-and-play tactical-on-the-move sensor-unmanned systems networking capabilities combined with global reachback to remote expert/command sites and augmentation by rapid integration of applied research services.

The goal for this paper is to describe an innovative interagency experimentation testbed environment which has evolved into a unique research service of social and information networking, enabling

synergy of the military, academic, government, and industrial communities in designing, operating, and evaluating emerging self-organizing tactical networks as well as other related technologies.

Introduction

A program was initiated at NPS in 2002 in order to provide faculty and graduate students the opportunity to extend, when appropriate, their research into the field environment. In the first two years the program was driven by the operational experience of (then) CW02 Chris Manuel, U.S. Army special Forces, which identified a shortfall in situational awareness for the current warfighter. During this initial period, a team of Naval Postgraduate School researchers together with sponsors from USSOCOM, and later joined by the OSD and DHS S&T Programs, also initiated a new program of discovery and constraints analysis experiments (Alberts and Hayes 2007). This is now collectively known as the Tactical Network Testbed (TNT) Experiments. The TNT interagency experimentation program has two major venues.

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 systems as well as collaboration between geographically distributed units with focus on high value target (HVT) tracking and surveillance missions. The TNT experimentation process with USSOCOM is focused on both technologies associated with networking and the human aspects of networked forms of organization. Technologies investigated have included network-controlled unmanned systems (air, ground, sea), various forms of multiplatform wireless networking, mesh networked tactical vehicles, deployable operations centers, collaborative technologies, situational aware-

ness systems, multi-agent architectures, biometrics, and management of sensor-unmanned vehicle-decision maker self-organizing environments.

The second venue involves Maritime Interdiction Operation (MIO) experiments with Lawrence Livermore National Laboratory, USCG and First Responders (San Francisco Bay, New York/New Jersey), and is supported by Homeland Defense (HLD) and HLS S&T Programs and Department of Energy (DoE) agencies. These experiments are conducted twice a year and are also supported by overseas partners from Sweden, Germany, Denmark, and Singapore. This series of experiments is being conducted to test the technical and operational challenges of searching large cargo vessels and interdicting small craft possessing nuclear radiation threats. One goal is to test the applicability of using a wireless network for data sharing during an MIO scenario to facilitate *reach back* (a current technologically challenging operational gap) to experts for radiation source analysis and biometric data analysis. This technology is being tested and refined to provide networking solutions for MIOs where subject matter experts at geographically distributed command centers collaborate with a boarding party in near real time to facilitate situational understanding and selection of the most appropriate course of action.

Each MIO experiment has been a significant next step forward in evaluating the use of networks, advanced sensors, and collaborative technology for rapid MIO response, including the ability to search for radiation sources, set up ship-to-ship and ship-to-shore communications while maintaining network connectivity with command and control (C2) organizations, and collaborating with experts on the radiological threat and biometrics identification.

In all of these experiments, the focus has been on adapting both emerging and commercially available technologies to military requirements and on investigating new social networking/collaboration elements associated with the addition of such technologies to

the new type of battle space and maritime security operational scenarios. The definitive feature of such new network controlled battle space is heavy reliance on self-organizing (self-forming) last mile mesh networking between man and machine at the tactical level, as well as globally distributed collaboration between tactical and operational command centers enabling "flattening" of the traditional command and control ties. Finding operationally viable solutions for this new social and information networking problem requires scaled sustainable field experimentation studies between military operators, researchers from academia, government laboratories, and industry innovators. The TNT interagency plug-and-play testbed becomes and enabler of it.

With the continued rapid evolution of technologies the TNT program has had to also adapt and evolve. The network and applications have to be continually updated and the technologies and types of scenarios in which they are utilized continues to change. What hasn't changed is the need for the collaborative experimentation testbed that facilitates easy participation and prototyping on a short timeline.

Tactical Networking Testbed: Man-Machine Plug-and-Play System Enabling Sustainable Interagency Experimentation

Each quarter, the growing team of NPS researchers, USSOCOM operators, and government, commercial, and academic participants get together on the grounds of Camp Roberts, California as well as other network-linked locations to explore synergy and impact of emerging technologies with a major focus on sensor-unmanned systems-decision maker self-forming networks and unmanned vehicles. Figure 1 illustrates the state of the experimentation team during FY2008.

Large Interdisciplinary NPS Team

27 Thesis Students
31 Faculty, 4 Staff; 9 Departments and Institutes
Includes 21 PhDs
Course Projects: IS, OR, MET
28 NPS Field Experimentation Projects

Examples of Programs Utilizing TNT Testbed

AFRL JASMAD	JIEDDO
AFRL Marti	MCWL TW Radio
AFRL N-CET	Team TACLAN
AFSOC CP/BI	JFCOM EC-08

Examples of Participating Universities

ASU	Univ. of Bundeswehr - Munich
Carnegie Mellon	Univ. of Florida
Case	Virginia Tech
JHU/APL	WPI
MIT	WVHTF
NDU	UM, Columbia, UCSD, UCCS
UC Berkeley	

Figure 1a. Academic and government programs utilizing TNT in FY08.

Foreign Country Participation in MIO

Univ. of Bundeswehr at Munich
Swedish Naval Warfare Center
Turkish Air Force Academy
Systematic/Danish Navy Training Center

National Guard

West Virginia – Camp Dawson
Indiana – Camp Atterbury

State and Local Government in MIO

Alameda County Sheriff's Office
Oakland Police Dept.
San Francisco Police Dept.
Port Authority of NY/NJ
Fire Department New York
California Office of Emergency Services
California Dept. of Health
U.S. Park Police

Broad DoD and Gov't. Participation and Support

- USSOCOM	- USASOC
- AFSOC	- NAVSOC
- MARSOC	- JSOC

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

AFRL	LLNL	SPAWAR
ARL	NAWCWD	TSWG
BTF	NECC	USASMDC
DARPA	NIST	USCG/D-11
DHS/S&T	NRL	USCG-Staten Island
DNDO	NSA	USMC-HQMC
DOE RAP	NSWCCD	USMC-MSTSSA
DTRA	ONR	USMC-MCWL
JFCOM	ONR 113	USATC (Fort Eustis)
JIEDDO	OPNAV N8F	
JITC	OSD/HD	
LBNL	OSD/RRTO	

Figure 1b. TNT testbed federal, local, and foreign participants in FY08.

Industrial Participation		
Adaptive Flight	I-C Mobilisa	Remote Reality
AGI	iGov Technnologies	Restech
Amrel	ImSAR	Retica
AOptix	IST-Textron	Sarnoff
Applied Signal Technology	L-3 Com	Space Data Corp.
BAE Systems	LMCO	Step Labs
Blackbird Technologies	McLane Adv. Technologies	Strategic Initiatives
CDI	Metson Marine	Swe-Dish
CHI	Mission Technologies	Toyon Research
Commsfirst	Mitre	Trident Tech. Solutions
CrossMatch	Networx	TrellisWare
DRS	NGC	Triggerfinger
ESRI	Orion Networking	WinTech Arrowmaker
Extreme Endeavors	P&LE	XTAR
General Dynamics	Persistent Systems	
Harris RF Comms	Procerus	
Honeywell	QinetiQ	
Hoyos	Redline Communications	

Figure 1c. TNT industrial participants in FY08.

Self-Organizing Tactical Networking and Collaboration

The experiment members plug-in their sensors, networks, UASs, aerial balloons, ground vehicles, situational awareness systems, and operator units into the TNT testbed comprised of segments and layers.

- At the physical level the testbed reaches to the hardware utilized, such as airborne and ground unmanned systems.

- The TNT participants can integrate their sensors, mesh, and local area networking elements.

- Users can connect using the reachback wide area network, including those to other operational areas, remotely located experts, command and operation centers.

- Sensors and unmanned vehicles can be integrated with the TNT situational awareness environment.

- Human operators (both remote and local) can access the testbed collaborative environment.

All the network (Camp Roberts and MIO clusters) infrastructure is operated and maintained by students and staff (especially Mr. Eugene Bourakov and Mr. Michael Clement), and is itself often the subject of some experimental activity. A network operations center (NOC) on the NPS campus acts as the hub for linking the various off-site participants as shown schematically in Figure 2.

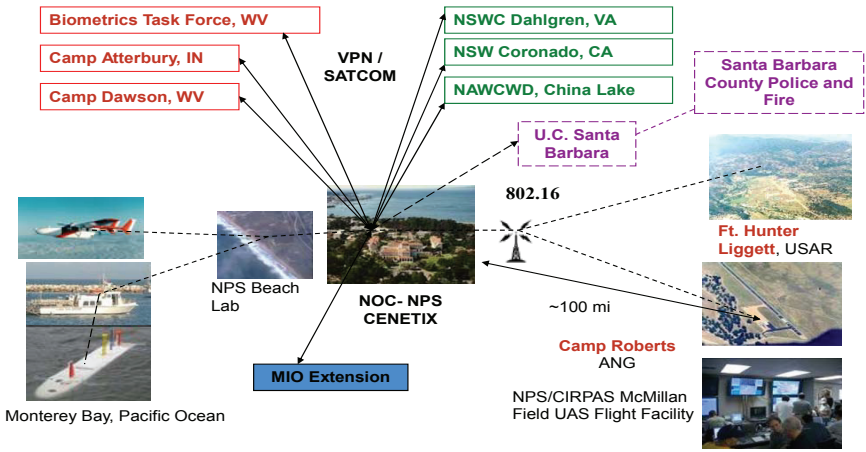

Figure 2. Plug-and-Play testbed with global reachback.

As seen pictorially in Figs. 2 and 3 the fixed TNT wireless (802.16) tactical backbone between NPS and Camp Roberts/Fort Hunter Liggett (slightly over 100 mi in length) is augmented by various

on-site wireless networks and an ever-changing set of virtual private network (VPN) tunnels on top of satellite links or the commercial IP cloud to permit remote site connection to the TNT infrastructure. They reflect the complexity of the TNT network setup. For example, the light reconnaissance vehicle (LRV) in Figure 3 is a mobile OFDM1 node. As such, a large portion of each experiment is concerned with the collaboration and coordination necessary to integrate the large number of sites and interested parties into the ongoing activities.

For example, the Biometrics Fusion Center (BFC), located in West Virginia, has been a participant in many of the experiments. They have been interested in ways of connecting remote, tactical field users to biometrics databases removed from the battlefield. In this manner, field agents looking for suspected terrorists can take sensors (fingerprint, facial recognition, etc.) directly to the area of interest while drawing on the full (and likely updated) databases provided by the BFC. Conversely, information gained in the field can be immediately made available to analysts back at headquarters or located in other locations around the world. Figure 3 illustrates one of the self-forming mesh segments of the TNT testbed at work with unmanned aerial systems (UAS) and different combined applications to land and sea environments at remote sites.

1. Orthogonal Frequency Division Multiplexing—this is the technology that underlies 802.16.

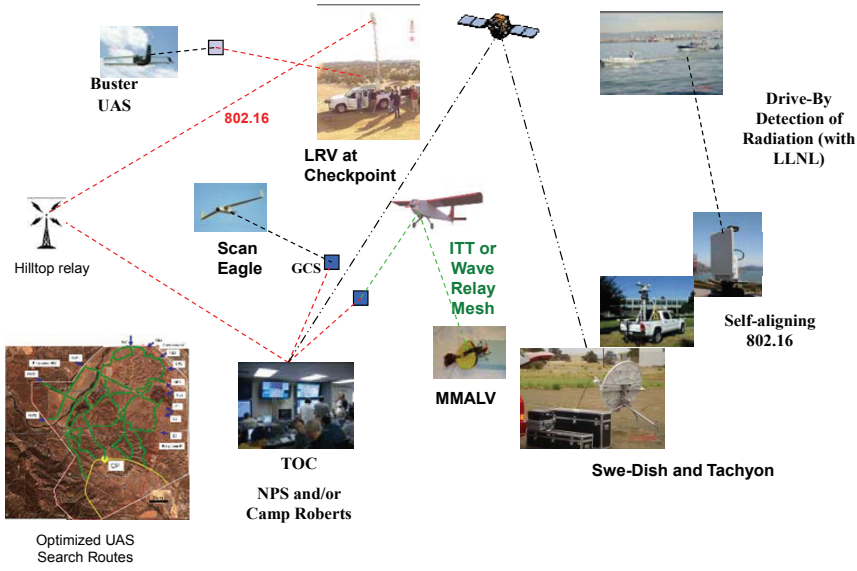

Figure 3. Typical self-forming mobile mesh segments of TNT testbed.

MIO Experimentation

The MIO experimentation historically started as centered in the San Francisco Bay area with multiple participating sites within the continental United States (CONUS) and overseas. However, it is not longer the case. TNT MIO 08-4 was actually centered in the Port Authority New York New Jersey (PANYNJ) area with a riverine operations component in the Hampton Roads/Ft. Eustis area. The network infrastructure that supports the MIO segments of the TNT testbed are described in Figure 4. Figure 4a shows the social/collaborative network linked by various communication/reachback networks. Figure 4b shows an example of the specific VPN links utilized in TNT 09-2.

From an operational standpoint, the TNT MIO testbed represents a unique geographically distributed field model of specialized sensor-unmanned systems-decision maker clusters.

- **San Francisco:** 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 Naval Special Warfare (NSW), USSOCOM, Army swimmers and divers, speed boats, and unmanned surface vehicles, and utilization of the C2 Center at Lockheed Martin Center for Innovation

- **Port Authority NYNJ-ARDEC:** Data sharing and collaboration with NY-NJ area Police and FD first responders, interoperability with DHS Joint Situational Awareness System (JSAS)

- **Swedish NWC:** Wearable sensor and unmanned surface vehicle (USV) swarm, interoperability with BFT

- **Danish Naval Systematic Center:** Diver detection in the port security area, interoperability with NATO Maritime Boarding Systems

- **University of Bundeswehr:** Check points in the smuggling routes, tagging and monitoring

- **NATO MIO TC in Crete:** Expert center for NATO small boat interdiction operations in Mediterranean and Black Sea

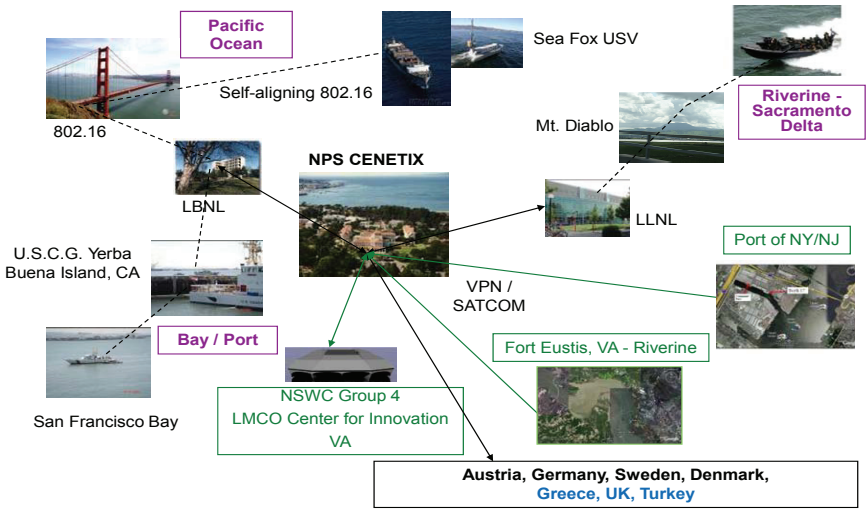

Figure 4a. Plug-and-Play TNT MIO testbed segment: San Francisco Bay, East Coast and overseas.

With the use of collaborative technologies and adaptive ad-hoc networking, TNT-MIO experiments have shown the ability to return a positive match within 4 minutes of collecting nuclear radiation and biometric data (Bordetsky, Dougan, Foo, and Kihlberg 2006). While this is under somewhat controlled experimental conditions, results even within an order of magnitude of this time would allow the boarding party to take action while they are still on board the suspect vessel and long before the suspect can evade. Figure 5 illustrates the MIO testbed in action, supporting simultaneous interdiction of target vessels in open waters, inner bay, and riverine and with an immediate reachback to expert sites and multipoint video/data exchange between the boarding parties.

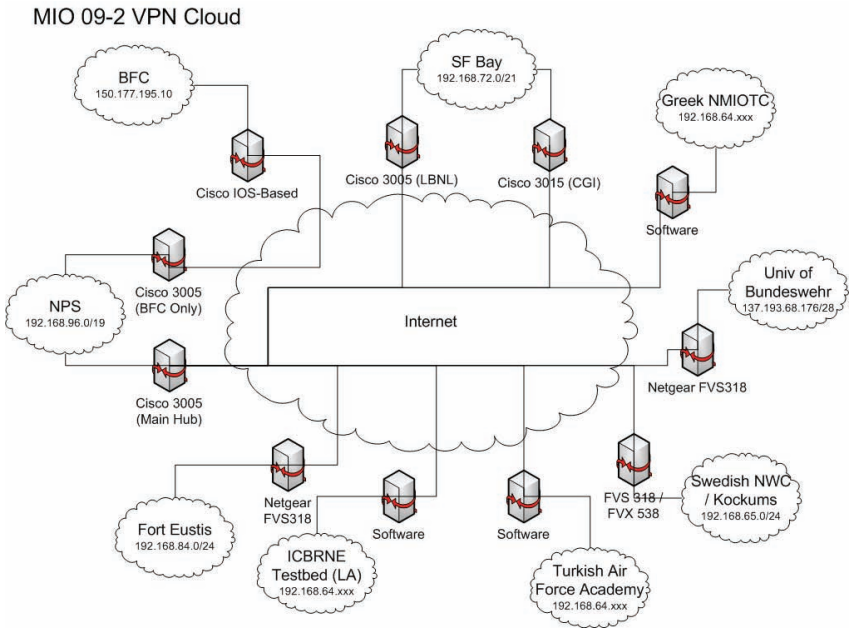

Figure 4b. The VPN links in MIO testbed interconnecting geographically distributed tactical and expert sites in MIO 09-22.

2. Diagram prepared by Michael Clement, NPS

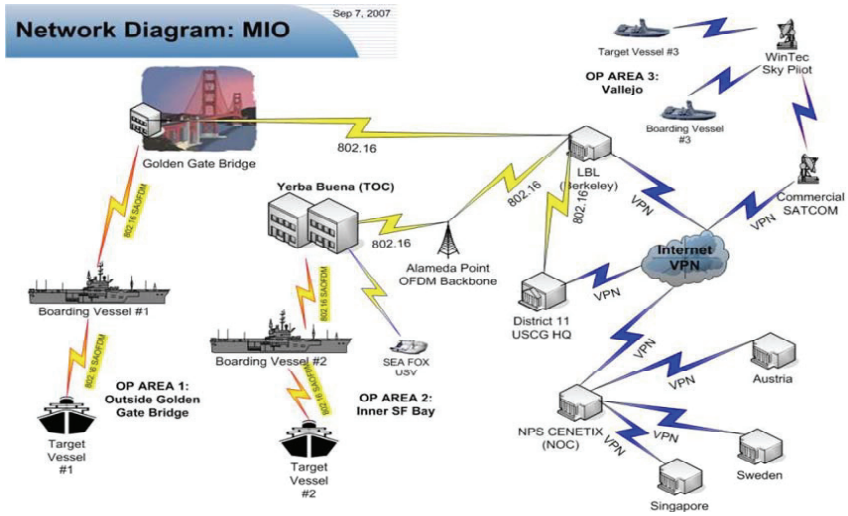

Figure 5. Simultaneous interdiction and data sharing between boarding parties conducted in three geographically distributed locations, including data sharing and collaboration with additional overseas sites.

The specific goal for the MIO 08-4 experiment was to explore new sensor, networking, and situational awareness solutions for interagency searching of large cargo vessel as well as tagging, tracking, detecting, and interdicting multiple small vessels which threaten the security of the coastal metropolitan areas in the Port of NY and NJ and the riverine area of Hampton Roads, VA.

The situational awareness focus of the experiment was to explore the requirements for broad interagency collaboration and data sharing using the capabilities of the PANYNJ JSAS, Domestic Nuclear Detection Office Joint Analysis Center (JAC) feedback, and two-way data sharing with the remote riverine area of operation.

Figures 6-10 illustrate the TNT MIO testbed in action during the MIO 08-4 multiple agency search of the large cargo vessel in the Port of Newark and interagency data sharing on simultaneous small

craft interdiction in the Port of Newark, Sweden, and Denmark. Such real-time data sharing between remote nuclear radiation detection experts, boarding officers, and local commanders at different geographical locations, allows findings to be associated into a holistic pattern of the emerging threat and to assist boarding officers in properly assessing otherwise low detection levels. For example, if a boarding officer was acting alone, the low level radiation source that was found on board vessel of interest, might have been neglected due to the lack of information on similar experiences of other boarding teams. However, by getting real-time input (including video feeds) on findings from the other locations, the same low level source could be correctly evaluated by its content and look as part of a more significant threat.

Also, multipoint collaboration between the small craft interdiction crews, allows for positional and video surveillance awareness sharing in association with the detection alerts. Figure 7 illustrates how the video feed on a suspect vessel leaving the Birth 17th rendezvous area is associated in the JSAS view (right frame) with expert alert on results of the primary drive-by detection analysis. The expert alert stated that the residue on the boat detected during the primary screening appeared to be suspicions. This triggered the incident commander to send a patrol boat with sensor closer to the suspect vessel for an immediate secondary stand-off screening.

Figure 6. Data sharing on simultaneous small craft interdiction; Port of Newark.

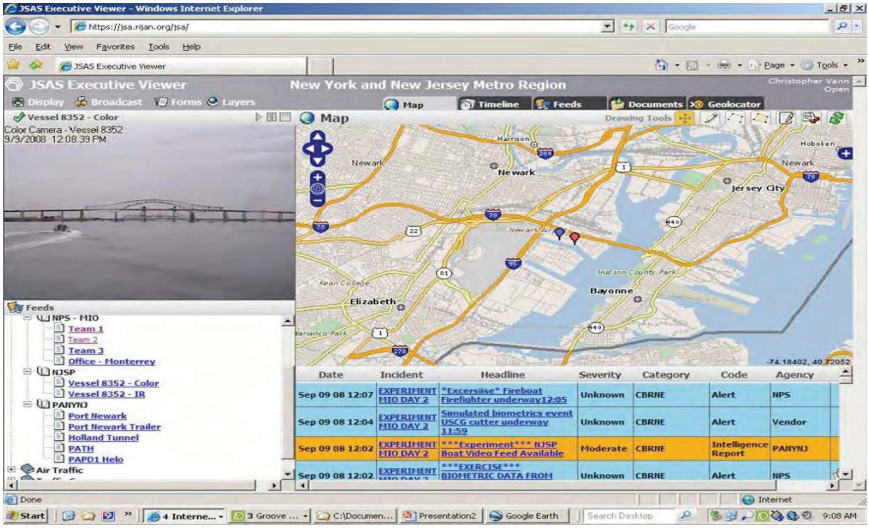

Figure 7. PANYNJ JSAS portal for sharing video/text alerts on small boat interdiction: NJ State Police patrol and Fire Department NY video/text alert exchange.

Figure 8. Shared video surveillance feed from the NSWC in Karlskrona, Sweden, on the Piraya USV drive-by detection of the suspect vessel.

Figure 9. Viewing the JSAS alerts at the MIO TOC in Sweden.

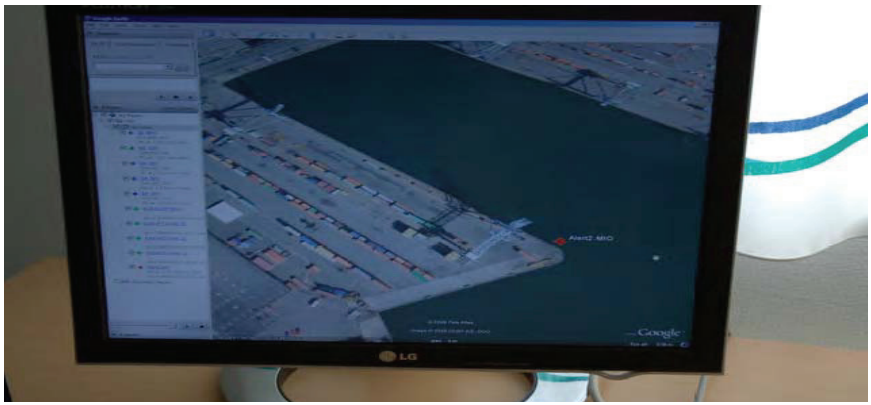

Figure 10. Shared view on the sonar detection of suspect diver in the port security area (Aarhus, Denmark).

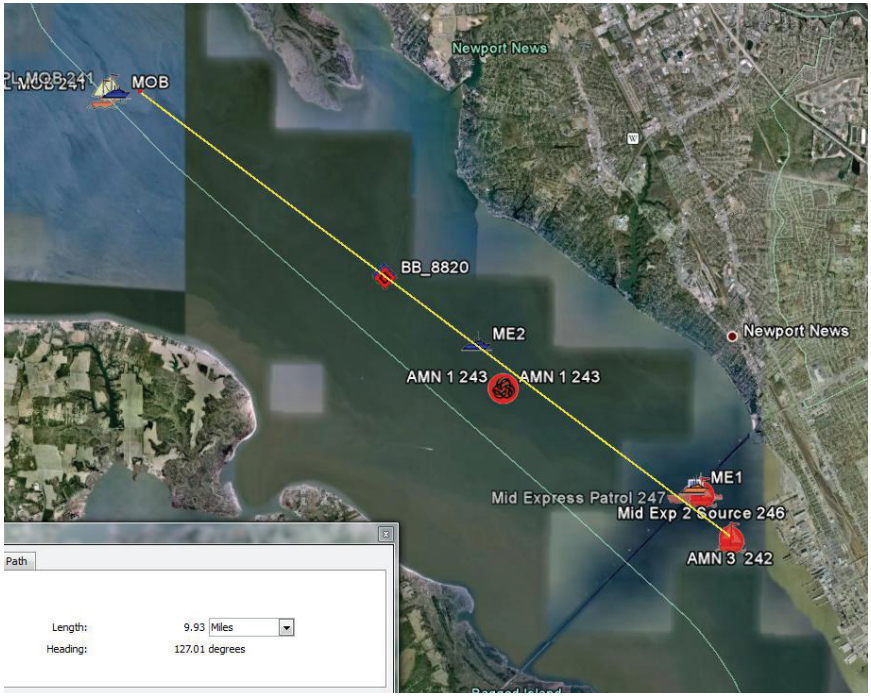

Figure 11. Synergy of extending mesh network by unmanned surface vehicles during a high-speed riverine chase of the target vessel.

In the high-speed stand-off detection captured in Figure 11, the patrol boat with sensor (ME1) was following on target vessel keeping the needed detection distance of 75 ft. As the distance from the Mobile Operations Base (MOB) increased, two manned boats (ME2 and AMN 1-243) and a USV (BB-8820) became needed to quickly extend the MIO mesh network for keeping the detection process (reachback to remote experts) uninterrupted beyond the 12 nautical mile zone. The USV was operated remotely over the alternative control link for taking needed relay node position. Once within the broadband wireless link reach to its neighbors the USV maintained mesh networking with the boats on-the-move automatically.

Testbed Service Architecture: An Interface System for Field Experimentation

From the systems theory of networking standpoint (Barabasi 2003; Miller and Page 2009) the TNT testbed represents a unique interagency research capability for social and information networking. It provides for adaptation and integration processes between people, networks, sensors, and unmanned systems. For a few days of intense experimentation, military, academic, government, and industry users become a community of *tactizens* engaged in rapid system design processes, which produce new forms of synergy in the TNT cyberspace of man and tactical machinery. The new term of *tactizens* is our reflection on the *Second Life* metaphor of *netizens* (Sectliffe 2009).

The testbed enables several layers for integrating models, tools, and experimentation procedures.

- The TNT tactizens can integrate their sensors and mesh networking elements in the unclassified but closed IP space of the TNT testbed by getting fixed IPv4 and lately IPv6 addresses. Figure 12 illustrates the online portal enabling rapid integration of experimental assets in the TNT testbed IP space.

- Users can connect their remote local area network, including command and operation centers, via the virtual private network (VPN) client on top satellite or commercial IP cloud services.

- Sensors and unmanned vehicles can be integrated with the TNT Situational Awareness Environment via the applications layer interoperability interface. The current option includes cursor-on-target (CoT) integration channel, an interface initially developed at MITRE (Miller 2004). The CoT interface defines an XML data schema for exchanging time sensitive information on situational awareness of moving objects' location in terms of "who," "what," "when," and "where." The typical testbed integration model would be comprised of the CoT message router and CoT XML adapters for each node needed to be integrated (Figure 13). In the very near future we will consider adding the Common Alert Protocol (CAP), which is becoming widely used by the DHS community. The CAP represents slightly different XML interchange format of "who," "what," "when," and "where" events, which is tied up with the types of hazardous warnings and emergency response actions at local, regional, and national levels.

- Human operators (both remote and local) can access the testbed collaborative environment via the collaborative portal or peer-to-peer collaborative clients, situational awareness agents, video conferencing room (Figure14), and video client. This is human layer interface to the testbed.

- At the physical level the testbed reaches to even lower levels (e.g., multiple mesh network enabled unmanned systems) which permit researchers to experiment with such things as airborne sensors and cooperative control (Figure 15) without having to be concerned about network connectivity.

By accessing the TNT testbed at different levels, varying from application to physical, the users could have unique capability for exploring possible adaption patterns, i.e., management of their resources by experimenting with applications load or physically moving and re-aligning their assets. Figure 16 represents the TNT testbed adaptive management interface. The diagram highlights the fundamental challenge of tactical networks adaptive management. We typically measure the performance of self-forming tactical networks by capturing network (IP) or data link (wireless) layer packet flows. However, in most practical cases we can't bring our feedback controls directly to the same layer. The most feasible options available to the tactical NOC crew or local commanders would be limited application load controls (less video, still images only, voice only, etc.) at the top most applications layer, or node physical location (mobility) control at the lowest physical layer. By moving the nodes around, the local commander could bring them back to the line-of-sight with the closest neighbors, or change their location for better performance due to improved signal strength. In either case, the effect of such actions on the network performance is implicit. It requires substantial tacit knowledge of how the application load changes, or physical relocation of nodes, would effect performance of tactical network in a particular setting. The TNT testbed enables vital continuing learning of such adaptive management patterns.

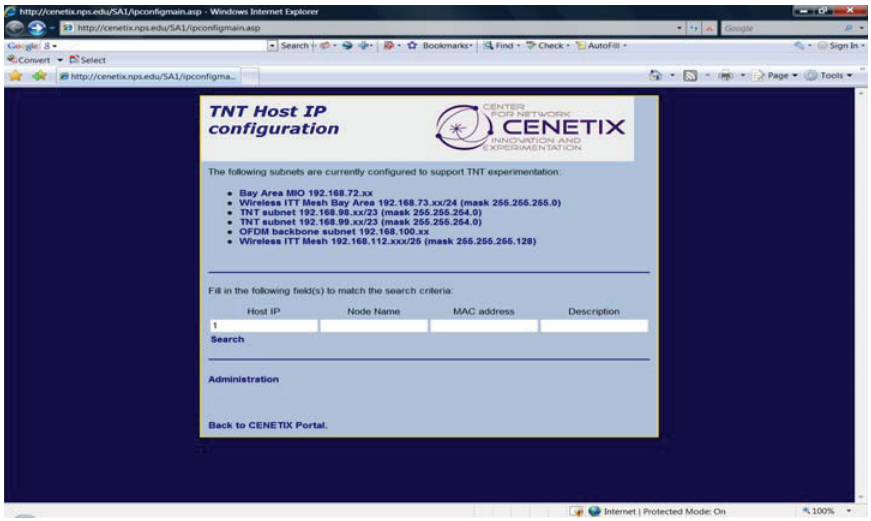

Figure 12. Plugging IP assets in the TNT testbed: IP Space Portal3.

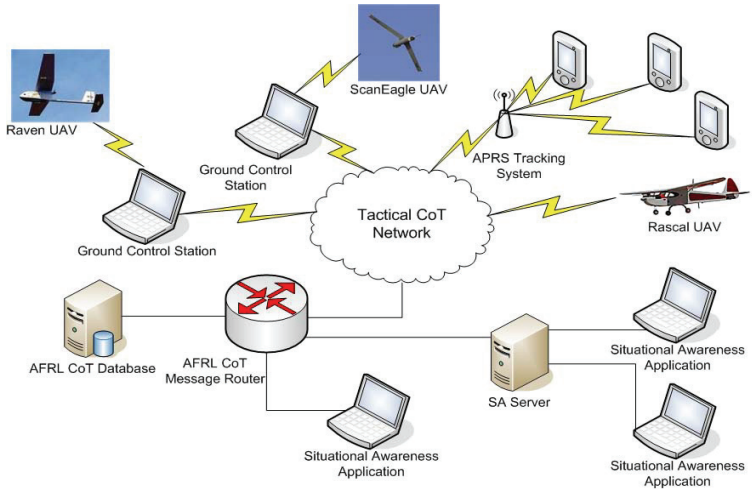

Figure 13. Applications layer testbed interface via the CoT channel.[4]

3. Designed by Eugene Bourakov
4. Diagram prepared by Michael Clement

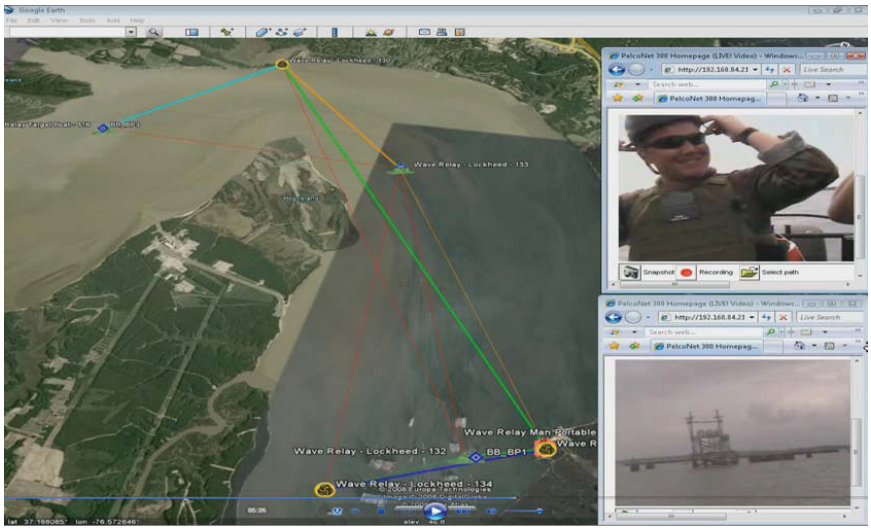

Figure 14. Operator interface: video clients and SA view in the riverine operations.

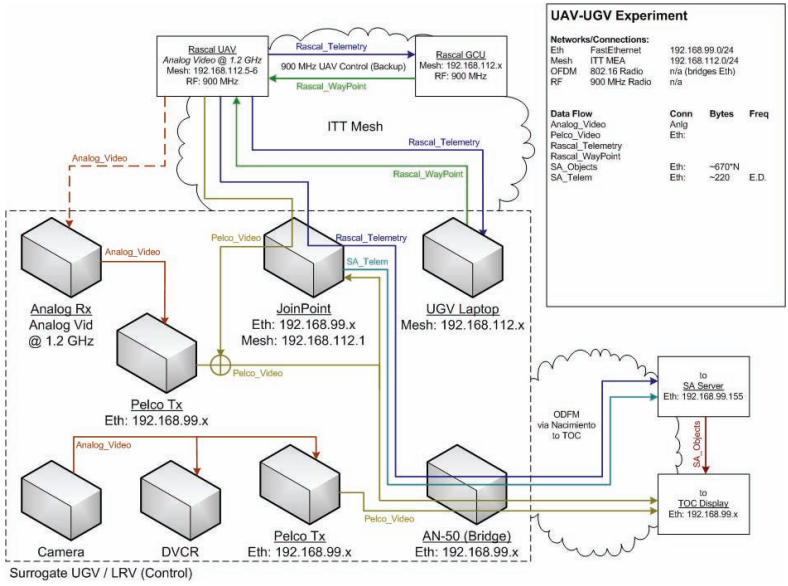

Figure 15. Mesh network interface enabling cooperative control of UAV and UGV.[5]

5. Diagram prepared by Michael Clement

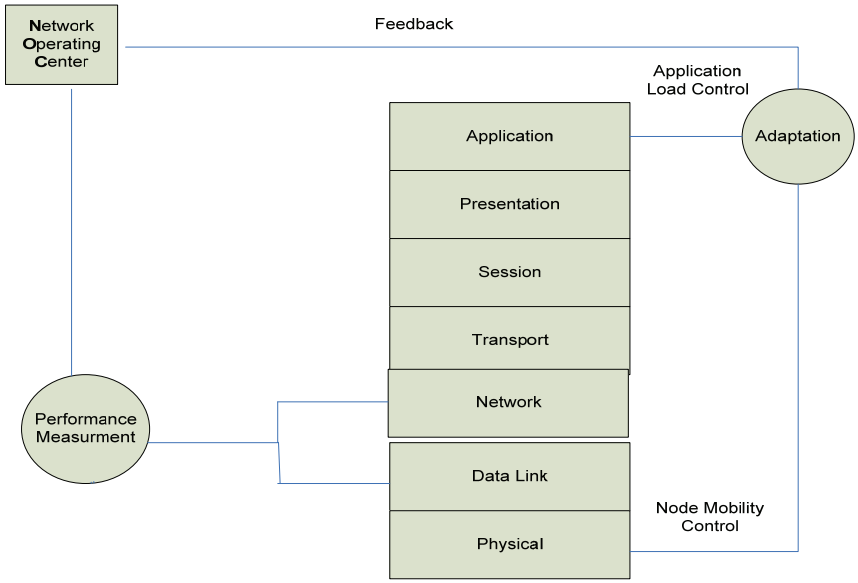

Figure 16. Layers of adaptation in TNT testbed.

Field Model for Exploring Tactical Networking and Collaboration Frontier

From the scholarly stand point (Alberts and Hayes 2007), the TNT testbed represents a unique field model for learning complex relationships between man and machine. In the emerging environment of tactical networking and collaboration. Exploring feasibility and major operational constraints associated with those relationships allows the TNT experimentation team to identify critical elements of tactical networking and collaboration frontier. Tables 1 and 2 illustrate several examples of these findings.

Table 1. Shaping Tactical Networking Frontier

New Solutions for Self-Organizing Tactical Networking	Study Team	Content and First Results
Network and SA controlled UAVs, USVs, UGVs	An ongoing study with Bourakov, Clement, Jones, Dobrokhodov, Kaminer (Clement, et al., 2009) and (Jones, et al., 2009)	Unmanned vehicle is controlled by submitting the way points via tactical N-LOS mesh network
Network-on-Target	(Bordetsky & Bourakov, 2006)	Peer-to-peer links configured from the top of Common Operational Picture interface, self-aligning directional antennas
Hyper-Nodes with 8th Layer	(Bordetsky & Hayes-Roth, 2007)	Extending tactical self-forming networking nodes to miniature network operations centers
Decision Makers as sensors to unmanned systems	First results accomplished in the thesis project of LCDR James Gateau, (Gateau & Bordetsky, 2008)	Creating military operator Management Information Base (MIB) for navigating human decision space and making it available to the unmanned system agents
Networking-by-touch	First results accomplished in thesis of Rideout & Strickland (NPS), continuing research with Bourakov (NPS) Elman (MIT), and Lindeman (WPI): (Rideout and Strickland, 2007), (TNT 08-2 QLR), (TNT 08-4 QLR)	Transmitting data via highly adaptive human network by using physical or electronic touch
GPS denial navigation and Ultra Wideband (UWB) Mesh networking	An ongoing study since 2007 with Bourakov (NPS), Win (MIT), and Dougan, Dunlop, Romero (LLNL) team (TNT 07-4 QLR, 2007), (TNT 08-2,QLR 2008), Since 2009 study team is joined by George Papagonopolus, Ketula Patel, and Greg Blair (ARDEC, Fire Storm group)	Providing small unit operator as well as sensor location by posting alerts from inside the building and from under the deck on-the-move, integrating the UWB link into the peer-to-peer wireless mesh network
Projectile-based Networking:	TNT MIO 07-4 After Action Report, 2007	New data collection and reachback networking technique based on the bursty mesh networking with on board sensor or wireless base station node during a few seconds of projectile descend
Small Distributed Unit Private Tactical Satellite Network:	Study started in 2007 with thesis project of MAJ Conrad and LCDR Tzanos (Conrad and Tzanos, 2008)	Creating private orbital network for geographically distributed small units
Small Distributed Unit Private Tactical Cellular Network	Study with Bourakov (NPS) started in 2008 (TNT 08-4 QLR, 2008)	Creating private cellular network on-the-move for geographically distributed small units. The macro and micro base stations are ground and aerial based, including on board unmanned vehicles

Table 2. Shaping Interagency Collaboration Frontier

Interagency Collaboration Solutions	Study Team	
Collaborative networks for rapid interagency data sharing and expert response in Maritime Interdiction Operations (MIO) Collaboration:	An ongoing research with Dougan & Dunlop (LLNL), Bourakov, Hutchins, Looney, Clement , Vega , Hudgens, Bergin-NPS; Friman (Swedish Defence Research Agency), Pickl (University of Bundeswehr): (Bordetsky et al, 2006), (Hutchins, et.al., 2006), (Bordetsky & Friman, 2007), (Bordetsky & Hutchins, 2008)	Bringing the remote expert advice to an immediate support of the boarding officers
Synergy of social and information networking	Study started with Hudgens, Vega, Koons, Bergin, Bekatoros: (Hudgens and Bordetsky, 2008), (TNT MIO 08-4 Report)	Achieving synergy of interagency response network by creating new weak and strong ties in the workspaces of virtual collaborative environment. Flattening hierarchical relationships in the cyber space of MIO operation
Interoperability of Situational Awareness (SA) and Collaborative platforms, collaboration with Coalitions partners	First results accomplished with Bourakov and Clement (NPS), Reimers (BAE), Poulsen and Cooper (PANYNJ), Hanson and Lindt (Swedish Naval Warfare Center and Kokums, Sweden), Hoy-Petersen and Nielsen (Systematik, Denmark): (TNT MIO 08-2 Report, 2008), (TNT MIO 08-4, Report, 2008)	Propagating alerts between NPS SA tools, Port Authority NY-NJ (PANYNJ) Joint Situational Awareness System (JSAS)

Figures 17 and 18 illustrate how the ongoing MIO experimentation contributes to studies of collaborative networks for rapid interagency data sharing and expert response.

In the series of MIO experiments conducted during the 2007-2009, which have been focused on interagency collaboration for cargo vessel search and identification of nuclear radiation threats, the experimentation team observed how the emergency response

network is "flattening" itself, trying to execute the required expert reachback process (Figure 17) by means of end-to-end networking and collaboration.

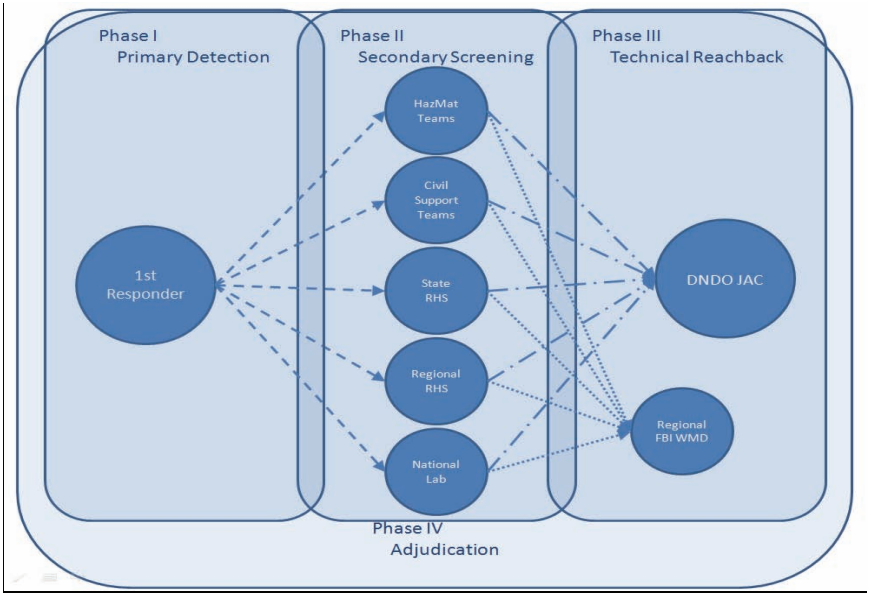

Figure 17. Hierarchy of reachback process for boarding teams, belonging to different agencies, during the nuclear radiation source detection.

The experiments with cargo vessel search in the San Francisco Bay Area (TNT MIO 07-4 and TNT MIO 09-2) and Port of NY-NJ (TNT MIO 08-4) revealed that during the interagency collaboration with nuclear radiation and biometrics identification experts, the response network tends to self-organize into the "flattened" infrastructure of committee, team, and group team working clusters, as depicted in Figure 18.

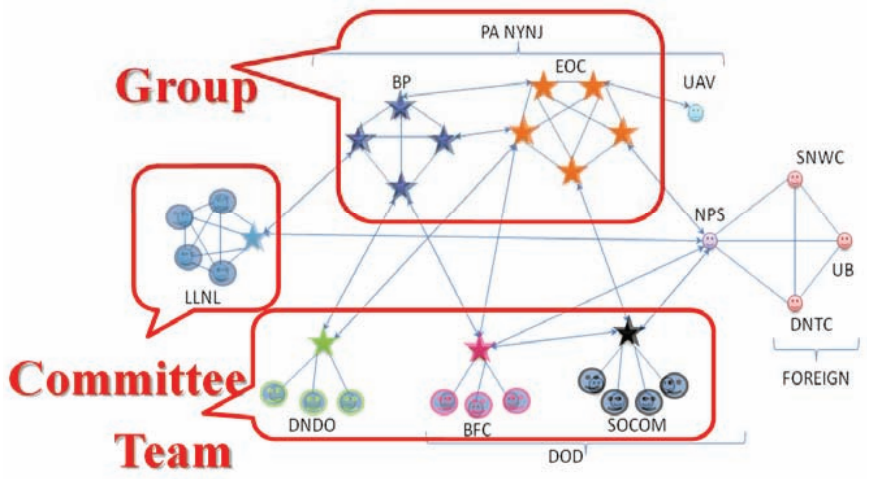

Figure 18. Group, committee, and team topology of MIO response network in the virtual space of collaborative environment.

In addition, the observations produced a collaborative technology features adaptation matrix (Figure 19). Results like this provide vital background for the interagency teams in defining the data sharing requirements for emerging MIOs.

		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

Figure 19. Adaptive collaborative technology features.

Conclusion: Enabling Interagency Synergy Development

On top of the TNT testbed interfaces there is a unique business process of interagency experimentation, which allows participants from different agencies to explore synergy of their solutions. Quarterly experiments, supported by student and faculty experimentation services, allow the tactizens (vendors, academic, federal, state, and local government agencies) to rapidly adapt their solutions to the TNT environment and provide a unique collaborative environment in which the innovation of participants often results in additional unscheduled experimentation using combined technologies. The shortest adaptation cycle is 3-4 days of rapid team design during the TNT experiment. The next level cycle includes 8-10 weeks of research projects delivering feasibility or constraints analysis experiments. The longer adaptation term is in conjunction with dedicated student thesis project (about 6 months).

To the business community participating in the experiments (Figure 1c), the TNT testbed research services and interfaces, which enable discovery and constraints analysis for frequently immature and disintegrated prototypes, provide a unique incubation path to the market of emerging tactical operations.

The TNT testbed infrastructure must continue to evolve in order to keep abreast with networking, sensor, and unmanned systems technologies. For example, we plan to extend the testbed networking infrastructure by employing ad hoc orbital nodes, such as those based on nano and pico satellites, make combat swimmers/divers a part of the network, and utilize nano sensors and the IPv6 domain.

We would also like to explore the possibility of making the testbed a modeling tool available to the theater operators for rapid analysis of new technologies and operational scenarios, and for accessing the remote experts.

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