



Networks and Unmanned Systems:

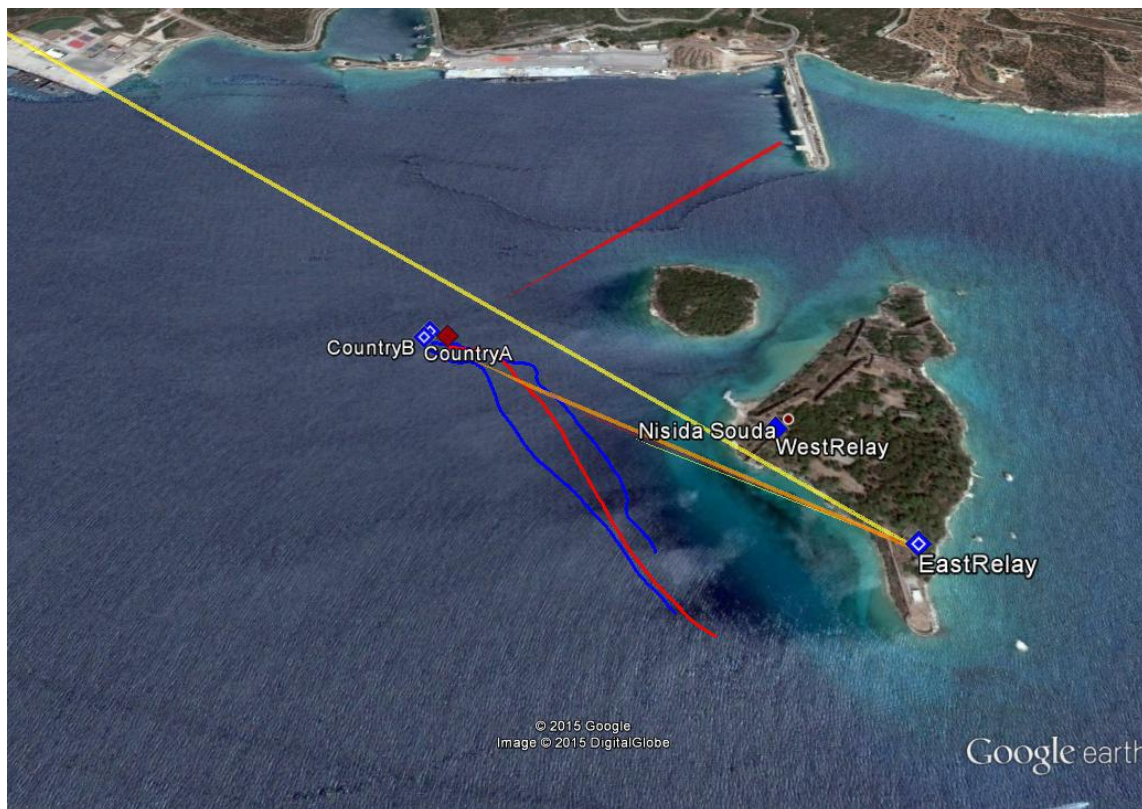
What Can We Learn About Networking in Littorals From the Recent MIO Experimentation Lessons?

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Naval Postgraduate School 23 April, 2014

Littoral Mesh Networking: LCS-UAV and Relay Boats Solution





CGC Hawksbill Joining the Littoral Network from Monterey



TNT Video Conference Room #1

Participant: alex

Chat

eb: 11/26/13 12:32:27 (PST)

eb: 11/26/13 12:32:28 (PST)

eb: 11/26/13 12:32:38 (PST)
yes you are

Hawksbill: 02/26/14 15:58:27 (PST)
Hello

NPS: 02/26/14 16:00:14 (PST)
NPS is ready

hawksbill: 02/28/14 02:52:50 (PST)
Hello

me: 02/27/14 14:52:04 (PST)
hi

me: 02/27/14 14:52:04 (PST)

hawksbill: 03/05/14 11:31:26 (PST)
Hello hawksbill checking in

Room #2: [Clipboard icon]

Room #3: [Clipboard icon]

Lobby [Door icon]

Send Audio/Video

Send

Self-Forming Mesh with Cube Satellite Orbital Nodes

6/16/2015 13:12:32	MOC: Country B has directed its team to board Vessel of Interest.	
6/16/2015 13:10:04	NPS NOC: Satellites are passed by	 Replace Delete
6/16/2015 13:02:24	Technion: Sats are moving	 Replace Delete
6/16/2015 13:00:12	MOC: Country B reports positioning its patrol boat 100 meters from Country A boundary.	





Technion Robotic Cube Satellite Formation Flown Above the Littoral Operations Area





Cube Sat Way Point Operation of Remote UGV across the Littoral Ops Island

3/19/2015 16:31:55 **NPS-UGV:** third mission accomplished. we'll load visual to the observer and discuss the results on Monday



Replace Delete

3/19/2015 16:31:00 **Technion:** This time I was using <http://192.168.99.158/rmpmc/> and it was working

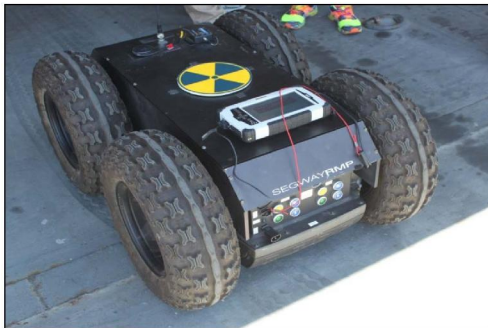


3/19/2015 16:30:53 **NPS:** GCS screen

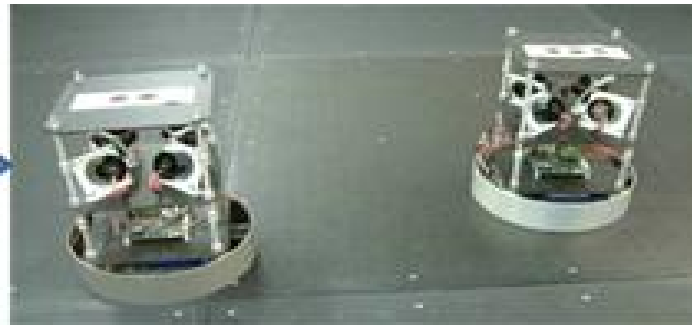


Replace Delete

3/16/2015 08:56:14 **Technion:** I just finished checking the Robosat software in preparation for the experiment on Thursday. There are still some small changes I'd like to do associated with delays in the communication but in general it seems that the system is ready for the experiment. I attach a short movie documenting my test.

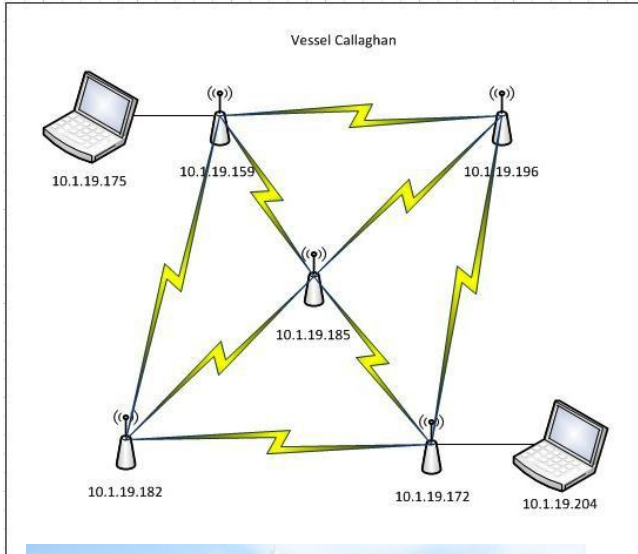


NPS CENETIX UGV



Technion Robotic Cube Satellites

BT networking via ATAK wearable units with Wave Relay Mesh radios, Mar, 2014



- Performed with failures within the skin, short LOS
- Relays improve the performance



3/5/2014 22:30:22

e. Multiple points of failure in MIO ops, but network structure mitigates.
 f. Wave relay systems have degraded in environment (e.g., those exposed to weather). Need to consider different system characteristics for "full production" versus test/demo. (Note: Latest versions are ruggedized.)
 g. Detections worked both port-to-starboard (near sides) and vice versa (far sides).
 h. Successful short-range voice/data transmission using Persistent Systems radio connected to ATAK network. Very distance-limited today, but working to address it. (Fix in place during hotwash, with optimistic results.) Pairing two systems causes freeze, requiring time-consuming reboot of both. This pairing also not user/operator friendly. Application-layer software design problem at work.



BT Networking Coordination & Observations

BT is learning how to self-form to cover a larger area

Critical observation at 19:01:12; adding relays works and allows BT to improve data transfer quality

Important networking quality measurements and quantitative data

3/6/2014 19:26:35	TOC Alameda: All units - please report status/progress.	
3/6/2014 19:12:37	Trelis ware: comms check at lower tween 4-6, no joy	
3/6/2014 19:12:20	TOC Alameda: Android phone - No spectrum uploaded. Please repost.	
3/6/2014 19:07:40	android phone: Spectrum from Polaris	 Replace Delete
3/6/2014 19:02:50	Trelis ware: Calling in all members of BTM to regroup to exploit the vessel	
3/6/2014 19:02:02	Trelis ware: Voice comms improved	
3/6/2014 19:01:46	Trelis ware: Top side node, moved along the weather deck at the bow	
	TOC Alameda: Trelis ware data collection:	
3/6/2014 19:01:15	1. Started with 3 nodes. Verified out of line of sight; 3rd radio allowed continued connectivity between other 2 radios. Chat & video relatively quick, with short audio/video clips being nearly instantaneous.	
	2. Added 4th node and improved oral comms but marginal gain (if any) for data.	
3/6/2014 19:01:12	Trelis ware: Comms check test with all comms sat	
3/6/2014 18:58:35	Trelis ware: Location of all nodes and testers: Van is located at the lower hold 3. Chief, located on the main deck. Killian, ramp leading to lower deck forward 2.	
3/6/2014 18:56:14	Trelis ware: Need to conduct physical location of all nodes and testers	
3/6/2014 18:56:05	TOC Alameda: Trelis ware team: Please note locations at each test.	
3/6/2014 18:53:51	Trelis ware: 4th node, audio loud and clear	
3/6/2014 18:53:03	Trelis ware: attempt to pushout 5 secs of video as a last test	
3/6/2014 18:51:13	Trelis ware: Testing video, and voice again	
3/6/2014 18:50:43	Trelis ware: sending Chief to explore vulnerabilities	
3/6/2014 18:50:09	Trelis ware: 2nd attempt with a 2 sec voice, 4 secs	
3/6/2014 18:48:54	Trelis ware: voice, 1st attempt scrubb after 1.53min	
3/6/2014 18:46:39	Trelis ware: Commence voice test	
3/6/2014 18:45:57	Trelis ware: 2nd video, 44 secs	
3/6/2014 18:44:54	Trelis ware: Vidoe took 2 secs	
3/6/2014 18:44:18	Trelis ware: commencing video test	



Collaboration on-the-move observations

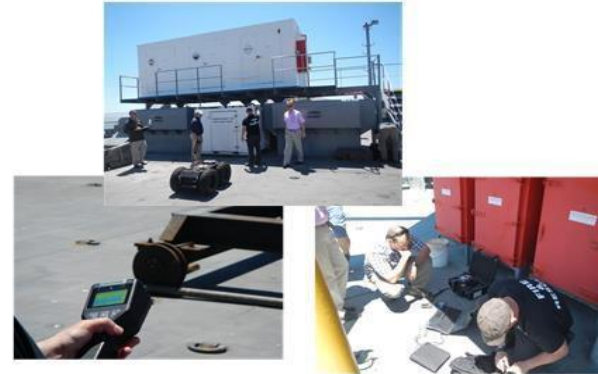
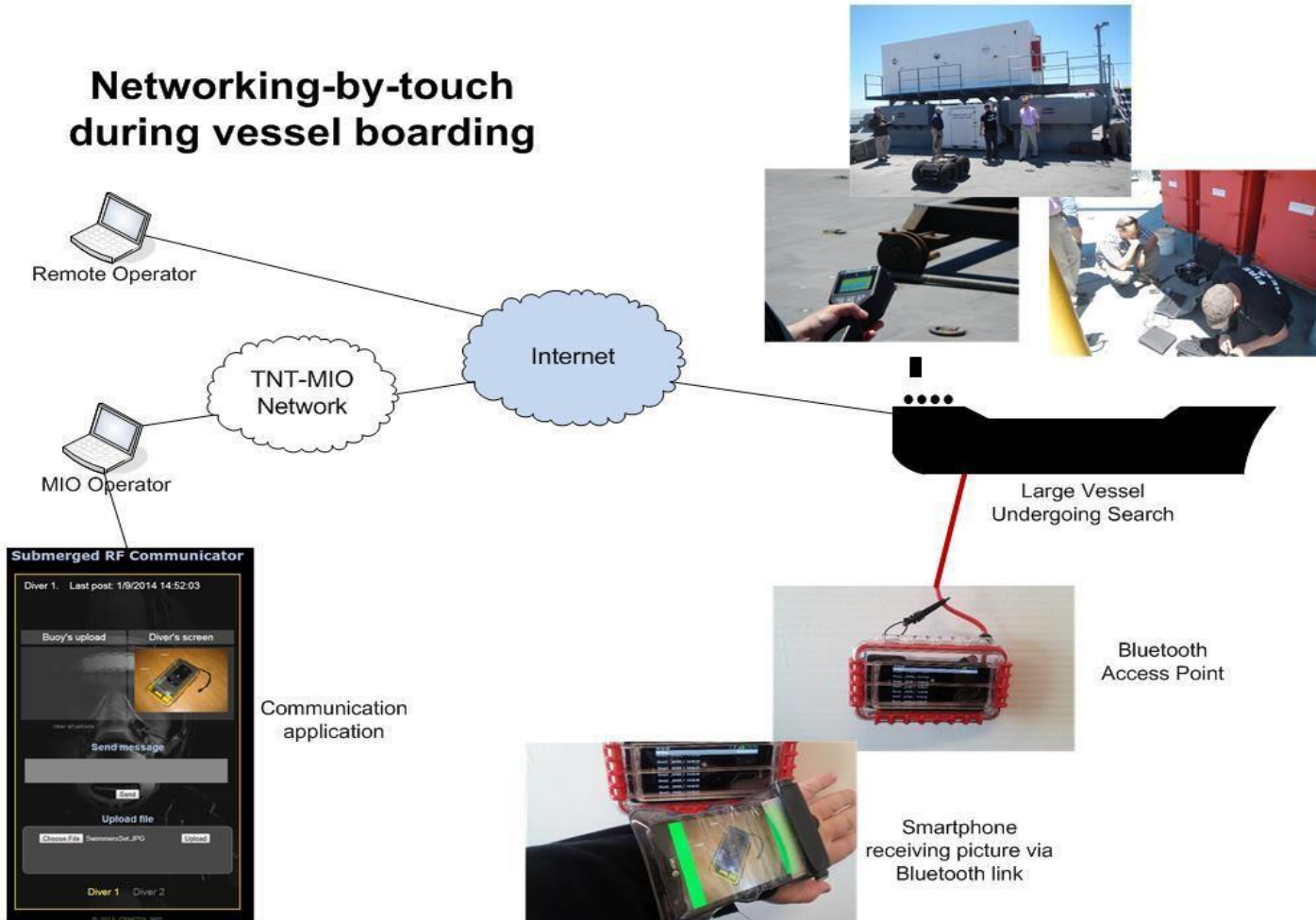
3/6/2014 21:38:51

1. USCG opinion - All capabilities tested & demonstrated have good functional utility. Need to describe matrix to describe boarding team tasks & thinking process, to map to our technologies. Need to develop CONOPS mapping boarding team tasks to technologies & capabilities.
2. Ultra wideband - Point to point between 2 devices gave continuous voice-only comms, across 5 decks. One way had broken (but understandable) comms, other way was clear; reducing deck distance to 4 decks improved comms in the broken direction. Need to capture power requirements.
3. TrellisWare - See below; comms weakened end-to-end at 8 deck distance. Need to capture power requirements. For next time, with one relay midship, comms/ops opinion is TrellisWare can reach from any point to any point on a large vessel. Was able, with relays on deck, to have good voice comms to end of pier (hundreds of yards, estimated).
4. MFK - Broke at some distance, but asynchronously populated when deck distance reduced by one deck. Point-to-point worked 4 decks with no relay; did have open bays/ramps, but still reasonable real-world distance.



Unconventional Solution: Networking-by-Touch during vessel boarding by Sector SF team

Networking-by-touch during vessel boarding

















Networking-by-Touch at Work

Picture transmitted
via NFC connections
by SSF BT

Multiple moments
of NFC touch based
data transfer
and BT members
location detection

3/6/2014 20:43:18	TOC Alameda: Confirming successful, clear NFC transferred picture.	
3/6/2014 20:35:27	phone: Nfc transferred picture	 Replace Delete
3/6/2014 20:27:42	TOC Alameda: Rgr CP1: Thanks for posting location.	
3/6/2014 20:27:16	Golden Gate CP 1: NFC tag 3 (wrist red) passed by.	
3/6/2014 20:26:40	Golden Gate CP 1: NFC tag 3 (wrist red) returned to detection area. note received: lower hold	
3/6/2014 20:25:51	Downtown 1 Checkpoint: NFC tag 3 (wrist red) passed by.	
3/6/2014 20:25:22	Downtown 1 Checkpoint: NFC tag 3 (wrist red) is detected.	
3/6/2014 20:23:57	Golden Gate CP 1: NFC tag 3 (wrist red) passed by.	
3/6/2014 20:23:30	RFID Tag Reader: NFC tag 3 (wrist red) passed by.	
3/6/2014 20:23:28	Golden Gate CP 1: NFC tag 3 (wrist red) is detected. note received: upper tween 4	
3/6/2014 20:22:58	RFID Tag Reader: NFC tag 3 (wrist red) returned to detection area.	
3/6/2014 20:22:56	RFID Tag Reader: NFC tag 3 (wrist red) passed by. note received: test guidance message	



Prospective new direction of on-the-move throw-able or/and quickly moving UGV emplaced relays

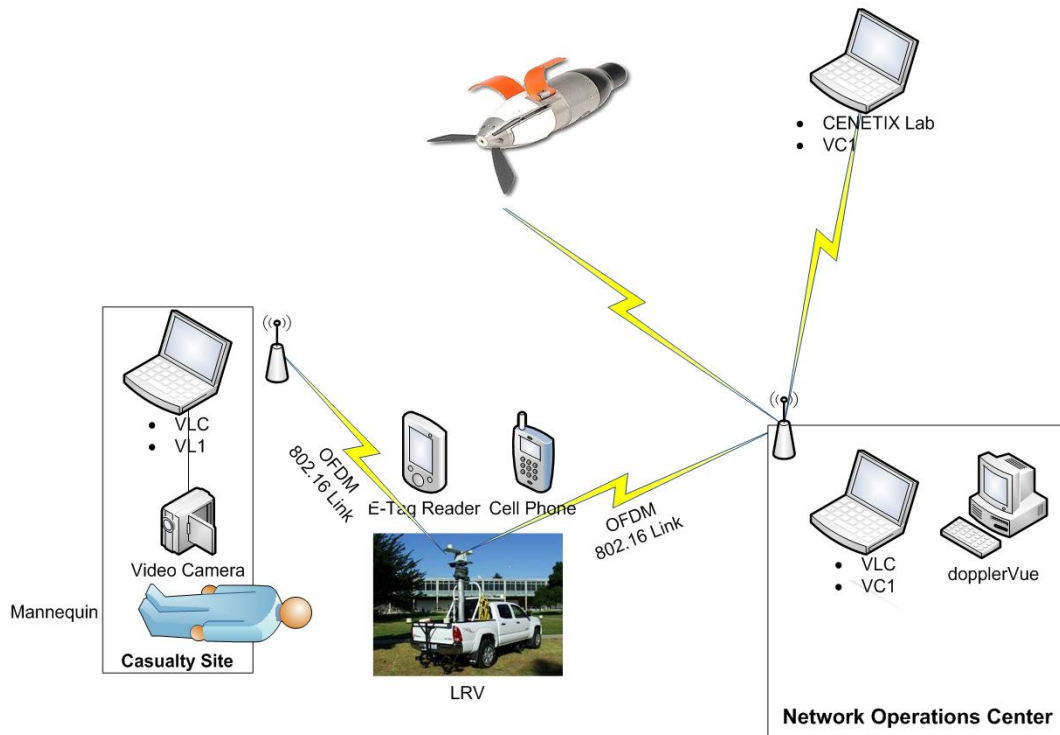


Placing relays by UGV



Throwable
autonomously
moving relays

An Unconventional Solution: Projectile-Based Networking (data collection and relay network with 2-8 sec life time, 3D space dispersed)

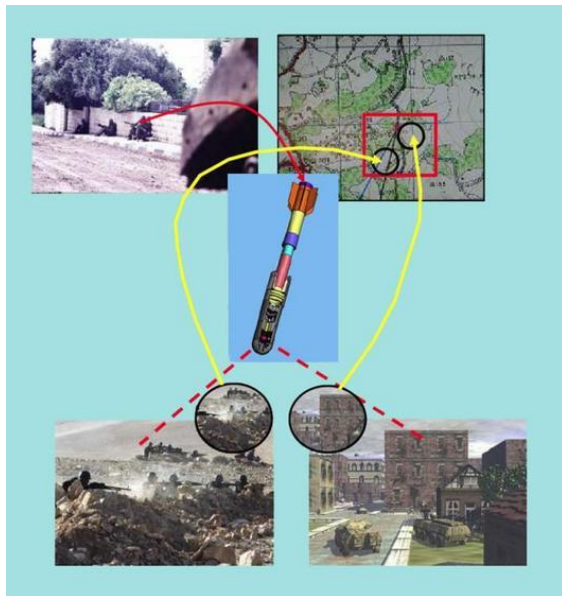


Projectile-Based Networking (data collection and relay network with 2-8 sec life time, 3D space dispersed)

Rafael Firefly 40 mm LV video round (Israel), 40 x 46 LV Other Grenades

The projectile contains two CCD color video cameras with a resolution of 20 cm per pixel at the maximum altitude of 150 m, at which a coverage of 1,200 m² is provided. The maximum flight time of the projectile is 8 seconds. The signal from the cameras is sent back to a hand-held computer for storage and analysis

TASER International Inc. XREP wireless 12-gauge Neuro Muscular Incapacitation (NMI) projectile.



Projectile-Based Networking in MIO Experiments: Small Boat Drive-by Detection at High Speed

