"Special Reconnaissance/Unconventional Warfare---
How about an UxV for a Teammate?"

Miles Libbey, Ph.D.
Robinson Harris, Ph.D. (Cand.)

One of the core national security/defense lessons learned during the first decade of the 21st century is the critical need for reconnaissance-enabled intelligence that is orders of magnitude different, faster, and more accurate than previously anticipated. Examples of the need include the difficulty coalition forces experienced in countering IEDs in Iraq and the challenges Israeli forces experienced in countering Katyusha rockets in Beirut during the summer of 2006. This trend is expected to continue, thereby placing strains on already taxed environments. It is believed that the use of unmanned system "teammates" will provide the next level of disruptive technology in reconnaissance-enabled intelligence.

Fast forward to 2008--significant improvements in stability have been achieved in Iraq with concomitant reductions in violence. Indeed, Army Brig. Gen. John Campbell, Deputy Director for regional operations for the U. S. Joint Chiefs of Staff, told reporters at a Pentagon news conference this past summer that May 2008 marked the fewest attacks in Iraq in four years, "…the number of bombing attacks involving deadly, armor-piercing charges and homemade explosives decreased in May and continues to fall."

Much of this improvement has been attributed to improved reconnaissance and intelligence derived there from. Bob Woodward, in his latest book, *The War Within*, notes that "the surge" worked, but at least three non-surge factors were as important as, or even more important than the surge. Woodward notes that beginning in the late spring of 2007, the U.S. military and intelligence agencies launched a series of top-secret operations that enabled them to locate, target and kill key individuals in groups such as al-Qaeda in Iraq, the Sunni insurgency, and renegade Shia militias, or so-called "special groups." Woodward notes that covert activities had a far-reaching effect on the violence and were very possibly the biggest factor in reducing it. Indeed, he reports that 85 to 90 percent of the successful operations and "actionable intelligence" had come from the new sources, methods and operations. Lt. Gen. Stanley McChrystal, the Commander of the Joint Special Operations Command (JSOC) responsible for hunting al-Qaeda in Iraq, employed what he called "collaborative warfare," using every tool available simultaneously, from signal intercepts to human intelligence and other methods, that allowed lightning-quick and sometimes concurrent operations. Asked in an interview about the intelligence breakthroughs in Iraq, President Bush offered a simple answer: "JSOC is awesome."[1]

The notable improvements in reconnaissance and intelligence in Iraq have been largely **terrestrial** in nature. Regrettably, it is probably only a matter of time before the focus of irregular warfare turns to the **maritime environment** vice the terrestrial environment. How will SO/LIC forces deal with those changes? Will the same level and quality of reconnaissance-enabled intelligence that has been achieved on the ground in Bagdad be available on the waterways, e.g., in the **riverine** environment? Lockheed Martin and its teammates believe the answer is, yes, and to that end they conducted a series of experiments and demonstrations featuring the use of unmanned terrestrial and maritime sensors, autonomous unmanned air and sea surface vehicles, and a collaborative command and control architecture that ensures optimum reconnaissance-enabled intelligence for faster OODA loop operations.

The Lockheed Martin team anchored its tack on first principles with pre-planning spirals for warrior supplied improvements while relying on expected technology advancements like Moore's law to ensure and accelerate future capability growth for the "edge"[2] warrior. Additionally, it seemed only to make sense to use an open architecture baseline and a Service Oriented Approach (SOA) to ensure software adaptability and flexibility to avoid stovepipe proprietary systems and to preclude massive future interoperability adaption costs. Finally, leveraging the success of Lockheed Martin's "open business model" experience in providing year-to-year submarine combat system upgrades to meet changing threats, the Lockheed Martin team adapted an incremental improvement—or spiral development approach. This translates into a ***"UxV SO/LIC Rapid Development Activity Rule Set"*** something like the following: Stick with the art of the possible, and every four months or so make the solution both easier and more realistic for the warrior at the leading edge of combat.

"Edge of combat" operations are characterized by lethality, confusion, lack of connectivity (comms), and difficulty to command pieces in a very fluid situation. Certainly this is not the desired tableau, nor does it have to be inevitable. It is possible to skip a generation of command and control

---

[1] The introductory section of this paper draws heavily from Bob Woodward, *The War Within*, Simon and Schuster, 2008.
[2] "Edge" refers to "edge of combat operations."

(C2) for unmanned vehicles (UxVs)[3] and start using UxVs as teammates rather than manpower intensive tools. Our system, designed to help this generational skip from flying and driving UxVs to commanding organic UxV sensors while demanding ever better intra-machine and inter-human collaboration was designated "*Edge Command and Control and Hybrid Operations*" (ECCHO). Thus, the Lockheed Martin team envisioned an ECCHO capability that could allow UxVs to:

• <u>face fire first</u> and therefore reduce human vulnerability;

• <u>work collaboratively with each other</u> to reduce humans "driving/flying" platforms and relieve humans from simple non-lethal problem/mission execution/logistics solving;

• <u>work collaboratively with humans</u>—act as a teammate--to provide persistent, meaningful ISR, tailored to the needs of dismounted SO/LIC warriors;

• <u>provide timely, geo-marked, fused info to higher echelons</u> in common Google earth or similar open format; and,

• <u>reduce edge and TOC footprint</u> (people and equipment).

With these first principles in mind, an eleven-month spiral development plan was executed with a feasibility assessment Spiral One experiment in coastal waters in December 2007. Spiral One included several USVs, a hand-launched UAV linked to a fixed land-based Tactical Operations Center (TOC), a mobile TOC on a coastal patrol craft, and dismounted 'warriors' in the area placing ISR demands on the unmanned assets. Several communications approaches were used adapting a robust "mesh" network to provide "beyond LOS" capability. This first experiment, Spiral One, validated the team's general CONOPS. Indeed, military observers noted benefits to include reduced manning and the ability to keep all in the AOR level-set with tactical information/sensor video.

Spiral Two was conducted with the U.S. Navy's Network Warfare Command (NETWARCOM) as part of the Navy's annual Trident Warrior 08 battle experiment---a formal four-day Navy experiment conducted in coastal waters with USVs and UAVs with dismounted warriors as the "customer." The Spiral Two of ECCHO was labeled to suit the Trident Warrior series and was called Littoral

[3] We are agnostic among land (UGV), sea surface (USV), air (UAV)…etc.: hence the term **UxV** with ***x*** standing for any domain.

Collaborative Tactical network (LCTN) and the experiment was designed to evaluate an expeditionary SO/LIC-like, scalable, UxV C2 concept that provides tactical ISR at the individual manned and unmanned vehicle, watercraft, and dismounted soldier level. The experiment consisted of a Tactical Operations Center (TOC) working in conjunction with a Mobile C2 unit and dismounted soldiers equipped with a networked C2 handheld computer known as Small Unit Situational Awareness (SUSA). The Lockheed Martin/ONR-developed ICARUS-based software package was integrated with other functional C2 and control software on PC computers in the TOC and the C2 vehicle to provide control authority for both the unmanned vehicles and organic sensors. The unmanned vehicles used were the Lockheed Martin-developed Desert Hawk Unmanned Air Vehicle (UAV) and Lockheed Martin-modified Unmanned Sea Surface Vehicle (USV) based on an 18 ft. Sea Doo pleasure craft based on previous algorithm work done on UGVs in the DARPA Urban Grand Challenge. The small hand-launched UAV featured GPS and a color pan/tilt video camera as well as a wing mounted forward black/white camera. The USV was equipped with Furuno commercial radar, a color pan/tilt/zoom video camera, GPS/IMU navigation, radios, and an Automatic Identification System (AIS) receiver. Communications and data transfer among these units were provided by an 802.11x radio network with antennas at the TOC and onboard the C2 vehicle. The network linked the manned nodes and the SUSA operators to provide control of the unmanned vehicles, their sensors, and to receive video and track data. Using the ICARUS software package, the network provided a shared tactical Common Operational Picture (COP). The Littoral Collaborative Tactical Network (LCTN) live data stream was made available to a list of (IP address controlled) subscribers at remote locations using a DARPA and LM-developed Google Earth-based C2 display tool known as FastC2AP (“Fastcap”). This capability provides unclassified access to the system-generated tracks as well as in some cases, live streaming video and snapshots. The LCTN/ECCHO assets are depicted in Figure 1.

Figure 1: Assets used in LCTN/ECCHO experiment, TW'08

The high level objectives were to increase situational awareness, reduce risk, and to provide warriors at the edge with integrated unmanned systems with user-friendly interfaces. Additional goals included the provision of a network at the tactical level between manned and unmanned nodes and to higher command nodes from the TOC. Finally, the experiment provided a venue to develop initial CONOPS and Tactics, Techniques and Procedures (TTP's) that will be required successfully to integrate collaborative unmanned assets into tactical SO/LIC missions.

Figure 2, below, gives the operational view of the LCTN/ECCHO experiment. The location offered a variety of targets for ISR imagery on land and offshore where various small boats were employed as targets.

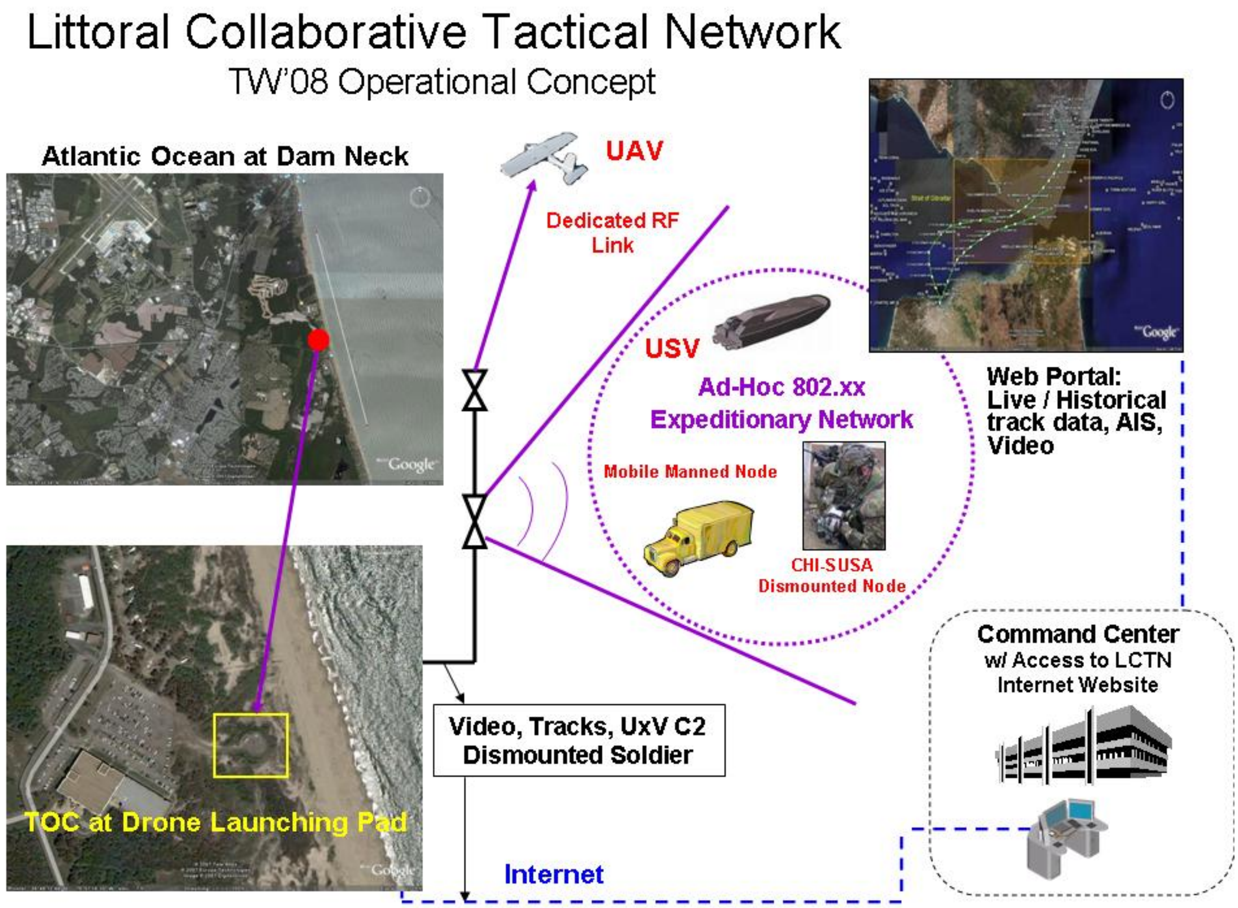

Figure 2: Operational View of LCTN/ECCHO in TW'08

The Spiral Two experiment plan consisted of five SO/LIC vignettes designed to measure the sensor performance (cameras, radar, AIS) and software features in the UAV and USV control software. Another vignette was used to allow the Mobile C2 vehicle and dismounted soldier to test and evaluate the features built into the software. One example of this is the UxV control being passed from the TOC to the Mobile C2 vehicle, and then down to the dismounted soldier. And, a final scenario evaluated a Vessel Boarding combined with a man overboard scenario where the UAV orbited above the "boarded" vessel to provide security and check for weapons, and then was used to search for a simulated man overboard using a USCG provided mannequin.

The Spiral Two experiment successfully demonstrated the ability of ECCHO system to provide access (including timeliness) to information and provide sufficient situational awareness "around the bend" to decision makers in SO/LIC-like environments by networking unmanned vehicles and their sensors. User interfaces were found to be intuitive for tasking, C2, and the display of sensor data. Ease of mission planning also was demonstrated. The experiment was selected by a Navy board as one of only a few commercial systems nominated for continued development and assessment under military user assessment (MUA) process.

In October 2008, Spiral Three was conducted under circumstances similar to Spiral Two, but with the added goals of demonstrating UxV collaborative activity and integration with unattended ground sensors (UGS). Also, Spiral Three was dedicated partially to working with the technical team for the OSD-approved 09 JCTD (Joint Capability Tech Demo) which, at the end of three years, should lead to approval for a Program of Record. Spiral Three scenario involved two USV (boats) at Ft. Eustis, Virginia. On cueing from combat tested ground sensors integrated into the system in less than two weeks, the USVs “decided” between “themselves” which boat should investigate and then transit to the active area and subsequently sent ISR video to an operator without any human intervention. Combined between Spirals Two and Three, over a hundred military associated staff saw the Lockheed Martin concept of operations in operation in and an operationally significant scenario.

In summary, the three Lockheed Martin ECCHO spiral experiments demonstrated:

- Simultaneous command (much more than mere control) of multiple heterogeneous unmanned craft (UAV, USV) by a single operator [4]
- Single operator Mission Manager setting tasks for multiple vehicles during the execution of changing missions
- Validation of an Open Architecture/Service Oriented Architecture Command and Control (C2) system for autonomous control of diverse unmanned systems in dynamically changing environments
- Shared Situational Awareness with a Common Operating Picture and imagery throughout the network, publishable in Goggle earth format to the GIG, land TOC, mobile TOC, dismounts (web-formatted and unattended ground sensors integrated into the ECCHO system as sentinels to cue tailored ISR vehicle response in an expeditionary/edge warrior scalable UxV C2 concept that provides *tactical ISR* compatible reach-back)
- On screen cursor "select/click" for collaborative UxV sensor operation shared among land TOC, mobile TOC, and dismounts;
- Vehicles able collaboratively to "decide" which unit will respond to internal or human generated commands
- ECCHO is Vehicle Agnostic, i.e., compatible with legacy or new unmanned systems (UxVs), including recently integrated unattended ground and water sensors

Conclusion

Reconnaissance-enabled terrestrial intelligence greatly enhanced SO/LIC operations in Iraq during 2007-8. These authors believe the riverine experiments conducted by Lockheed Martin and its partners during the same period (2007-8) show that similar benefits can be obtained in the riverine/littoral environment with the employment of increasingly autonomous unmanned vehicles connected on an ECCHO network and working on ever more sophisticated collaborative tactical problems.

---

[4] By contrast, whereas the Israeli Protector USV requires three operators to operate a single USV, with the LM CONCOPS one operator can command 3+ UxVs.