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Unmanned Surface Logistics Concept of Support

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TACTICAL WIRELESS MESH NETWORKS (WMN) CONCEPT FOR UNMANNED LOGISTICS SURFACE VEHICLE (ULSV) EMPLOYMENT IN COMMUNICATION-CHALLENGED ENVIRONMENTS

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EXECUTIVE SUMMARY

Project Summary
Logistics support plays an essential role in the United States Navy's success at sea as fuel, food, and equipment are delivered to underway ships on a daily basis via the Combat Logistics Force (CLF). However, with the advent of unmanned vehicle technologies, unmanned logistic surface vehicles (ULSVs) have the potential to provide a less costly and more efficient alternative to conventional CLF ships. Additionally, ULSVs have the potential to enhance freedom of maneuver and lethality in contested environments as they require little to no human intervention during transit. The ability to maintain communications is critical to ULSV operations, especially in a communication-challenged environment such as the Philippine Sea. Through review of literature and experimentation via wargaming, this thesis proposes an additional or alternative communication architecture onboard ULSVs by exploring the impact of tactical wireless mesh networks (WMN) in communication-challenged environments.

Keywords: *unmanned surface vehicle, unmanned logistics surface vehicle, USV, ULSV, tactical mesh networks, wireless mesh networks, WMN, directional antenna, ultrawideband sensor network, UWB, data flow, logistics, communication architecture, MUNIN, tactical airborne network, TAN, wargame, LITMUS, Unity, Combat Logistics Force, CLF, Philippine Sea, communication-challenged environments*

Background
By studying and conducting operational testing of large unmanned container ships, organizations such as the Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) project, were able to provide publicly available documentation concerning communication challenges that ULSVs may potentially face during maritime operations. These challenges are further increased in contested areas such as the Philippine Sea, as China has placed great emphasis on the development of cyber and electronic warfare units to support its maritime expansion (Office of the Secretary of Defense, 2018).

For this reason, this thesis explores alternative ways to maintain data flow that may be less prone to cyber-attacks and more localized. This thesis suggests that this may be achieved through the use of directional antennas, ultrawideband (UWB) sensor networks, and range augmentation using tactical airborne networks (TANs) and the Defense Advanced Research Projects Agency's (DARPA's) Towed Airborne Lift of Naval Systems (TALONS).

The main attribute of directional antennas is that they have a preferential direction, therefore granting more powerful communication capability over omnidirectional antennas (Kim & Ko, 2005). This was demonstrated during Space and Naval Warfare Systems Command's
(SPAWAR) tests of its Directional Ad Hoc Networking Technology (DANTE) antenna in 2010, which achieved a maximum link range of 58 nautical miles (Meagher, Olsen, Cirullo, Ferro, Stevens, & Yu,

2011). As these antennas must be directed (Zhang, Liu, Fang, & Wu, 2006), a UWB transmission system may provide an optimal localization method due to its low probability of detection and high location determination accuracy (Zhang et al., 2006).

TANs may potentially extend the range of ULSVs to other nodes by allowing air assets to exchange data with the ULSVs or to serve as relay nodes via their own directional antennas. Another alternative is through the use of TALONS. TALONS is a system that enhances intelligence, surveillance, and reconnaissance communications onboard naval ships. During DARPA's 2016 demonstration, TALONS was able to extended the ship's surface-track radar by 500 percent and triple the range of a handheld omnidirectional radio onboard (DARPA, 2016). This thesis theorizes that TALONS could potentially achieve similar results in tactical WMNs through a robust communication architecture integration.

Findings and Conclusions

As the main focus of this thesis is the operational feasibility of the proposed communication architecture, we used one of the OA4604 (Wargaming Applications) unclassified sponsored wargames as the basis for our experimentation. Through the use of Lightweight Interstitials Toolkit for Mission Engineering Using Simulation (LITMUS) and its associated Unity engine, Red and Blue teams executed their respective missions to determine optimal ways to implement ULSVs by Blue forces. The proposed communication architecture consisted of SPAWAR's DANTE, UWB sensor networks, TANs, and TALONS onboard the ULSVs and selected friendly units.

One of the key findings is that the proposed tactical WMN architecture demonstrated to give Blue a tactical advantage over Red through an increase in Blue's situational awareness via TALONS and SPAWAR's DANTE antennas. SPAWAR's directional antennas also allowed the ULSVs to be controlled at a large distance. To note, it was assumed that any loss of communication or data link from and to the ULSVs would trigger the ULSVs to conduct an emergency stop as proposed by the Maritime UK MASS Code of Practice (2018). For this reason, it was imperative to maintain communication and data links with the ULSVs, as the loss of either one would require technical support from nearby friendly units.

Recommendations for Further Research

Considering that the experimentation was conducted at the unclassified level via LITMUS and Unity, much of the results and data acquired were operationally driven with a number of assumptions and technical limitations at hand. We believe that field experimentation involving the proposed communication architecture used in the wargame should be conducted to gain better insight into the potential technical flaws that the system may have. Due to the classification level of the wargame, we recommend conducting similar wargames with similar scenarios at higher classification levels to obtain more accurate data based on U.S. and our adversary's capabilities.

Cybersecurity onboard ULSVs in a tactical mesh network should also be researched in more depth given the potential cyber threats that ULSVs may encounter. Aside from field experimentation, we recommend

developing different plugins for LITMUS and Unity that allow adversarial units to conduct cyber-attacks. Alternative communication methods, such as through the use of lights and visual signals from ULSVs, should also be explored.

Finally, the propoal to weaponize unmanned vehicles, as put forth by the U.S. Navy's surface warfare director earlier in 2019, suggests installing combat and weapons systems onboard ULSVs (Larter, 2019). Via field experimentation and wargaming, we recommend researching the feasibility of ULSV weaponization to analyze its impact on fleet tactics. Considering that weaponizing ULSVs may increase the probability of adversarial targeting, deceptive operations similar to the Russian Club-K missile container system should also be researched (Stott, 2010).

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Acronyms

CLF	Combat Logistics Force
DANTE	Directional Ad Hoc Networking Technology
DARPA	Defense Advanced Research Projects Agency
LITMUS	Lightweight Interstitials Toolkit for Mission Engineering Using Simulation
MUNIN	Maritime Unmanned Navigation through Intelligence in Networks
SPAWAR	Space and Naval Warfare Systems Command
TALONS	Towed Airborne Lift of Naval Systems
TAN	tactical airborne network
ULSV	unmanned logistics surface vehicle
UWB	ultra wideband
WMN	wireless mesh network