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Analysis of the specifications and capabilities for the next-generation LRUSV

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Long Range Unmanned Surface Vessel
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LONG RANGE UNMANNED SURFACE VESSEL

EXECUTIVE SUMMARY

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Project Summary
Within the next five years, the U.S. Marine Corps is expecting to field the first generation Long Range Unmanned Surface Vessel (LRUSV) as part of its mission support element in the littorals. Introduction of this new type of autonomous support system serves to bring extended intelligence, surveillance, and reconnaissance functionality as well as greater lethality against sea and land targets in a compact yet highly capable surface vessel. While the Naval Operational Architecture outlined in the Unmanned Campaign Framework drives rapid accreditation and fielding, it also provides an opportunity for greater system optimization through examination of a system-level design space. This study analyzes the LRUSV in terms of platform engineering requirements balanced against mission performance and overall systems integration. Design parameter sensitives related to payload, speed, and range are compared and recommendations are proposed for future generations of the LRUSV system architecture.

Keywords: *Unmanned Surface Vessels, USVs, Long Range Unmanned Surface Vessel, LRUSV, hydrodynamics, trade studies*

Background
Unmanned Surface Vessels (USVs) will play a vital role in the future U.S. Navy and U.S. Marine Corps strategy. These vessels will be equipped with a variety of sensors and weapons and will be able to operate unmanned or minimally manned as part of a hybrid seaborne solution. Likewise, they will deploy autonomously or be controlled remotely by human operators. One example of such a vessel is the Long Range Unmanned Surface Vessel (LRUSV) for the Marine Corps. Although the importance of such vessels for future operations is readily acknowledged, the optimal shape, size, missions, and control of these vessels are yet unknown. Rapid introduction into the Fleet through experimentation and rapid fielding will aid in their acceptance and integration but not necessarily advance the understanding of the right size, form, and fit.

Naval architects have long struggled to design ships and other seagoing craft that find the delicate balance between stakeholders' desires and the fundamental constraints imposed by the laws of physics. To address this required balance, the complex dependencies of system requirements as tied to system parameters must be explored within the overall design space. An opportunity exists to marry the unique mission needs of the LRUSV with unmanned vessel design in advancing early-stage ship design practices using digital engineering.

The goal of this project is to determine the overall impact in considering various design tradeoffs between operational capability drivers and hull parameters. It is predicted that early incorporation of operational factors and an ability to interactively adapt the design based on operational inputs from experienced operators will produce a more robust and operationally sound product. Furthermore, this will reduce detailed design rework, shortening the overall design-acquisition timeline. First, we determine the operational mission requirements for the vessel. Next, a more detailed analysis is conducted to establish which of these primary factors will most heavily impact the vessel hull, mechanical design, and electrical design. Consideration will also be given to the timing for the insertion of operational modeling results into an early-stage design. Strict adherence to digital engineering fundamentals must be utilized to ensure overall design cohesion.

Findings and Conclusions

The LRUSV is envisioned as "an unmanned platform capable of traveling autonomously for long distances and launching loitering munitions to address sea and land targets" (Marine Corps Systems Command [MARCOMSYSCOM], 2020). The current production version is based on the Navy's "Defiant" 40PB which is a twin Cummins QSB 6.7diesel waterjet propelled, semi-planning hull patrol boat, manufactured by Metal Shark. It has a 40-knot sprint speed and 10-15 knot service. The desire to quickly field a working vessel has provided an excellent opportunity to further investigate the design parameters alongside field testing of this early production unit.

Some of the primary design variables for any platform are the desired payload, range, and forward speed. In conjunction with specific fuel consumption and overall loading conditions, they form a design space that can be used to quantify decision tradeoffs. Investigations using craft velocity versus range were conducted to explore payload throughput. Non-dimensional analyses were used to provide figure of merit results throughout the design space. From this, an optimum speed-range combination with respect to the selected measure of merit was observed. For a given range, higher or lower speeds than its optimum value result in lesser performance, that is fewer tons per hour. Similarly, for a given speed, there appears to be an optimum range as well. The sensitivity of these results was evaluated as a function of propulsion system efficiency. As expected, the optimum band shifts to higher speed-range combinations. Payload sensitivity was also studied and resulted in findings that showed that for a more lightly loaded vessel, the benefits of propulsion system efficiency diminished exponentially as a function of range. However, in the case of both a higher loading fraction and a higher efficiency propulsion system, the optimum band shifts up and in fact, it approaches that of a linear system; in other words, twice the speed results in approximately twice the payload throughput.

Recommendations for Further Research

Operator-reported observations from in-service use regarding the platform form factor suitability and functionality can be integrated with these design space findings to inform future models.

Based on the results of this study, the following recommendations for further research can be drawn. First, higher fidelity sensitivity analysis of various design parameters based on updated information of vehicle characteristics must be performed. Previous results can be used to identify the most sensitive regions of design parameters and their values. Based on the results of the sensitivity analysis, a set of recommendations will be obtained that can be used to quantify and guide decision-makers for optimum vehicle employment. Finally, we can extend the study to encompass the small Unmanned Surface Vessel which is proposed as a modular capability that is to interoperate as a component of the Long Range Unmanned Surface Vessel system.

References

Marine Corps Systems Command, (2020, November 16) *Long Range Unmanned Surface Vessel Autonomy* (MARCORSYSCOM Notice M67854-21-I-1820). https://sam.gov/opp/ac49b85912f144cb8d1546f104af05b9/view

Acronyms

LRUSV	Long Range Unmanned Surface Vessel
USVs	Unmanned Surface Vessels