2022

Expanding Rigid Hull Inflatable Boats (RHIBs) Survivability via Cost-effective Up-armoring

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https://hdl.handle.net/10945/71934

NPS NRP Executive Summary
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Period of Performance: 10/18/2021 – 10/21/2022
Report Date: 10/31/2022 | Project Number: NPS-22-N278-A
Naval Postgraduate School, Mechanical and Aerospace Engineering (MAE)

NAVAL RESEARCH PROGRAM
NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

EXPANDING RIGID HULL INFLATABLE BOATS (RHIBS) SURVIVABILITY VIA COST-EFFECTIVE UP-ARMORING

EXECUTIVE SUMMARY

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This research is supported by funding from the
Naval Postgraduate School, Naval Research Program (PE 0605853N/2098).

Project Summary
Small boat crews operating rigid hull inflatable boats (RHIBs) during maritime interdiction operations (MIO) are left exposed to adversaries' hostile actions. In conducting visit, board, search, and seizure (VBSS) and other close in surface actions, boarding teams are prone to gunfire from above, or directly on the beam, placing them and their small craft at significant risk. While the RHIB is well known for being swift, lightweight, highly maneuverable, and multifunctional, it suffers from an unshielded distant approach, a need for demanding boat handling skills, and assumes generally inferior positioning and full exposure while lying alongside larger vessels. To reduce the potential for crew casualties and increase RHIB critical component survivability without negatively impacting operational mission success, a cost-effective, lightweight, unencumbering, and easily installable retrofit is needed. This study investigates the function of critical components and systems, appropriate material solutions to protect the prioritized elements against small arms, and blast fragmentation effects, while not deterring from the vessel's mission capabilities. Additionally, impacts on buoyancy, stability and other ship's performance characteristics are studied to inform a suitable solution set for RHIB enhanced survivability.

Keywords: *rigid hull inflatable boat; RHIB; survivability; shielding; composite materials; up-armoring; maritime interdiction operations; MIO; visit, board, search, and seizure; VBSS; space, weight, and power; SWaP*

Background
A highly versatile waterborne craft, the RHIB serves as the primary mode of transportation for VBSS teams conducting MIO. It is lightweight, maneuverable, and gives operators direct access to their surroundings. However, these same characteristics place the RHIB and its crewmembers in a vulnerable position. Coming alongside a suspected hostile vessel, typically having the height of eye advantage, exposes the RHIB from above and at close range abroad. The crew, riders, engines, control systems, and structure are all potential targets for gunfire cascading down and inflicting casualties. Operationally, this last mile, the transfer of combat operators to suspect vessels, is required to conduct the mission. Thus, a material solution must be investigated to resolve this threat to mission failure and loss of equipment and Sailors.

Past military systems have benefited from postproduction changes in design to suit operational needs. The High Mobility Multipurpose Wheeled Vehicle (HMMWV), better known as the Humvee, is an example of this. After seeing higher-than-expected losses due to due to heavier caliber gunfire in the field, improvised explosive devices (IED), and landmines, Up-Armored HMMWV (UAH) kits and other self-protection enhancements were retrofitted to the M1114 HMMWV. The UAH consists of armor protection, which includes welded aluminum, composite, and steel plates, as well as reinforced glass panels which provide the Humvee occupants with enhanced ballistics protection against fragmentation and direct blast overpressure. However effective, these increases in survivability come at a significant cost in terms of overall vehicle weight. This is an area of particular concern in ships and small craft as changes in the center of gravity and mass distribution directly impact power, stability, and maneuverability, not only in the subject RHIB, but also in the ship deploying this asset.

The RHIB is typically deployed via a boat handling system that is an integrated subsystem of the ship. Additionally, the RHIB serves many functions within the ship system, being utilized for search and rescue, resupply, liberty launch, and even, perhaps, as the captain's gig. Thus, mission performance in a combat scenario must also be weighed against all other uses. Limiting the intrusions that survivability enhancements typically bring is a key factor in the successful implementation of a potential material solution. In order to come to a viable outcome, operational, technical, and programmatic input was necessary to ensure the mission-critical functions were not compromised.

For this study, the following methodology was used. A representative RHIB variant, the 11 m boat, was selected. Critical mission components and key characteristics were assessed for survivability in two cases, namely a top-down scenario and one at a broadside. Threat analysis was conducted using typical small arms and anti-personnel explosive devices in order to examine mechanical failure through impact, holing, and blast overpressure. Protection requirements were compared with the known material properties of the existing components. In the cases where material deficiencies were identified, parametric analysis was conducted to determine design solution modifications that increased strength or stopping power against the unwanted impacts of added weight, reduced stability, and interoperability considerations.

Findings and Conclusions

Cost-effective up-armoring of the RHIB will enable it to continue as the small craft workhorse of the fleet for years to come. To this point, lightweight-weight ballistic protection and armor-piercing resistive shielding materials and coating systems were investigated. Minimization of additional weight and bulk thickness as compared to failure strength and kinetic energy dissipation were viewed as primary attributes. Optimization of mobility and field of view is also highly desirable as inherent properties of a recommended solution.

Through the study of various threat cases, it was found that survivability enhancement of the RHIB could be enacted under certain conditions. Readily available explosive devices such as hand grenades, which pose multi-dimensional failure mechanisms, were found to be difficult to provide acceptable technical solutions against, while the small arms cases were more readily obtainable.

It was concluded through engineering analyses and system design studies that through the use of material characteristics changes such as an increase of thickness in the normal direction, small arms fire could be defeated, or adverse effects minimized to acceptable levels. Tradeoffs in stronger materials were considered to mitigate form factor interference and performance degradation at the expense of weight density. While the updated armor systems considered provide enhanced stopping power as measured through a reduction in residual bullet velocity, the additional weight considerations still preclude the liberal use of this solution to limit the puncture or holing of all decks, collars, and other key components. Additionally, it was determined that force protection of personnel was adequate using the currently available options to operators within the standard fleet practice.

Recommendations for Further Research

While the use of computer modeling and simulation in support of the analytical analyses performed herein provides insight into the survivability enhancement recommendations necessary for the rigid hull inflatable boat (RHIB) against the representative threats that were studied, it is recommended that these technical solutions be tested at sea with operators' input to fully assess any impacts on operational mission capabilities. Furthermore, potential adverse effects introduced into the larger ship system through changes to the RHIB must be verified via field testing while being operated at sea. Detailed study of changes to the center of gravity, righting arm, and stability curves through the addition of topside mass are suggested, as are additional studies regarding launch and recovery performance as a result of selected material modifications. Additionally, the operational impacts on the cost to the fleet in modifying the RHIB and/or providing piecemeal up-armoring solutions (kits) should also be examined in greater detail to understand the benefits given constrained resources.

In the course of study for this problem, it was discovered that additional investigation of composite materials used in marine craft is necessary. While engineering data in ballistics and blast is readily available for traditional metals, less is known regarding the failure of the lightweight, flexible, and multi-scale materials being utilized in the RHIB and autonomous unmanned vessels entering the fleet. Specifically, it is recommended that blast and impact effects against composites are studied further.

Acronyms

HMMWV	High Mobility Multipurpose Wheeled Vehicle
IED	improvised explosive device
MIO	maritime interdiction operations
RHIB	rigid hull inflatable boat
SWAP	size, weight, and power
UAH	Up-Armored HMMWV
VBSS	visit, board, search, and seizure