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**REMOTE MUNITIONS DEPLOYMENT FROM AN UNMANNED GROUND
VEHICLE**

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ABSTRACT

Unmanned Ground Vehicle's (UGV) are becoming more adapted and have increased mission capabilities to support Warfighter ground forces. Researchers develop and enhance unmanned ground vehicles to better aid Warfighters and increase their mission capabilities while mitigating their risk. High risk missions are often performed for infiltration of potential hazardous points of interests that contain anti-personnel obstacles. Ground forces have traditionally utilized live munitions to quickly create a footpath through these anti-personnel obstacles. These munitions often require personnel to be exposed to enemy detection/fire during placement.

This paper presents the development of an UGV remote deployment system to mitigate Warfighters risk by generating a stand-off distance between the obstacle(s) and the ground forces. The stand-off distance enables ground forces to stage, arm, and deploy the munitions from a covered/concealed position. Solutions that encompass low cost, rapid fielding, high mobility and durability, munitions accuracy, and leverage of existing fielded equipment have been considered. This paper discusses the deployment system development, integration with the UGV, and the proof of concept testing results.

INTRODUCTION

Warfare has tremendously evolved since September 11, 2001. Our Army has had to adapt to the always changing battlefields and threats through the use of technology. Our nation's Warfighters have had to continually evolve and adapt their methodologies and concept of operations over the years due to increasing threats. This has caused them to turn to technology to increase their mission performances and mitigate risk. Through research and development, Unmanned Ground Vehicles (UGV) have become more adapted into the Warfighters concept of operations and are now readily available for use. Unmanned systems are often utilized for high risk missions, which may include infiltration of potential points of interests that contain anti-personnel obstacles. Traditionally, ground forces have employed live munitions to create a footpath through these anti-personnel obstacles. The emplacement of breaching munitions is a high-risk, but high payoff mission, potentially exposing Warfighters to enemy fire during setup and execution of the mission. A safer method for obstacle breaching is highly desired.

For this reason, this paper will present research, development, and testing results that have been conducted in

an effort to integrate live munitions with UGV platforms. The implementation of UGVs with live munitions in current mission operations mitigates mission risk by generating an increased stand-off distance between the ground forces at the hazardous point of interest. This paper will also discuss the live munitions deployment systems that have been integrated into UGVs.

UGV-MOUNTED MUNITIONS DEPLOYMENT

Researchers initially reviewed and implemented a commonly used munitions system package which was mounted onto a medium class robotic platform. The munitions system used was the Anti-Personnel Obstacle Breaching System (APOBS), an explosive line charge system that allows safe breaching through complex antipersonnel obstacles, particularly fields of land mines. The APOBS weighs approximately 125lbs and is designed to be transported and deployed by hand from ground forces without the use of any vehicle, deployment, or targeting/tracking systems. It has been desired to provide a method to deploy these munitions from a concealed standoff position. To minimize injury to the Warfighter and

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maintain concealment, the concept of utilizing a UGV to deploy these munitions was presented.

The design is composed of attaching the munitions to a payload deck atop of the UGV. The mounted system's configuration was initially designed to off-set the two ALICE packs according to the United States Marine Corps (USMC) operation manuals. This configuration was proven undesirable because the increased lateral footprint and payload weight severely hindered the UGV's range of motion and maneuverability. Figure 1 illustrates an offset placement configuration of the two munitions ALICE packs as guided by the USMC operation manuals.

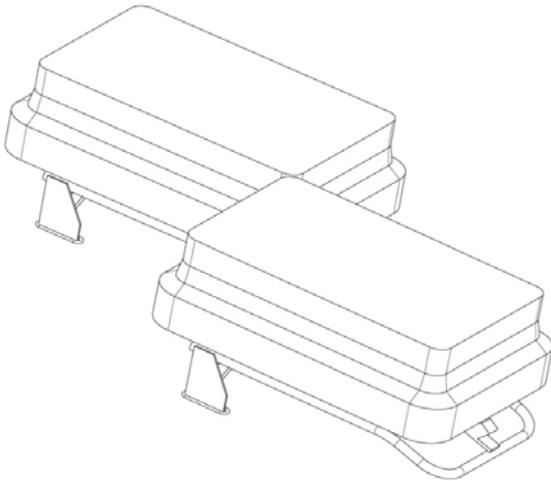


Figure 1: APOBS offset configuration

A new, more compact, in-line design was then studied and implemented with better success. This compact design, as illustrated in Figure 2, allowed the munitions to be deployed without hindering maneuverability of the UGV. However, these are still several issues with the concept of UGV mounted munitions approach.

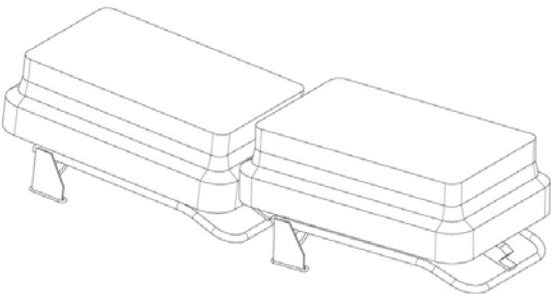


Figure 2: APOBS in-line configuration

One issue is that the medium class UGV was used in testing is a prototype and is not field-able until further development is completed. The UGV would have to

undergo ammunition testing and MIL qualification testing before it could enter the field. The system's chassis needs to be further matured to increase the system reliability during operation. Another issue is that it increases logistical loads on the Army to support additional robotic platforms. The system has a large footprint and is not easily transported. In order to implement the UGV out onto the battlefield, an additional transportation method would also be required.

This is a difficult avenue since robotic systems of this sort would require more development before being fielded, even though this is the most inexpensive remote deployment system solution for munitions. Overall, the Warfighters' observations indicate the APOBS mounted UGV effectively supports the mission of breaching an anti-personnel obstacle or minefield on certain terrain, but there are several user concerns. The warfighters would like to see the system operated in other terrain conditions (steep mountains, swamp lands, etc). A system unable to perform in a wide variety of terrains would be of limited effectiveness. Another Warfighter observation stated that the robotic platform would be difficult to transport in current transport vehicles. Currently, the UGV does not possess a series of pre-set poses for firing, transport, etc. It is a great desire to have a system that has this type of munitions deployment functionality. Another concern from the user is the attachment system for the APOBS onto the UGV deck caused the UGV to bounce harshly while in motion. This type of severe vibration could accidentally cause damage to the munitions prior to deployment. The Warfighters also expressed concern with the difficulty and time required to load and attach the APOBS munition set. The Warfighters would like previously mentioned items addressed before the system is fielded [1, 2].

TRAILER-MOUNTED MUNITIONS DEPLOYMENT

After the successful completion of the UGV-Mounted APOBS integration and receiving the feedback from the Warfighters, the development team began to consider alternative methods for deploying the munitions. The concerns raised by the previously attempted integration of UGV-mounted breaching munitions led to the creation of a platform that would haul, aim, and launch the munitions over unimproved terrain while being towed by a currently fielded UGV. The secondary developed result was a lightweight, reusable trailer that would allow fast setup and arming of the munitions, towing to the obstacle, target alignment, and deployment of the munitions, all from a concealed standoff position. Using a trailer to haul the munitions allows the towing UGV to retain its base mission capabilities and does not require the UGV to carry the full weight of the munitions during travel to target and deployment, which enables smaller class UGV's to perform the mission. After the munitions are deployed, the trailer

can be towed back to a cover position to be reloaded or stowed for reuse.

The deployment system consists of an independent four wheel C-channel steel frame trailer with Ackerman style steering and pneumatic tires. The drawbar of the trailer is connected to the UGV via a pintle ring and hitch. Figure 3 illustrates a line-drawing of the developed trailer deployment system.

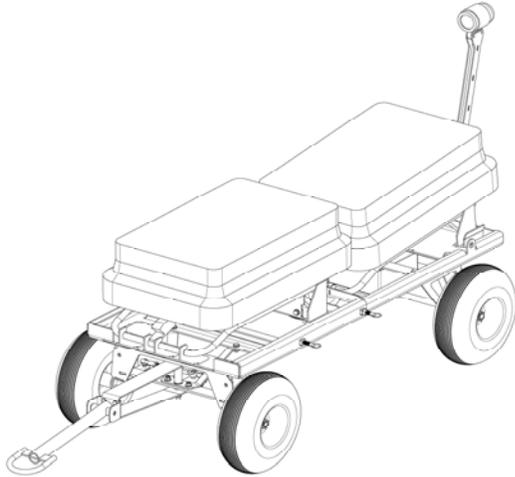


Figure 3: Trailer deployment system with munitions

A forward-facing camera is mounted at the rear of the trailer to facilitate aiming, range estimation, and local situational awareness while at standoff distance, as illustrated in Figure 4. The camera arm is attached using quick-release pins, allowing folding of the arm for stowage and removal for shipping. The camera is attached to the UGV via video signal cable that is routed along the frame and up the drawbar, terminating at a break-away connector attached at the rear of the UGV. The break-away connector allows the trailer to be disconnected remotely without causing harm to the trailer's electronics/components.

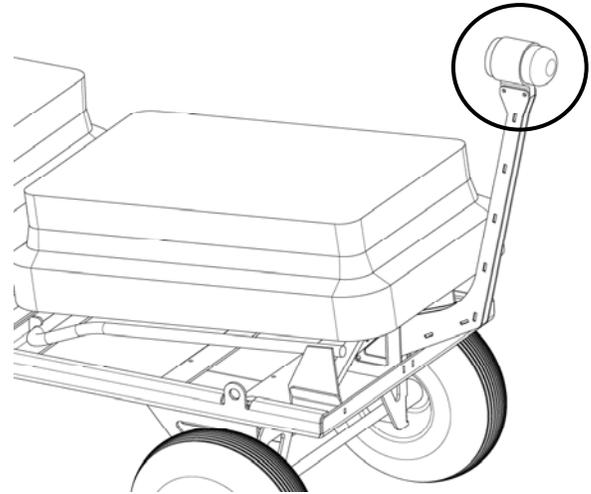


Figure 4: Rear target aiming camera

The system also consist of an enclosure which is mounted underneath the trailer frame to house camera electronics to produce cross-hair overlay imaging (as shown in Figure 5) to estimate wind-age and range to target. Figure 5 also illustrates the displayed view for the operator through the rear camera to estimate the appropriate range to the targeted point of interest.

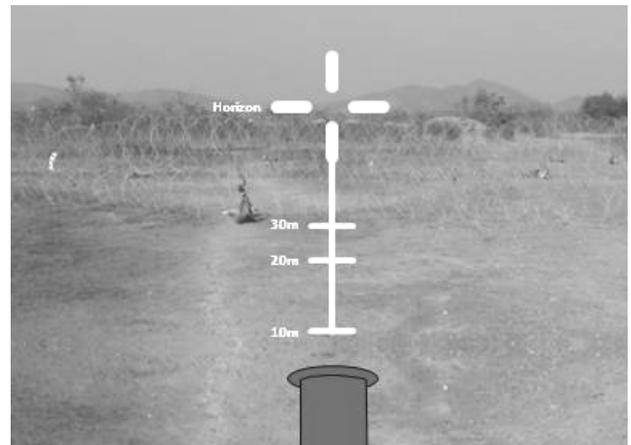


Figure 5: Notional rear target camera view

The two ALICE packs comprising the munitions are set on the trailer in line with each other, front to rear. The front ALICE pack is loaded by locating the front of the pack in a series of toe lugs. Then the rear of the pack is pushed downward over a novel spring-loaded latch/release mechanism, remaining locked in place until the mechanism is manually released. The rear ALICE pack is loaded similarly, captured at the front by toe lugs as previously described. Since the rear pack must separate from the trailer during launch, discovered in previous mentioned

developments and testing, it is not secured by a latch/release mechanism. However, the locating tabs act to wedge the pack in place while still allowing it to pull free during launch.

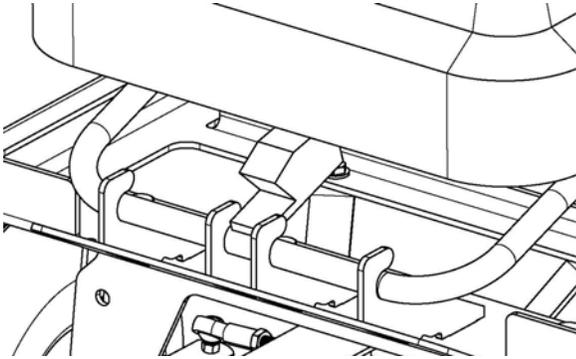


Figure 6: Munitions secured and located by toe lugs

The trailer is separable into two halves allowing it to fit within the confines of a second shipping container that is identical to the one used by this particular UGV which reduces logistical requirements when fielding such an appliqué kit for UGV's. This is shown in Figure 7.



Figure 7: System disassembled for stowage or shipping

This is accomplished by nesting the frame C-channels of the rear section within C-channels of the front section. Four spring-loaded plunger pins engage through holes in both frame halves, allowing quick assembly and disassembly without requiring tools, as shown in Figure 8. The drawbar is hinged on a captive clevis pin and is removable for shipping.

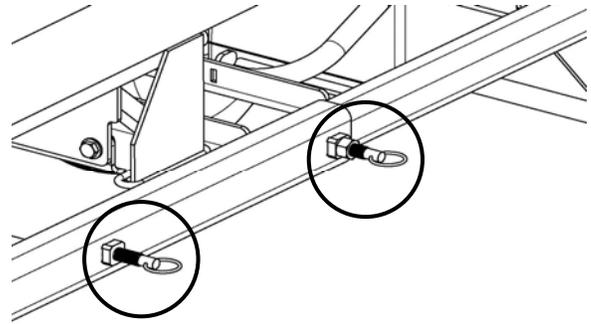


Figure 8: Quick release pins

The trailer leverages a variety of Commercial Off-The-Shelf (COTS) items and fabricated components to reduce material, manufacturing, and lifecycle costs. The COTS items used are all commonly available items and are conducive to field repair and replacement with basic tools. Fabricated items were simplified to eliminate the requirements of any special tooling. Additionally, the frame and undercarriage of the trailer are made of heavy gauge mild steel for formability and weldability.

By designing a bolt-on appliqué kit for currently field UGV's, the improved capability is implemented and fielded without permanent modifications to the UGV. The deployment system also uses a specialized trailer hitch mechanism and break-away video cabling to enable the UGV to remotely release the trailer/munitions if operationally required. The particular UGV is capable of being integrated with a COTS remote firing system.

The complete system was recently demonstrated as part of a large-scale live fire exercise. The system performed successfully and a full report with valuable user feedback was generated [3]. Based on this, a second trailer is currently in development by TARDEC. Numerous improvements to improve mobility, durability, ease of use, and mass-manufacturability are being incorporated.

CONCLUSION

This paper considered hazardous missions Warfighters face while infiltrating points of interests that contain anti-personnel obstacles. Two pioneering approaches to resolve these issues using unmanned ground vehicles as a conveying platform for live munitions were presented. The first approach for deploying obstacle breaching munitions encompassed a medium sized robotic platform where the munitions were directly mounted to the system as a payload. Since systems of this capability are not currently fielded, this approach proved to be successful yet insufficient. The second utilized a currently fielded small robotic platform to tow a specially designed deployment trailer for the munitions. This solution proved to be very successful and encompassed a low cost appliqué kit that does not require

permanent platform modifications while leveraging current assets.

Future efforts could include continued development to integrate the deployment system onto other small robotic platforms. Funding could support additional testing for safety, durability, and user assessments to better prepare the system for fielding.

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