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SAND2022-6946C

Proceedings of the INMM 63rd Annual Meeting

Title: Systems and Implementation: Integrating Unmanned Aircraft Systems into Physical Protection Systems at Fixed Sites and During Transportation

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Abstract:
Physical protection systems, and response forces in particular, are designed to prevent an adversary from successfully completing a malevolent act against a facility or transport operations. Timely detection and assessment of any potential adversary action against a target is an essential element of materials security. The timely detection and assessment must then be followed-up by a capable and timely response that might be enhanced with the additional situational awareness provided by unmanned aircraft systems (UAS). The United States Department of Energy's National Nuclear Security Administration Office of International Nuclear Security has been exploring capabilities provided by UAS to support response force operations within the physical protection system. UAS have the potential to provide response force commanders and operators with situational awareness in assessing adversary locations and actions as well as the locations of responders. UAS may be utilized for area searches ahead of responder pathways to identify potential threats and to provide situational awareness of areas not normally covered by cameras (such as areas outside the fence line at fixed facilities). In addition, UAS can provide real-time information to transportation convoy teams that pass through constantly changing public access environments. This paper will provide operational recommendations to be addressed when integrating UAS into existing physical protection systems at fixed sites and during transport. Recommendations will include aspects of the following: UAS goals; tactics and techniques to support detection and assessment as well as response force deployment; remote pilot selection, qualifications, training, and currency; UAS selection criteria; UAS laws and regulations; possible cost sharing with other facility operations; and on-scene emergency management.

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1. INTRODUCTION

The United States Department of Energy's National Nuclear Security Administration Office of International Nuclear Security works partner countries to increase the ability to respond to emergency events that can potentially result in loss of control of nuclear assets. These are collaborative efforts in policy development, response plan coordination, equipment development, capacity building, and even the integration of response force use of unmanned aircraft systems (UAS/drones) and counter-UAS CUAS) equipment into physical protection strategies.

Physical protection systems, which include response forces, are designed to prevent an adversary from successfully completing a malevolent act against a facility or transport operation as well as other events that may result in loss of control of nuclear materials. Timely detection, assessment, and response of any potential threat are essential elements of material security. As technology changes, the physical protection system should likewise adapt to meet potential new threat capabilities and by learning to utilize new technology.

Traditionally, fences coupled with alarm and detection systems have been the primary method of protecting items within the fence while keeping threats outside the fence. With modern technology, an adversary has additional tools to potentially begin malevolent acts from beyond the perimeter fence line or outside the field of view of an off-site transportation team. Also, closed-circuit television cameras used to assess alarms and possibly track a situation are fixed in place and limited by their infrastructure. This paper will discuss considerations to increase response force effectiveness through enhanced situational awareness via the use of UAS. By using UAS as part of physical protection strategies, our goal is to: decrease response times by effective deployment of available resources in order to increase survivability and reduce damage to facilities through increased situational awareness.

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2. TACTICS TO REACH THE GOAL

What are we protecting and what is the threat? Every country has their own method of determining what must be protected, what is the current threat, and what graded approach to take towards protection. As mentioned above, the goal of any effective physical protection system should be to decrease response times by effective deployment of available resources in order to increase survivability and reduce damage to facilities. Will increased situational awareness assist in protecting a facility or off-site shipment? Can a UAS support an emergency response during an emergency situation where intelligence will be limited, and decision-making time frames compressed? Can the response force's capability to quickly and effectively deploy UAS increase the emergency manager's knowledge as to what is the best course of action? To address these questions, one should consider that a threat can be man-made or the result of an accident or environmental/natural event.

Tactics and techniques to support detection and assessment

While critical facilities are generally encircled by a perimeter equipped with a physical protection system, that system is fixed in place with limited ability to look inside and outside the perimeter. Alarm annunciation requires rapid assessment, and if a threat is verified, a determination of scope and possible pathways must quickly ensue. While the closed-circuit television system is placed to observe these pathways, monitoring gaps could occur depending on operational activities.. Using UAS to observe the facility grounds more completely from a strategic position, provides the ability to "look both inside and outside the fence," especially during times of increased security postures such as on-site transportation, reactor refueling, construction activities etc. Also, a UAS may be an option to monitor and assess locations that would normally require responders to don protective equipment or those areas too contaminated to permit human entry.

Maintaining situational awareness is especially difficult during the transport of material off-site. A shipment route can change depending on the environment and threat. Getting real-time updates and information of a route is key to maintaining situational awareness and being postured to react to unexpected situations that arise. Route reconnaissance and convoy coverage can be increased by unmanned systems through several means. The use of tethered UAS attached to one of the vehicles can provide long endurance sensor coverage when the conveyance is static or moving slowly. Some airborne systems can also provide longer route reconnaissance ahead of the conveyance. These systems can be multi-copter, fixed wing, or a hybrid of both. With the increase of technology, it isn't uncommon to see some UAS platforms exceeding 6 hours of flight time with the capability for vertical takeoff and landing (VTOL) and to carry multiple different sensors simultaneously.

Tactics and techniques to support response force deployment

With compressed time frames for decision making during an emergency, having rapid, accurate information is critical. Responders have an initial response planned in the event that an attack or other emergency occurs; however, the actions of the adversary or situational aspects of other emergencies (e.g., fire, chemical spill, etc.) will impact those pre-planned responses and may require ad hoc adjustments. Regardless of the type of emergency, there is a very high likelihood that off-site responders will be arriving to provide support. UAS monitoring the affected area can provide the rapid situational information that allow responders to determine what resources are required and where best to place them. Video downlink from UAS can be shared with both organic response teams and also off-site responders, to include emergency personnel. This allows for situational awareness to be increased by all players at the same time. The control of these UASs and encryption of data being transmitted can be set up in many ways, depending on SOPs and protocol of the governing body.

3. UAS INTEGRATION CONSIDERATIONS

Incorporating UAS into physical protection strategies requires some amount of forethought and planning to ensure that relevant authorities and approvals are covered. As with any piece of security equipment, selection and maintenance are essential to properly cover and/or improve the overall security posture. Flying UAS generally requires having certified remote pilots, which should reside within the Response Force. It is critical that UAS and any CUAS activities be integrated. Without this integration, CUAS activities might render response-force UAS ineffective. In addition, if the facility airspace has been designated as restricted, one needs to be aware that new UAS might be pre-programmed not to fly in restricted airspace, requiring additional effort to get the manufacturer to unlock that system and allow its use within the airspace. It is also important to understand the airspace restrictions for the route a conveyance takes, whether it be the primary, backup, or other non-planned route. The airspace can become very complex, especially when operating near urban areas and other government facilities. This adds to the planning requirements for convoy commanders and response force operators of UAS.

Remote pilot selection, qualifications, training, and currency

Remote pilot skills under emergency conditions will require specialized training, licensing, flight currency (recent flying proficiency), and knowledge of response tactics. In order to effectively operate within the response system, the remote pilot must be fully integrated within that system, and this requires first-hand knowledge and experience. Remote pilots will need the aptitude to think and operate in three dimensions, which requires adding a vertical axis to their ideas of how to move the UAS through space. Also, when the remote pilot is a member of the response team, they can contribute towards training other members in the capabilities and limitations of the UAS as well as the development of tactics and policies.

Regarding training and flight currency, when possible, remote pilots and UAS should be made available to support operations, facility maintenance, etc. This will also allow for wider utilization of the UAS resource. For example, rather than shutting down plant operations, UAS could be used to inspect areas of high radiation, confined spaces, etc., when cost effective. Depending on the type of inspection required, application of the UAS's exceptional imaging and access capabilities may eliminate or reduce the amount of disruption to plant operations.

Communication is also a very important aspect of training with UAS. Practicing the communication flow between the UAS operator and the other personnel involved with response activities is a valuable tool. This would include how the video feed is presented and transmitted to key responders. Testing the performance of the communication range of a UAS is very important, because this changes due to many factors such as RF interference, line of sight, and other barriers.

UAS selection (fixed facility, off-site transportation, free flight UAS, persistent/tethered UAS)

Free-flight UAS (i.e., not tethered) allow for the greatest ability to observe large areas while still being capable of being directed to specific areas of interest. Flights between battery changes are approximately 20 to 35 minutes depending on UAS type and environmental conditions. However, a tethered UAS has advantages that would complement physical security needs as well. The tether provides constant power to the drone, allowing for 24-hour sky coverage without the downtime needed to swap out batteries. In addition, data (camera feed) is transferred down the tether providing a secure data communication link. Tethered systems might be able to fly during a wider range of weather conditions than a free flight UAS, and since the UAS is tethered to a ground station, it eliminates possibility of a "flyaway." Though rare, a flyaway is when a UAS loses contact with a ground controller and departs the area. The tethered feature may make it easier to obtain permission to fly in or around restricted airspace (e.g., near airports). UAS integration within federal / local laws and regulations (primary focus is air space) varies from place to place and will have to be addressed. Though not addressed in this paper, fixed-wing and hybrid UAS are also available as options.

Transportation of Materials

During shipments of critical materials, the route conditions as well as land and sea traffic are frequently changing. Should an unexpected occurrence take place, such as a traffic accident, vehicle breakdown, etc., the convoy commander should have the ability to launch either a handheld or vehicle mounted tethered UAS to gain situational awareness. Many systems that are available have already been fielded as a turn-key setup, meaning that these UAS manufactures have taken into account how the UAS will be contained and attached to a vehicle. This makes it easier for a convoy commander or response element to integrate UAS into a conveyance. There are many systems that are easy to deploy and can be carried inside of a small case or pack to allow for versatility. In the case of an adversary attack, the convoy commander would then have information provided via the UAS to most effectively communicate on-scene conditions and direct both responders and follow-on resources. Many of these UASs can have navigation, tracking, and flight profiles/features already set up so that the operator has a reduced workload and can get eyes-on the situation quickly. Tracking of the conveyance itself, personnel, or other moving vehicles can be done autonomously, while the remote pilot can communicate and adjust sensor to provide the best situational awareness to the team. Many UAS also have obstacles avoidance to mitigate potential impacts during high workloads of the operator.

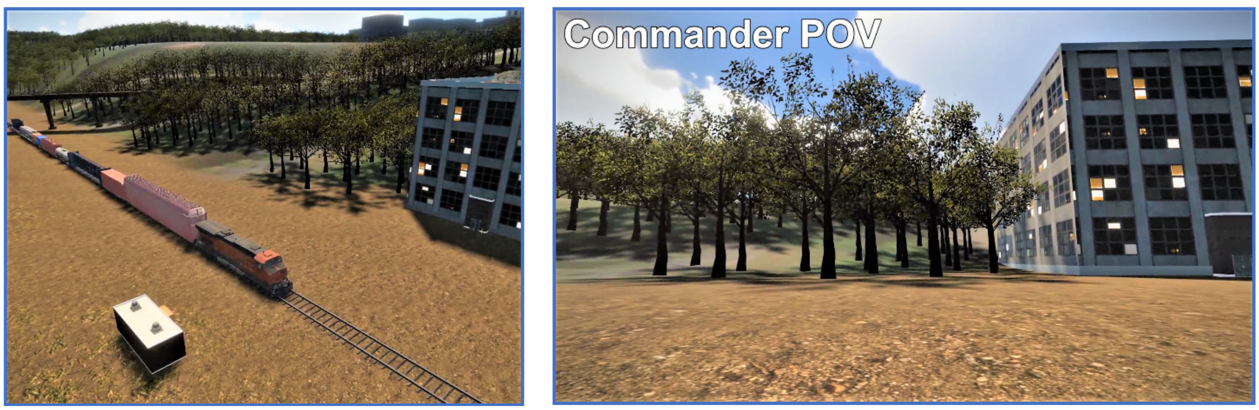

Figure 1: Stopped transport of material with Response Commander perspective of the scene

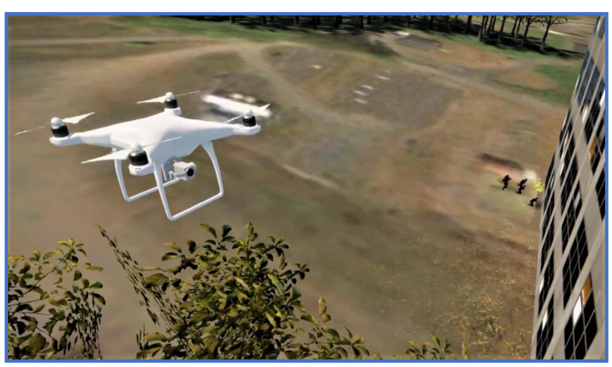

Figure 2: Gained situational awareness from UAS perspective

There are many profiles and types of sensors that can be utilized with a UAS supporting a conveyance. Understanding the environment and optimal sensor ranges at altitude is also important to getting the best use out of a UAS for a response during transport. Threat reactions and SOPs executed by the transport response element need to be integrated and practiced with the UAS remote pilot. This will help prepare and provide the best use of UAS during transport of material.

4. CONCLUSION

Protecting nuclear sites and material during transportation is critical to both national and global security. In the event of an attempted theft, sabotage, or other emergency involving nuclear material, reducing response time while increasing responder survivability is essential. UASs are tools to help in this response process and are being used more frequently for nuclear security. The capabilities and technology of UASs are constantly increasing; therefore, collaboration with other partners on best practices and new UAS technology is key to maintaining a tactical advantage. Working together as partners, sharing experiences and process with unmanned systems helps to alleviate some of the complex issues faced when integrating unmanned systems within physical security.

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