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Modelling performance of uncrewed autonomous system swarms against directed energy weapon systems

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Abstract: Countering swarms of uncrewed autonomous systems (UAS) is an ongoing problem in modern warfare. UAS attacks are becoming an increasingly prevalent aspect of modern combat, and large numbers of airborne or waterborne UAS can be deployed against high value targets and overwhelm systems employed in its defence. In addition to timely detection of incoming UAS, of particular concern is the need for a single system to spent time defeating each UAS in the swarm, as well as the cost of doing so per individual UAS. One such option for countering UAS swarms is the deployment of directed energy weapons (DEW). DEW system inflicts thermal damage to the targets, and can continue to process between UAS as long as it remains powered. However, to be effective a DEW has a dwell time during which it needs to remain focussed on a single UAS in order to inflict damage while the swarm continues its approach. Sufficiently long delays between processing individual UAS in the swarm may therefore result in defeat of DEW, as it fails to neutralise the threat.

Varying DEW characteristics to assess its ability to defeat UAS swarms is a common approach to assess the DEW system performance (Weinberg, 2023). However, characteristics of the UAS swarms can also be varied in order to determine how best to defeat DEW defences. The composition of the UAS in the swarm, as well as the composition of their types in the swarm, can be tuned to increase the chance of overwhelming the DEW. Rather than being uniform, UAS in the swarm can vary in their characteristics: some may be better protected while others may be unarmed decoys, both of which may be accompanied by the trade-offs in their speed and detectability. If the number and type of UAS that can be deployed is subject to constrains such as the availability or capability to launch them as well as their costs, the combination of UAS types in a swarm maybe be of critical importance for the successful defeat of DEW-protected targets.

Here we examine how characteristics of UAS swarms can be tailored to defeat DEW-defended targets. We extend the modelling framework of DEW performance described by Weinberg (2023), but change the perspective from DEW to focus on improving the success of UAS swarm to defeat it. For this, we vary the properties of the UAS in the swarm in order to determine the best-performing combination of UAS types. We consider that UAS characteristics impose trade-offs, so that their higher effectiveness is offset by constraints on their speed and detectability. We also explore the effect of decoys as part of the swarm to determine the preferred ratio of armed vs decoy UAS. The performance of the swarm compositions is then explored in a series of simulations that represent their approach against a DEW system which is trying to neutralise them. We then determine the combinations of UAS characteristics which results in increased delays needed for the DEW to process individual UAS, and therefore the lowered probability that DEW defences will effectively counter the swarm before at least some UAS are able to reach the target. We use these outputs to draw conclusions about the importance of UAS design decisions when faced with the possibility of encountering, overwhelming and defeating DEW-based defences in a modern battlefield.

REFERENCES

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