

Drone Swarming Tactics in a Contested Environment

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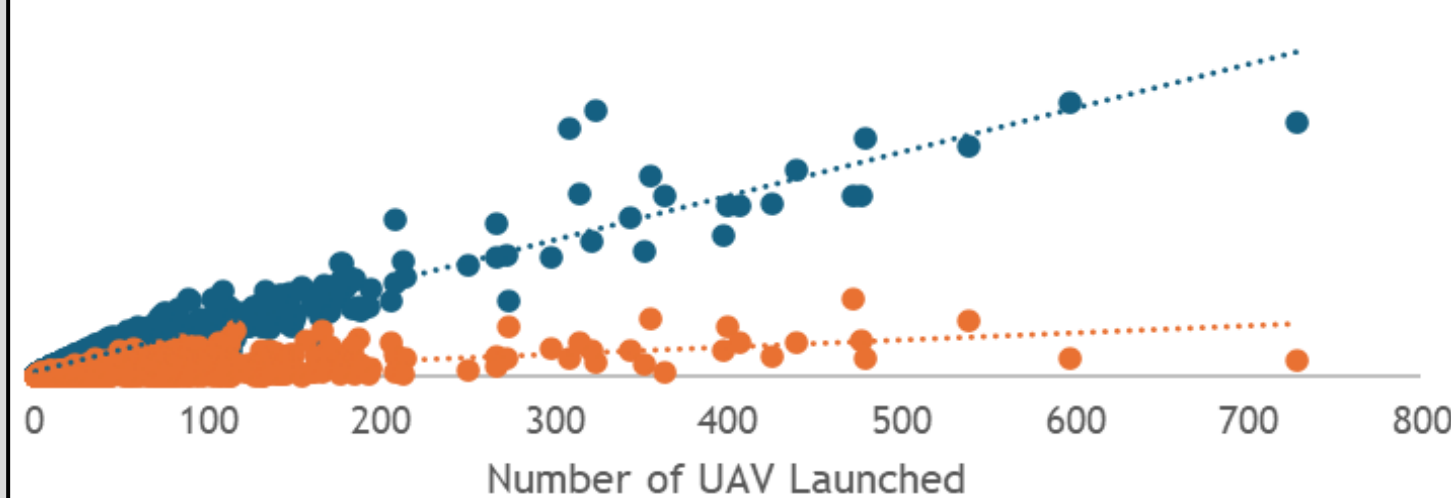
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BACKGROUND

Cost asymmetry and saturation tactics challenge layered defences

Number of UAV Launched vs (UAV/ Target Destroyed)

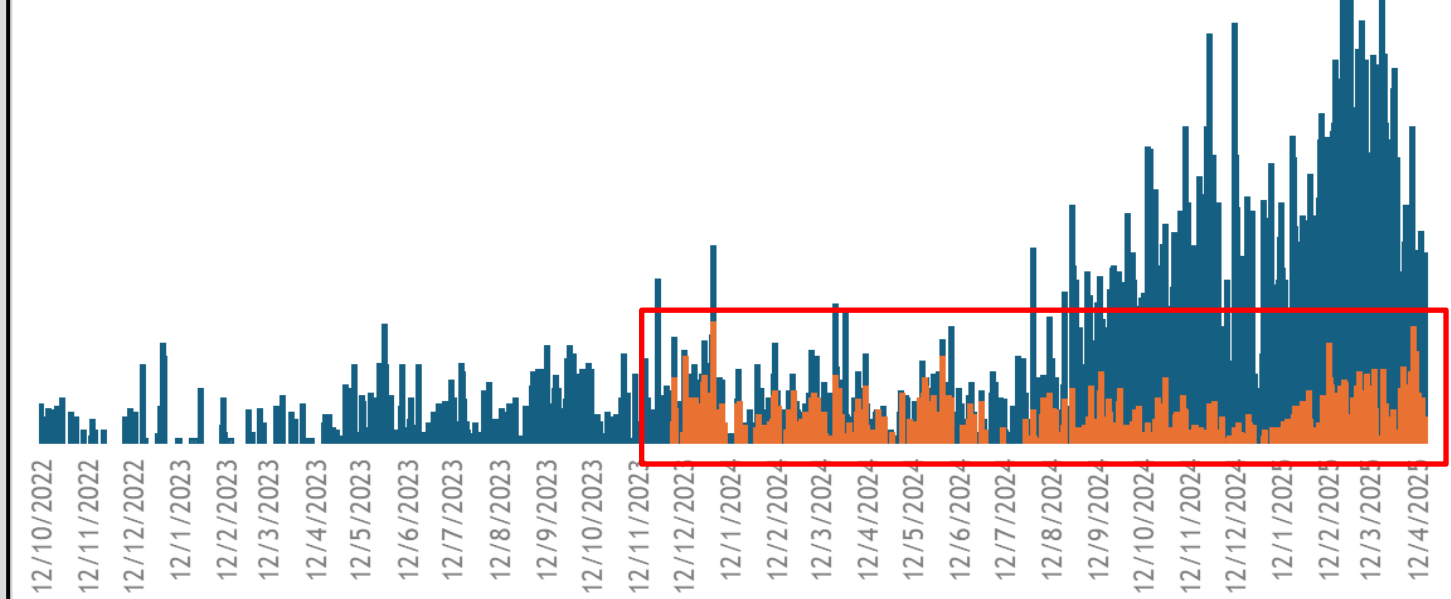
● UAV Destroyed ● Target Destroyed
..... Linear (UAV Destroyed) Linear (Target Destroyed)



Attacker's Perspective. Launching more drones does **not** guarantee more strikes

Number of UAV Launched/ Successful Target Destroyed over Time

■ UAV Launched ■ Target Destroyed

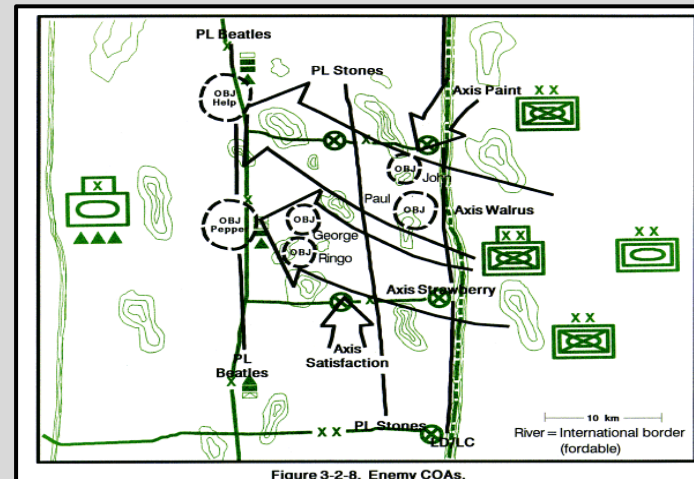


Defender's Perspective. Cost of expensive interceptor challenges defensive measures.

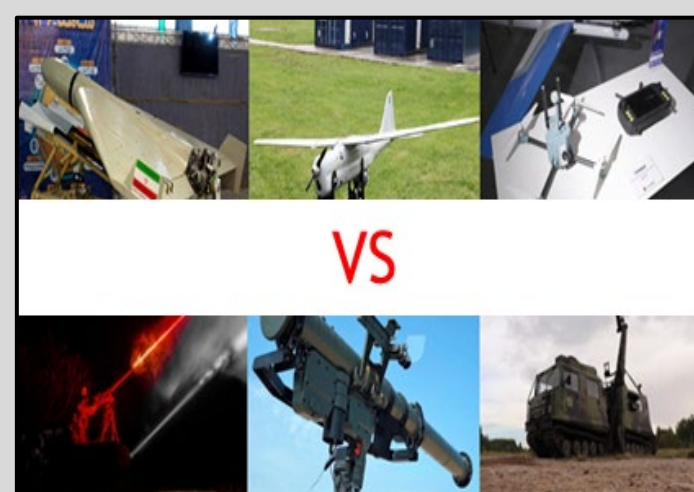
RESEARCH QUESTION

Observations	Research Questions
1 Interceptor Missiles cost ~100x more than lethal drones	Configuration of layered air defense systems under terrain-dependent conditions?
2 Misallocation of Interceptors due to decoy drones	Effect of sensor-based threat classification affect defensive counter-UAS measures?
3 Quantity does not imply a higher chance of successful strike	Integration of deception tactics within UAV swarm tactics to maximize mission effectiveness?
4 Sophisticated Drones does not reduce takedown rate	Balance between technological sophistication and cost-effectiveness in drone warfare?

METHODOLOGY



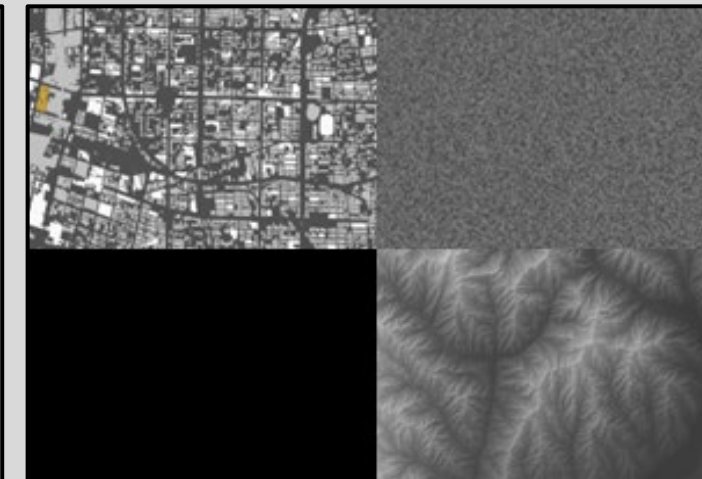
Analyze Real-Life Case Study. Sumy Oblast, Ukraine



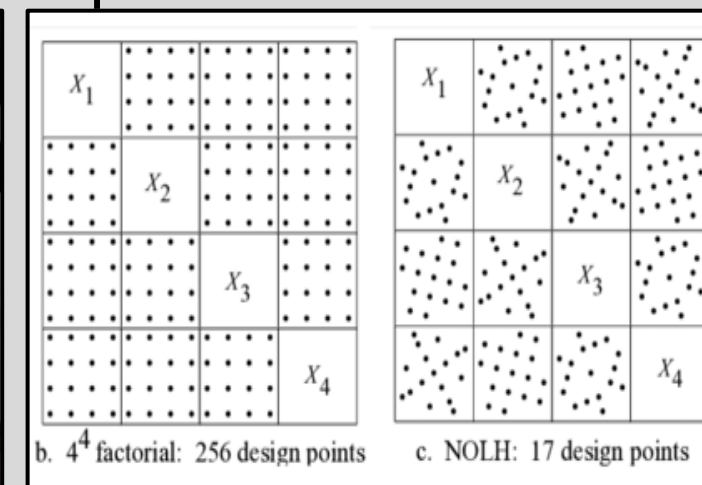
Weapon Modelling. Non-Kinetic and Kinetic Systems (Small Arms: Bivariate Normal, UAV interceptors, Missiles: Circular Error (CEP), Radar: Friis Equation)



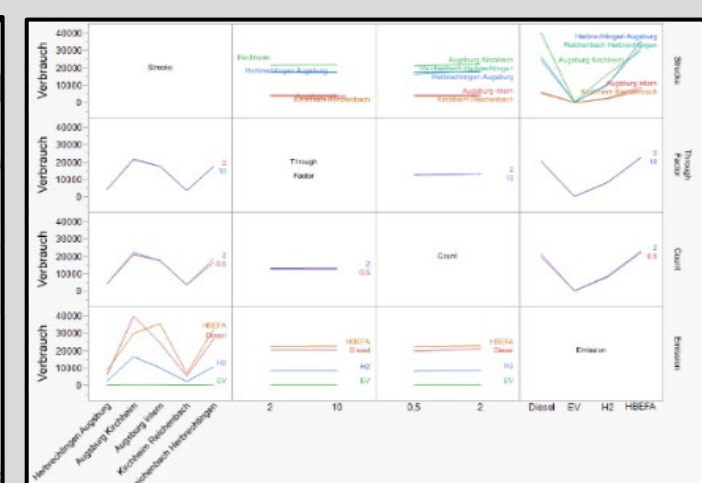
Simulation Model. Map-Aware Non Automata (MANA) based agent simulation



Develop Abstract Terrain. Urban, Forested, Mountain, & Open



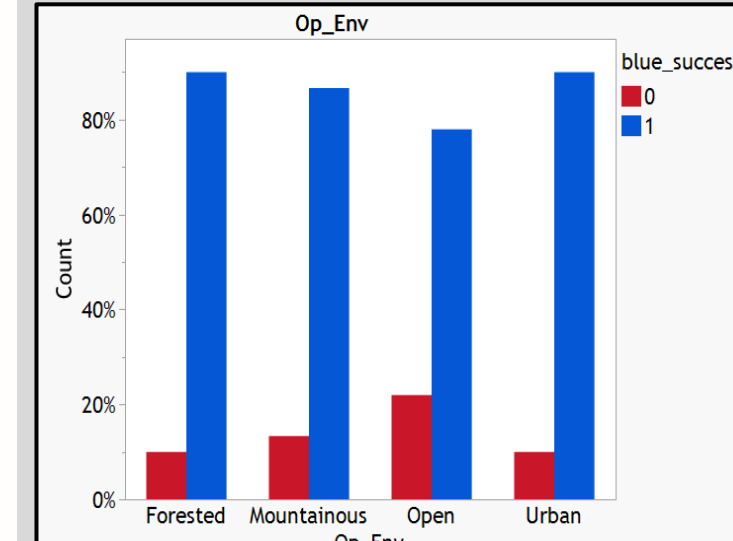
DOE (Design of Experiment). 256 pt Nearly-Orthogonal and Balanced (NOAB). 23 Factors, 256 Design Point, 50 replications



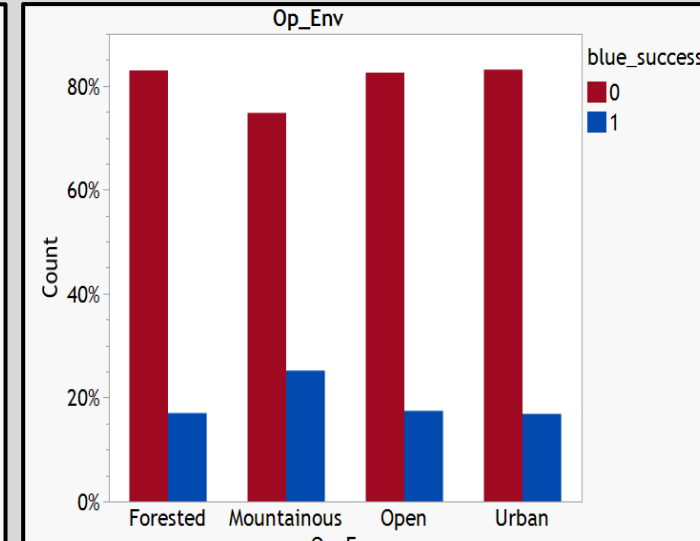
Supervised Learning Model. Logistic Regression Model (Analysis of Coefficient and Trendlines)

RESULTS AND DISCUSSION

Current Strategy (Low-Altitude)

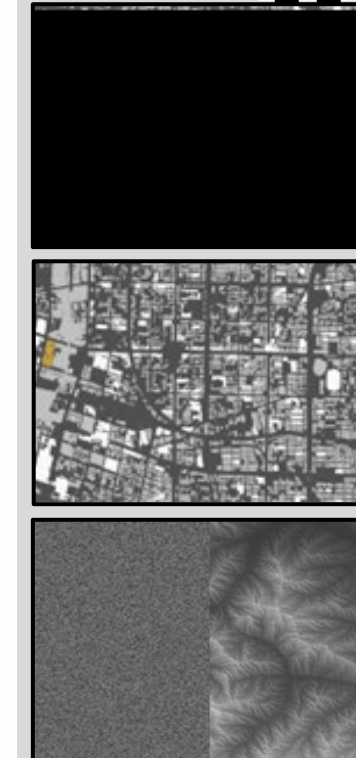


Mixed Strategy (Low- & High- Altitude)



- Terrain drives outcomes** - open terrain has the highest Red mission success. Mixing attacker's profiles reduces Blue's terrain advantage
- Defender Core Findings.**
 - Non-kinetic geometry is decisive.** Placement, coverage, range and dwell of NK systems drive success. Pair NK with high rate-of-fire short-range defensive layers for more cost-effective protection.
 - Moderate classification capability (target band **30%–50%**) is a high-value investment. Each +10% raises defender success odds by approximately **1.45x**.
- Attacker Core Findings.** Concentration and composition beat mass. Focus on 1-2 axes with a 60-70% lethal : 30-40% decoy mix and low intra-cluster spacing to maximize penetration. Technology helps only when embedded in concentrated, lethal-heavy tactics.

Terrain Snapshot



Open Terrain. Highest attacker success—defender emphasis on wide NK coverage and high rate-of-fire systems

Urban Terrain. Occlusion favours forward positioning of NK system and a lean missile layer. Attacker to adopt multi-axis approach.

Forested/ Mountain Terrain. Defender concentrate assets at choke-point and narrow NK coverage. Attacker single-axis concentration with lethal-heavy composition.

SIMULATION MODEL (URBAN TERRAIN EXAMPLE)

