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Drone Threat to Munition Storage

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Outline

- Background
- Methodology
  - Warhead performance estimations
  - Exposed site characteristics
  - Threat level definition and matching
- Drone threat matching
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Background

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Ukraine claims to have destroyed large Russian ammunition depot in overnight drone attack

By Niamh Kennedy, Maria Kostenko and Victoria Butenko, CNN

3 minute read · Updated 10:07 PM EDT, Wed September 18, 2024

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Ukraine

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Fire on the territory of the military unit in the city of Toropets. Photos by local residents

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Methodology

- How to assess the drone threat to explosive storage sites based on the drone size ?

Methodology

- Warhead performance estimation
  - For blast, fragmentation, penetrator and shaped charge warheads
  - Mass categories
    - < 2 kg
    - 2 – 5 kg
    - 5 – 15 kg
    - 15 – 25 kg
    - 25 – 50 kg
    - > 50 kg
  - Penetrator warheads dependency on impact velocity approximated by Young equations
  - Blast data interpolated to infrastructure destruction data based on TNT eqv.

Methodology

- Warhead performance estimation (fragmentation and shaped charges)

Mass category (total mass)	Warhead reference	Performance (in RHA)	Ref.
< 2 kg	DM51 hand grenade (with fragment sleeve)	2 to 2.5 mm *	[3]
2 – 5 kg	Carl Gustaf HE441D anti-personnel munition	2 to 3 mm *	[4, 5]
5 – 15 kg	120 mm mortar	10 to 12 mm *	[6, 7]
15 – 25 kg	122 mm artillery rocket BM-21 (RO Tohan)	13 to 15 mm *	[8, 9]
25 – 50 kg	155 mm artillery shell	14 to 16 mm *	[10, 11]
> 50 kg	Mk 82 (standard forged steel body; 20 g frag.)	26 to 30 mm	[12]

*Assumptions based on available data, Gurney and THOR calculations; combined blast/frag. effects not considered

Mass category (total mass)	Warhead reference	Penetration	Ref.
< 2 kg	WB Electronics Warmate HEAT WH	180 mm RHA	[20]
2 – 5 kg	Akeron MP (WH only)	1.0 m RHA (2.0 m concrete)	[21]
5 – 15 kg	PARS 3	> 1.0 m RHA > 1.6 m concrete *	[22]
15 – 25 kg	S-13T 122 mm unguided rocket	6 m soil + 1 m concrete (combined SC/Penetrator)	[23]
25 – 50 kg	Storm Shadow / SCALP Precursor charge	>> 2.0 m concrete**	-
> 50 kg	WDU-20 (AGM-65 Maverick)	> 1.5 m* RHA > 1.9 m concrete	[24]

*Assumption; **Assumption (real value classified)

Methodology

- Warhead performance estimation (penetrators and blast/thermobaric)

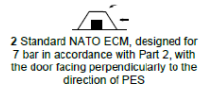
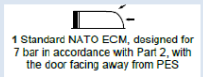
Mass category (total mass)	Warhead reference	Performance / Velocity (in reinforced concrete)	Ref.
< 2 kg	30x165 mm HE cartridge (USSR)	> 0.1 m	[14]
2 – 5 kg	H. Hansen test series	0.7 m / 422 m/s	[15]
5 – 15 kg	105 mm McKenzie simulation	Depending on velocity	[13]
15 – 25 kg	122 mm Rocket S-13	> 1.0 m / 650 m/s	[16]
25 – 50 kg	155 mm Artillery shell (XM982 Exc.)	> 1.2 m	[17]
> 50 kg	GBU-39/B SDB	> 0.9 m	[18]

Mass category (total mass)	Warhead reference	TNT equivalent	Ref.
< 2 kg	WB Warmate Loitering Munition	n. a.	[26]
2 – 5 kg	MGK Bur FAE RPG	6 kg	[27]
5 – 15 kg	9M133FM-2 Kornet	10 kg	[28]
15 – 25 kg	122 mm BM-21 (Tohan, RO)	12 kg*	[29]
25 – 50 kg	Shahed 136 FAE WH	>50 kg*	[30]
> 50 kg	TOS-1 / BM-1 MO.1.01.04 FAE	n. a.	[31]

*Estimated

Methodology

- Exposed site characteristics
  - Based on AASTP-1 and AASTP-1.3 [1, 32]
  - Structure characteristics of ECM, Heavy AGS, Medium AGS and light AGS identified at
    - Front
    - Side
    - Rear
    - Roof
  - ECM door structures assessed more in detail based on the Canadian CLSECM [32] and US Navy CLWS [40]

Orientation	Blast requirement	Structural requirement
Front 	7 bar	Estimated 600 mm reinforced concrete Door estimated 2 x 8 mm steel panels plus welded beams between
Side 	7 bar	600 mm reinforced concrete 600 mm earth cover
Rear 	7 bar	600 mm reinforced concrete Blow out area plus min. 600 mm earth cover
Roof	7 bar	900 mm reinforced concrete 600 mm earth cover

Methodology

- Threat level definition
  - Level 0: An attack will cause minor damage (surface only) to the structure. Munitions inside **remain safe and suitable for service**
  - Level 1: An attack will cause significant damage to the structure and the possibility is given, that a lucky strike to the weakest area causes secondary effects (i.e. spall projections with less than 50 m/s and 2500 J of kin. Energy acc. to AASTP-1 Part II 2.2.2.2) inside the magazine, which imply damage to munitions with **no probability of a munition reaction.**
  - Level 2: An attack will cause severe damage to the structure incl. secondary effects like spall (exceeding 50 m/s). A strike at the weakest area might enable the warhead to penetrate the protection and damage munitions inside, with **low probability of a munition reaction.**
  - Level 3: An attack will cause severe damage to the structure and the warhead's effects will penetrate the protection. Nevertheless, the structure consumes most of the energy and only a fraction reaches the stored munitions In addition, spall effects exceed 50 m/s and 100 kg m/s of projection impulse, resulting in an **intermediate probability of a munition reaction.**

Methodology

- Threat level definition
  - Level 4: An attack will likely destroy the structure and the stored munitions inside, resulting in a **high probability of a munition reaction**.
  - Summarized:
    - Level 0 – 1: No reaction probability
    - Level 2: Low reaction probability
    - Level 3: Intermediate reaction probability
    - Level 4: High reaction probability

Methodology

- Threat level matching
  - Based on warhead performance **estimations** and exposed site characteristics
    - For each mass class
    - For each site type (i.e. shown ECM table)
  - Provides interim **approximations** on required warhead mass at weakest location
    - For a certain acceptable threat level (i.e. lvl. 2)

Magazine type	Frag	Penetrator*	SC / EFP	Blast / FAE	Blast/Frag
ECM	> 50 kg (front/door)	2 – 5 kg (front/door)	< 2 kg (front/door)	25 – 50 kg (front/door)	25 - 50 kg (front/door)
Heavy AGS	> 50 kg (front/door)	2 – 5 kg (front/door)	< 2 kg (roof)	5 – 15 kg (roof)	5 – 15 kg (roof)
Medium AGS	> 50 kg (front/door)	2 – 5 kg (front/door)	< 2 kg (all)	5 – 15 kg (all)	5 – 15 kg (all)
Light AGS	< 2 kg (all)	< 2 kg (all)	< 2 kg (all)	2 – 5 kg (all)	< 2 kg (all)

*Assuming sufficient impact velocity and robustness for penetration process

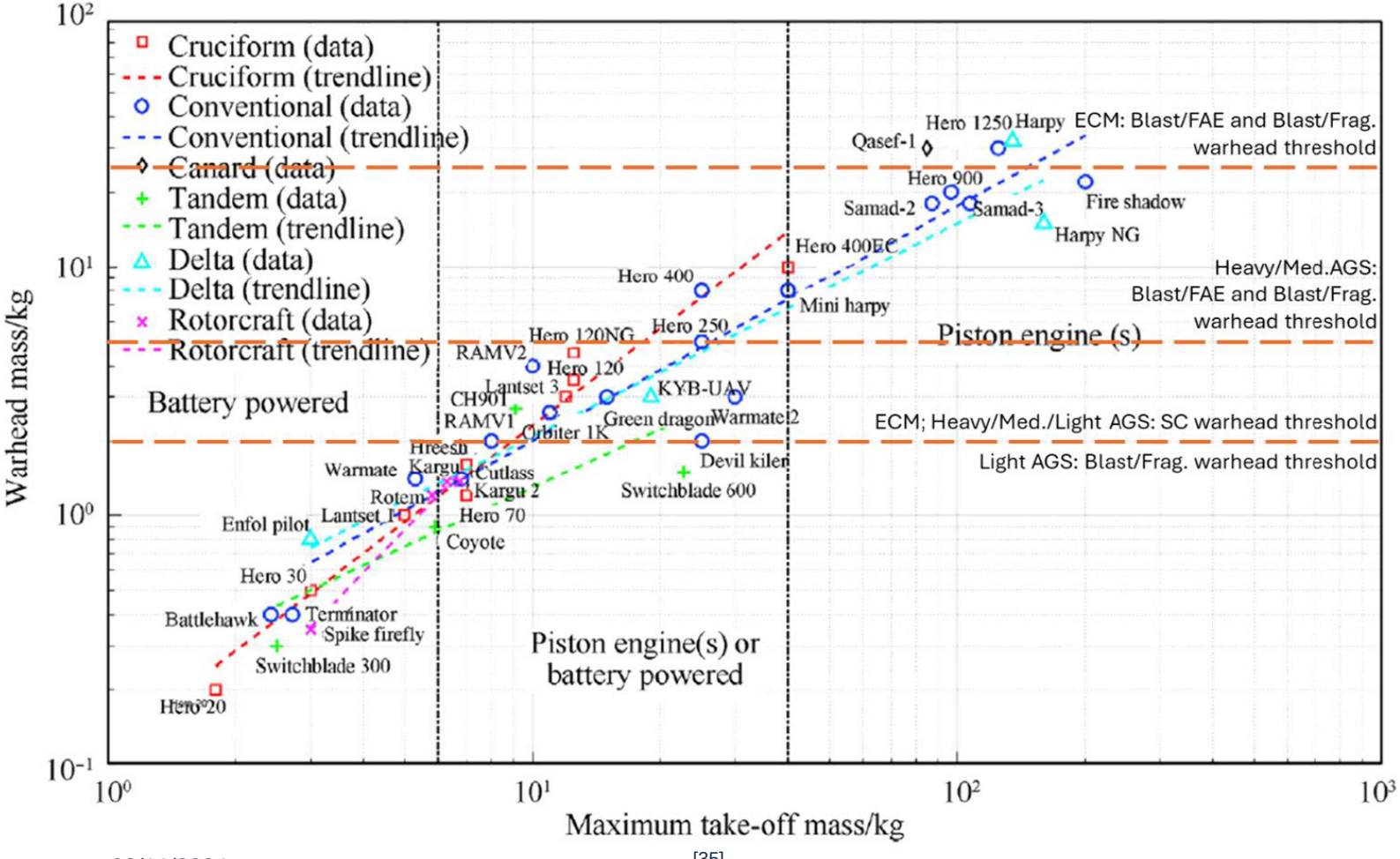
Attack orientation vs. Warhead type and mass	Front	Side	Rear	Roof
Threat levels of fragmentation warheads				
< 2 kg	0	0	0	0
2 – 5 kg	0	0	0	0
5 – 15 kg	0	0	0	0
15 – 25 kg	0	0	0	0
25 – 50 kg	1	0	0	0
> 50 kg	2 - 4	0	0	0
Threat levels of penetrator warheads*				
< 2 kg	0	0	0	0
2 – 5 kg	3	0	0	0
5 – 15 kg	4	3	3	3
15 – 25 kg	4	4	4	4
25 – 50 kg	4	4	4	4
> 50 kg	4	4	4	4
Threat levels of shaped charges / EFP warheads				
< 2 kg	2	0	0	0
2 – 5 kg	3	0	0	0
5 – 15 kg	4	4	4	4
15 – 25 kg	4	4	4	4
25 – 50 kg	4	4	4	4
> 50 kg	4	4	4	4
Threat levels of blast / thermobaric warheads**				
< 2 kg	0	0	0	0
2 – 5 kg	0	0	0	0
5 – 15 kg	1	0	0	0
15 – 25 kg	1	0	0	0
25 – 50 kg	2	1	1	1
> 50 kg	2 – 4	2 – 4	2 – 4	2 – 4
Threat levels of combined blast/frag warheads**				
< 2 kg	0	0	0	0
2 – 5 kg	0	0	0	0
5 – 15 kg	1	0	0	0
15 – 25 kg	1	0	0	0
25 – 50 kg	2	1	1	1
> 50 kg	2-4	2 – 4	2 – 4	2 – 4

*Assuming lucky strike at weakest area with appropriate strike velocity and trajectory (worst case); ** Estimation based on [25]

Drone threat matching

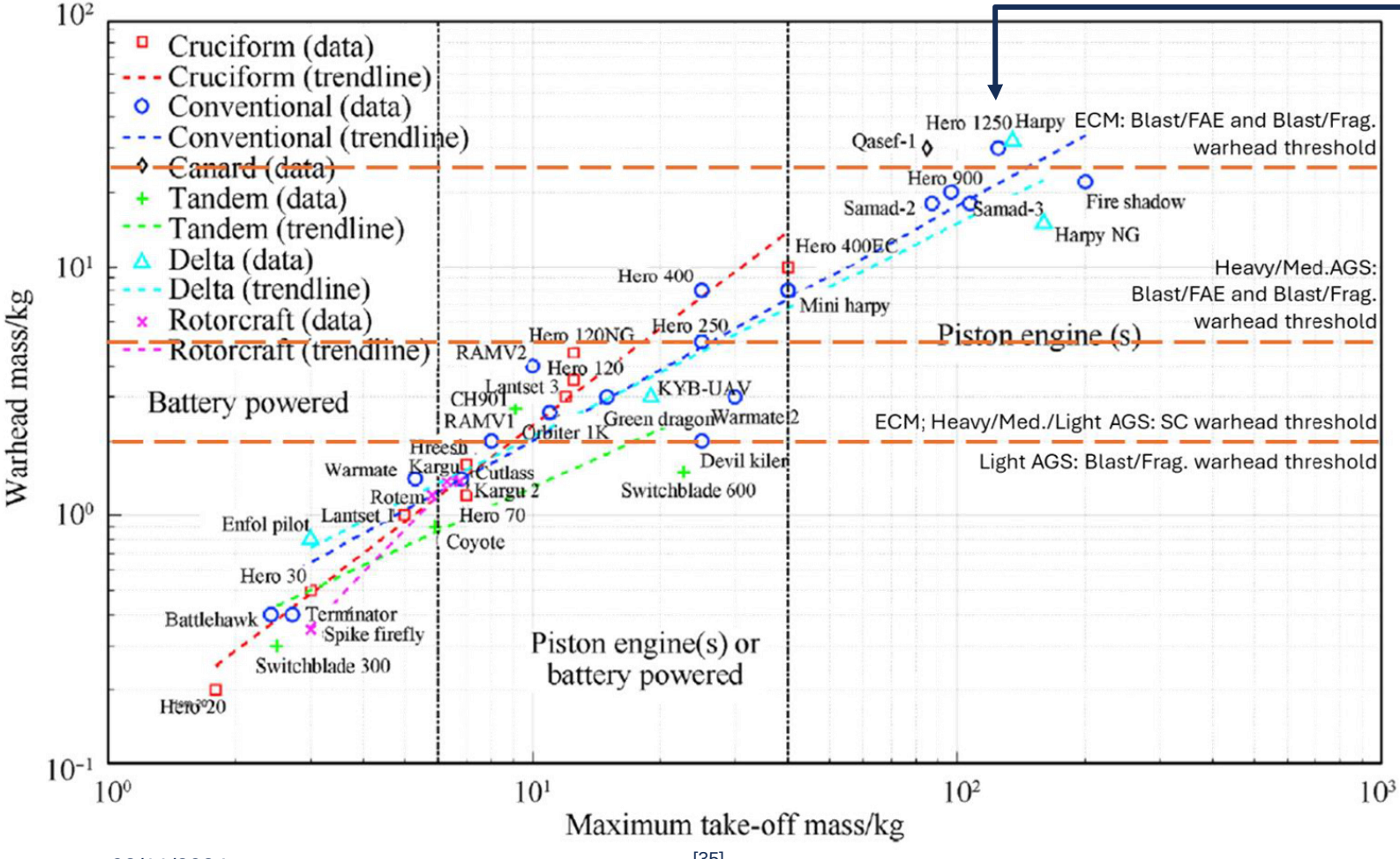
- Threat level matching
  - Sufficient literature data exists to match the required warhead payload with:
    - The LM type
      (i.e. fixed wing delta)
    - The max. take-off mass
  - Threshold lines for defeating specific structures at their weakest point included in the figure

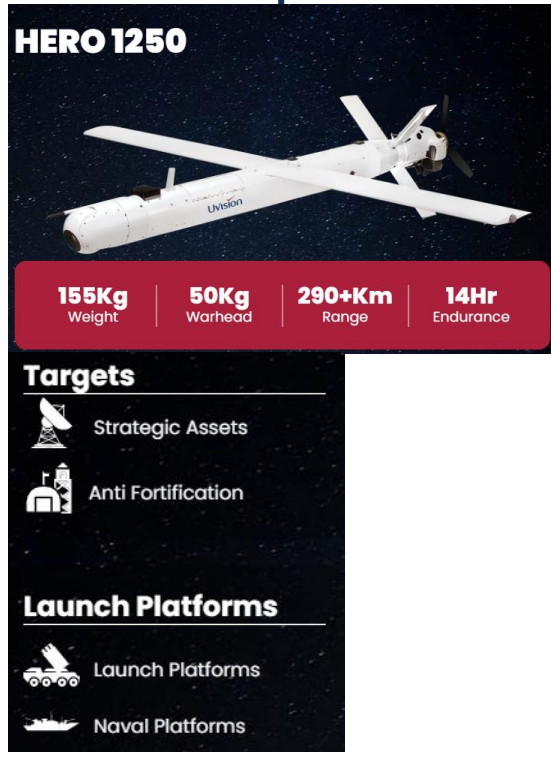
Drone threat matching



[35]

Drone threat matching

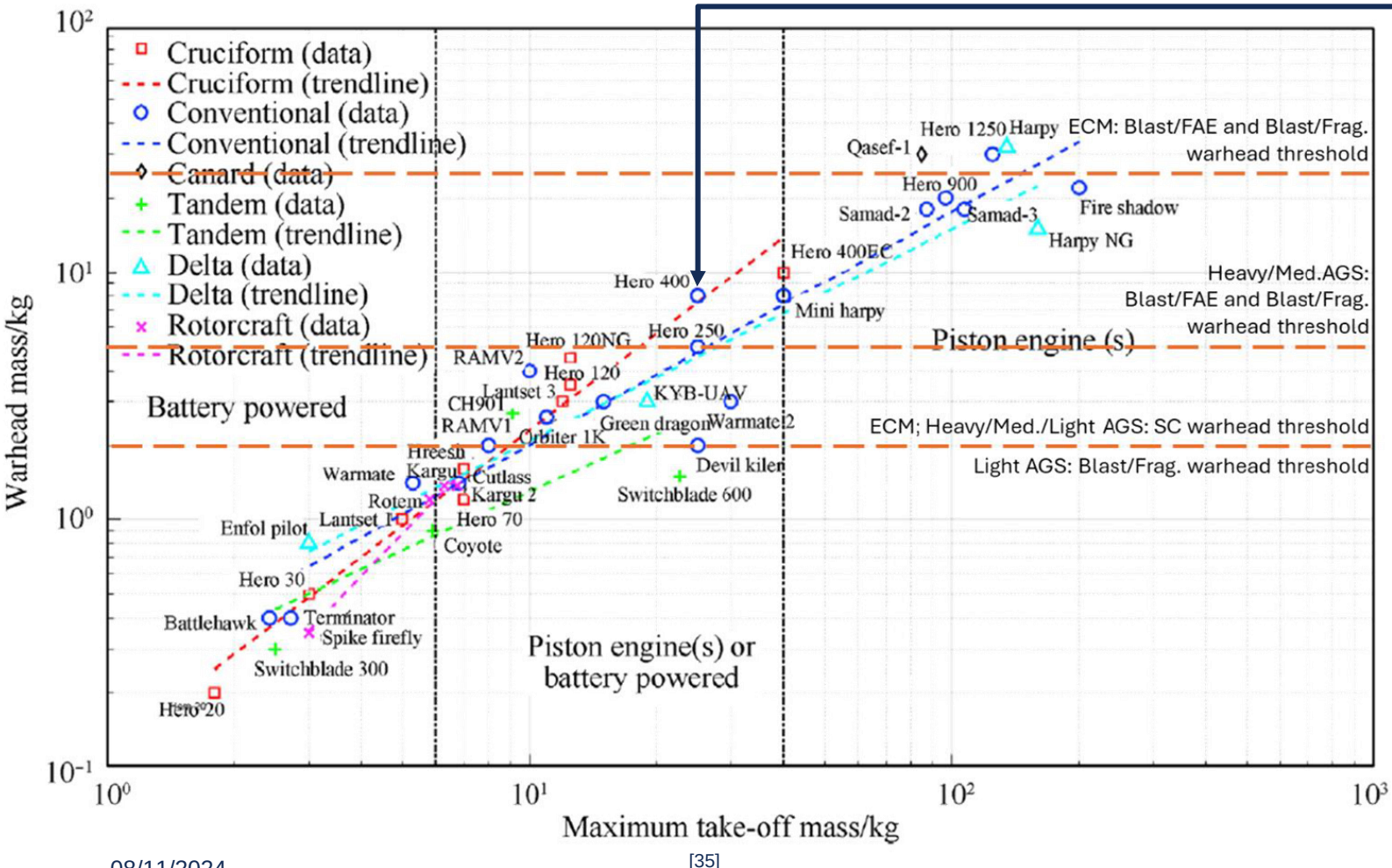


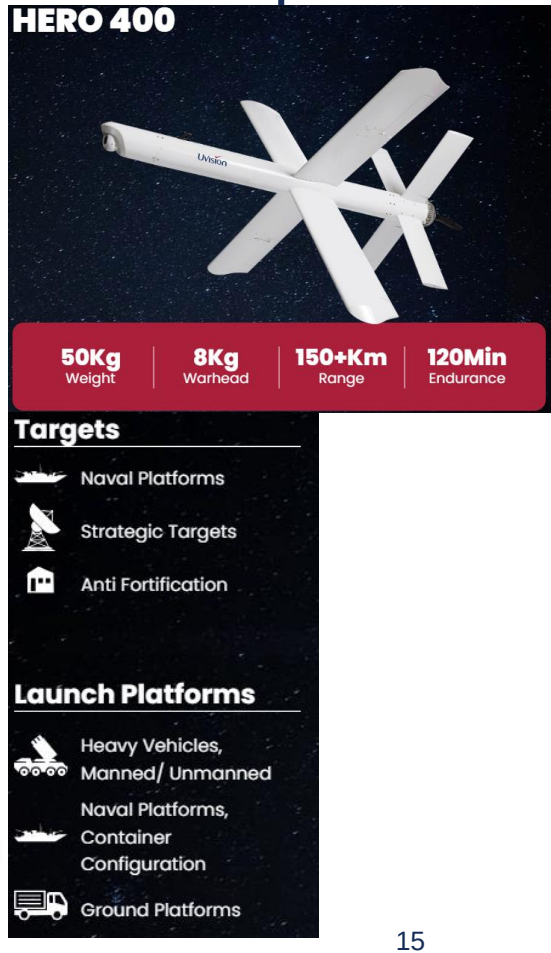


https://uvisionuav.com/loitering-munitions/hero-1250/

[35]

Drone threat matching

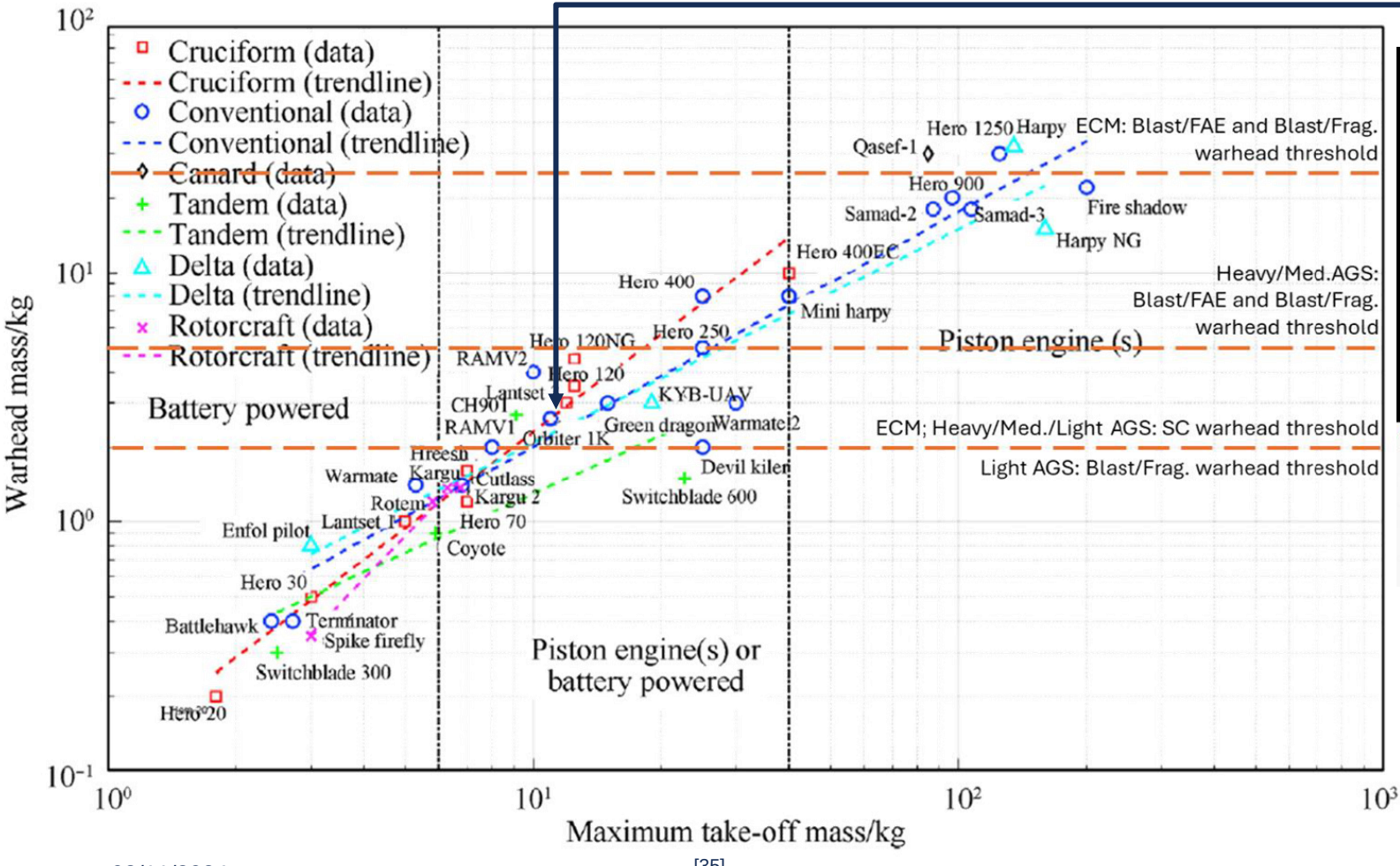


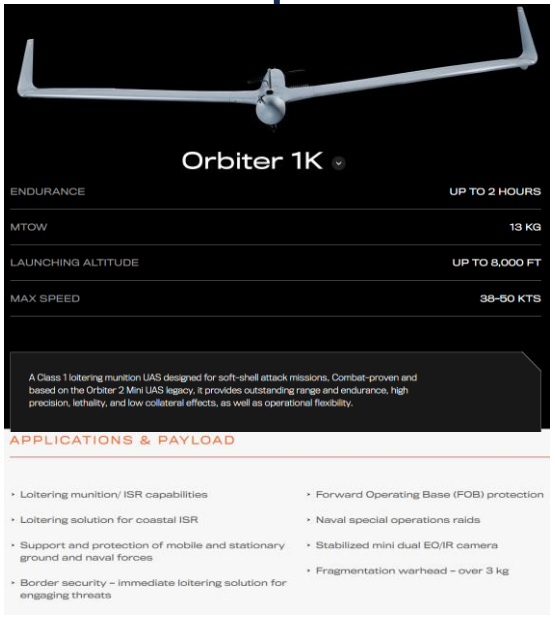


https://uvisionuav.com/loitering-munitions/hero-400/

[35]

Drone threat matching





https://aeronautics-sys.com/systems/orbiter-1k/

[35]

Summary

- Based on warhead performance, site characteristics and engineering estimations it is possible to define a threat level for each WH/site combination considering their weakest point (usually the door structure)

- The acceptance (i.e. low risk) and mass classes of warhead categories allows an engineering estimation regarding the required mass of a warhead

- Finally, the required Drone size and some characteristics can be derived based on the warhead payload required to oppose the acceptable risk level

- Pure penetrator warheads are technically possible but not likely to be used in UAS based on their slow terminal velocity (< 150 m/s). Multi-effect penetrator with precursor charges are more likely

Key take aways

- Door (ECM) and roof structures (Heavy/Medium AGS) are most vulnerable
  - But even the smallest warhead is sufficient if the doors are open…
- Small LM in the 10 kg class are sufficient to penetrate storage structures at their weakest points if shaped charges are used
  - Note: Of course they need to hit something and can be disturbed easily
- Medium LM in the 30 kg class are sufficient to penetrate Heavy/Medium AGS based on their door and roof structure (blast/frag - without the limitations of SC warheads)
- ECM are only threatened by LM exceeding 150 kg with very large blast/frag. or multi-effect warheads (i.e. HERO 1250)

Key take aways

Key lesson learnt from the UKR conflict: Munition storage sites are the top priority target in modern warfare

Ammunition storage buildings and a rail line in Toropets on September 7.Satellite image 2024 Maxar Technologies

A large crater, downed trees, and destroyed rail cars on September 22 after the Toropets attack.Satellite image 2024 Maxar Technologies.

Thank you for your attention

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