INSS Technology Platform

# Loitering Munitions (Explosive UAVs)

**Arie Aviram** | June 25, 2025

**The confrontation states and the terrorist organizations facing Israel are arming themselves with massive quantities of loitering munitions. Their low cost and ease of use make them a significant, clear, and immediate threat—especially when launched in swarms. Addressing this challenge will require substantial investment to improve detection and neutralization capabilities. This threat analysis concludes with recommendations for countering this threat.**

The wars in Ukraine, the Caucasus, and Israel's Operation Swords of Iron have all served as proving grounds for the new class of armaments: Loitering munitions, also known globally as loitering missiles, or—as they are referred to in Israeli media—explosive UAVs (unmanned aerial vehicles).

In Ukraine, loitering munitions have been used to strike buildings and high-value targets, causing both civilian and military casualties. These weapons are inexpensive to produce in large quantities, allowing operators to launch large numbers of precise attacks against valuable targets. Operating some types of loitering munitions (those equipped with GPS homing) is extremely simple and does not require high-level technical or operational expertise. The potential launching of large swarms of loitering munitions poses a significant, clear, and immediate threat, and the technical capability already exists in the current generations of these weapons.

During Operation Swords of Iron, several launches of loitering munitions against Israel hit civilian targets (explosive UAVs launched by the Houthis in Yemen struck homes in Tel Aviv and Yavne) as well as military targets (damage to the Golani Brigade basic training base near Binyamina and IDF positions in Arab al-Aramshe and the Golan Heights). The peak event was the launch of about 170 Iranian loitering munitions (most likely Shahed-136 UAVs), which were launched toward targets in Israel on April 14, 2024. These explosive UAVs failed to reach Israel due to the vigorous interception efforts by the Israeli Air Force and its allies. However, it is important to remember that Israel was not engaged in a full-scale war at that time, which allowed the air force to allocate substantial forces to handle the mass of incoming UAVs.

**Loitering Munitions (Explosive UAVs)—A Profile**

The loitering munitions family consists of weapons based on autonomous platforms, with launch ranges from a few kilometers to thousands of kilometers, carrying warheads in the range of 3–50 kg, and capable of precise strikes on pre-designated high-value targets or those selected in real time by the operators. These munitions have been developed over the past fifty years by several countries, with the pioneers being the United States and Germany. The original application was to use loitering munitions as a solution for suppressing mobile air

defense systems (SEAD—Suppression of Enemy Air Defenses missions). These countries viewed loitering munitions as autonomous battlefield robots that would provide a relatively cheap solution for neutralizing mobile surface-to-air missile (SAM) systems.

The United States and Germany—the original developers of these weapons—abandoned the idea early on. However, Israel and Iran, recognizing the future potential of these weapons, continued to develop the concept. This led to the creation of the Israel Aerospace Industries' Harpy (Figure 1) and Iran's Ababil (Figure 2) during the 1980s.

**Figure 1**. Harpy, Israel

**Figure 2.** Ababil, Iran

*Note*. Source: Fars News Agency

Loitering munitions are airborne platforms, essentially the "younger siblings" of cruise missiles. Below are typical parameters for loitering munitions:

- **Launcher**: Single or multiple. A single launcher can even be a disposable tube carried by a lone soldier;
- **Launch Method**: Mostly ground-based; some maritime or airborne launch systems exist, but these are rare;
- **Wingspan**: 0.5 m to 4.0 m;
- **Fuselage Length**: 0.5 m to 4.0 m;
- **Takeoff Weight**: 5 kg to 300 kg;
- **Propulsion**: Usually piston or electric engine; some use jet engines;
- **Midcourse Navigation**: Typically, GNSS (Global Navigation Satellite System), electro-optical, or communication-based;
- **Communication**: None ("fire and forget") or radio;
- **Terminal Guidance**: Radar-homing (Anti-Radiation, AR), electro-optical (EO), GNSS, or laser spot homing;
- **Warhead Weight**: 0.5 kg to 50 kg;
- **Operational Range**: 5 km to 2,500 km;
- **Range Limit with Ground Communication**: ~200 km;
- **Cruising Speed**: 150 km/h to 600 km/h.

Some loitering munitions—such as those homing on radar emissions (AR) or GPS signals—can be fully autonomous. Others, guided by electro-optical (EO) seekers, require an operator to select the target and trigger the attack phase of the mission. It is assumed that, with future advancements in Automatic Target Recognition (ATR) systems, even EO-guided loitering munitions will achieve full autonomy.

A weapon system based on loitering munitions includes the following components:

- **Launcher**—can be either single-canister or multi-canister;
- **Loitering Munitions**—installed inside launch canisters, which also function as long-term storage units;
- **Command and Control (C2) System**—responsible for preparing the munitions and the launch itself. If guidance relies solely on GPS and the number of munitions is small, the C2 setup can be as simple as a laptop. For systems launching many munitions, the C2 will typically include a shelter equipped with computers and displays capable of managing and controlling multiple launches and the launching process;
- **Data Link (Radio Communication System)**—mandatory only in EO-guided loitering munitions systems, optional in others;
- **Power Supply System**—usually a generator, batteries, or cells, depending on the UAV size and the number of units involved.

**Figure 3**. Components of a Typical Loitering Munition Weapon System


*Note*. Source: Iranian News Agencies

After launch, the operational envelope of loitering munitions includes two main phases:

1. **Midcourse Navigation to the Target Area**
    - Navigation is carried out using GPS (or other GNSS systems), the communication system, electro-optical navigation, or a combination of these methods.
2. **Terminal Guidance to the Designated Target**
    - Final guidance is executed using the UAV's navigation system (GPS or GNSS) or a seeker employing one or more of the following technologies:
        - **Passive Radar Seeker (AR)**—detects, identifies, locks onto, and tracks emitting targets such as radar transmitters. These seekers operate entirely autonomously without human involvement.
        - **Electro-Optical Seeker (EO)**—detects, identifies, locks onto, and tracks a target against the background. This process requires human involvement until the lock-on phase, conducted via a point-to-point data link between the loitering munition and the C2 system. This limitation is expected to be eliminated with the development of affordable, reliable ATR systems, at which point the communication system will become optional. EO seekers can be uncooled or cooled (and thus more expensive). Cheap loitering munitions typically use basic observation cameras, sometimes only day cameras, combined with a tracking system.
        - **Laser Spot Seeker (SAL—Semi-Active Laser)**—requires the target to be designated by a ground or airborne laser designator. Despite its low cost and proven technical feasibility, no known loitering munitions currently operate using this seeker type.

All loitering munitions are equipped with warheads triggered either by impact or by proximity fuses. Typically, the warhead belongs to one of the following categories:

- **Fragmentation Warhead**
- **Anti-Tank Warhead**
- **Combination of the Above**

Countries Developing and Manufacturing Loitering Munitions:

- **Israel**—Five major manufacturers (Israel Aerospace Industries, Elbit, UVision Air, Bird Aerosystems, Spear UAV and Aeronautics), with about 20 product families.
- **Iran**
- **China**
- **Russia**
- **United States**
- **Turkey**
- **Taiwan**

The Harpy system, developed by Israel Aerospace Industries, was the first operational system of its kind in the world. It has since inspired several imitations or copies by the defense industries of countries including Turkey, China, Taiwan, Iran, and South Africa. In Figure 4, one can see the strong similarity between the aerodynamic configurations of the Harpy and those of other loitering munitions.

The Harpy was not the only Israeli system to be copied. The HERO family, developed by the Israeli company UVision Air, was also imitated by Iran. This includes the short-range loitering munition called Rezvan, which is man-portable and can be carried by a single soldier (see Figure 4). The Rezvan resembles the Hero-90 by UVision Air, both in its physical design and operational concept.

It can be assumed that these imitations mainly replicate the aerodynamic design and operating concept, while the avionics is based on each country's domestic capabilities and technologies.

In Table 1, there is a description and key parameters of several loitering munitions.

**Table 1**. Key Parameters of Several Loitering Munitions

| System Name | Guidance Type / Seeker Head | Warhead Weight (kg) | Cruise Speed (km/h) | Range (km) | Takeoff Weight (kg) |
|---|---|---|---|---|---|
| **Harpy / IAI / Israel** | AR Seeker (Anti-Radiation—homing on emitters) | 32 | 185 | 200 | 32 |
| **Harop / IAI / Israel** | EO Seeker (Electro-Optical Homing) | 16–23 | 400 | 200–1000 | 16–23 |
| **Hero-1250 / UVision Air / Israel** | EO Seeker | 50 | ??? | 200 | 50 |

| | | | | | |
|---|---|---|---|---|---|
| **SkyStriker / Elbit / Israel** | EO Seeker | 10 | ??? | 100 | 10 |
| **Ababil T / HESA / Iran** | GNSS (Satellite Navigation Guidance) | 30 | 250–305 | 120 | 30 |
| **Shahed-131 / Iran** | GNSS | 15 | ??? | 900 | 15 |
| **Shahed-136 / Iran** | GNSS | 30–50 | 185 | 2,500 | 30–50 |
| **Samad-3 / Iran** | GNSS | 40 | 200–250 | 1,500–1,800 | 40 |

**Figure 4**. All Resemble the Harpy airframe geometry and dimensions: Imitations? Copies?

| | |
|---|---|
|  | **ISRAEL—HARPY** |
|  | **IRAN—SHAHED-136**<br>Source: Fars News |
|  | **CHINA—ASN-301**<br>Source: Army Recognition Group |
|  | **TAIWAN—CHIEN HSIANG** |

| | |
|---|---|
|  | **TURKEY—KARGI**<br><br>Source: defensenews |
|  | **SOUTH AFRICA—ARD-10**<br><br>Source: armedconflicts.com |
|  | **IRAN—TOUFAN 2**<br><br>Source: armedconflicts.com |

**Figure 5**. The Iranian Rezvan Resembles UVision Air's Hero-90

**Figure 6**. Hero 90 of UVision Air


*Note*. Source: UNIVISION

**Development of Loitering Munitions in Iran**

The Iranians identified very early the potential of loitering munitions. The idea of a relatively cheap, mass-produced, precision-guided weapon capable of carrying a warhead of several dozen kilograms over long ranges and striking high-value targets with precision fascinated them. They copied and independently developed entire families of loitering munitions. The most prominent among these families are:

- **Ababil**—including Ababil-T, Ababil-2
- **Samad**—including Samad-2, Samad-3
- **Shahed**—including Shahed-131, Shahed-136, Shahed-136b, Shahed-238
- **Mobin**
- **Arash**—including Arash-1

Iranian loitering munitions have operational ranges between 150 km and 2,200 km and carry warheads weighing between 30 kg and 50 kg. All are guided using GNSS, although it is assumed the Iranians use both the American GPS system and the Russian GLONASS. Some models are equipped with cameras or electro-optical seekers.

The Shahed-238, the jet-powered version of the Shahed-136, comes in three configurations: GNSS guidance, electro-optical guidance, and Anti-Radiation guidance. However, there is doubt regarding the operational status of the latter two models.

The loitering munitions that attacked Israel during 2024 were launched by Iran, Hezbollah, the Houthis in Yemen, and Shiite militias in Iraq. These attacks mostly involved the following types of loitering munitions, the majority of which have long operational ranges (except for those launched from Lebanon):

- **Ababil-T** (see Figure 7)
- **Shahed-101** (see Figure 8)
- **Shahed-136** (see Figure 9)
- **Samad-2** (see Figure 10)
- **Samad-3** (see Figure 11)

It is worth noting here the emergence of decoy loitering munitions produced by Russia, which were employed in the war against Ukraine to deceive air defense systems. An example is the Russian Gerbera system, which is largely based on Western components (see Figure 12). These decoy munitions visually mimic the Shahed-136 and are designed to confuse and saturate Ukrainian air defense operators.

**Figure 7**. Ababil-T

*Note*. Source: Fars News

**Figure 8**. Shahed-101

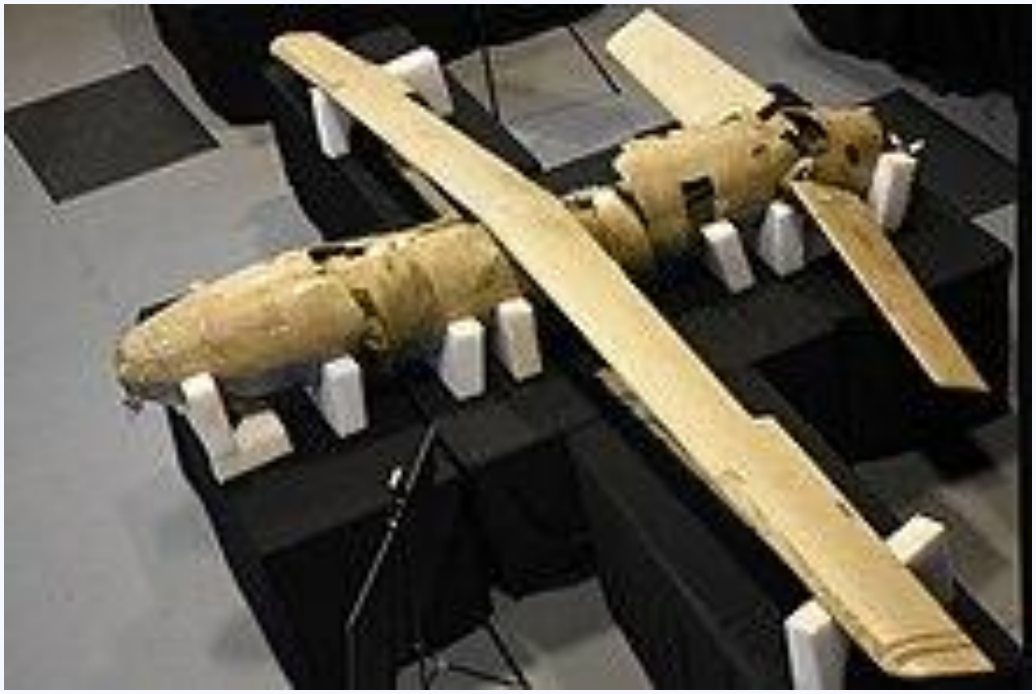


**Figure 9**. Shahed-136

*Note*. Source: armyrecognition.com

**Figure 10**. Samad-2

*Note*. Source:  en.topwar.ru

**Figure 11**. Samad-3

*Note*. Source: en.topwar.ru

**Figure 12**. Gerbera—Decoy Loitering Munition System


*Note*. Source: Defense Intelligence of Ukraine / Telegram

**The Dangers Posed to Israel by Loitering Munitions**

During Operation Swords of Iron, Iran, the Houthis, and Hezbollah attacked using loitering munitions launched at relatively low rates and in small numbers: on average 1–5 per salvo, every few days. The launching of loitering munitions in large quantities (swarms) could overwhelm and saturate defense systems. It can be assumed that if the Iranians, Houthis, or Hezbollah manage to attack Israel using large swarms of loitering munitions, their selected high-value targets would be:

- Major headquarters—the Kirya (Israel's main defense headquarters), military command bases
- Division headquarters and artillery batteries in the field
- Air Force bases
- Navy bases
- Intelligence organization headquarters—Mossad, Israeli Security Agency (Shin Bet)
- Large military training and instruction bases
- Power stations and communications centers
- Population centers

The technical capability already exists: The standard launcher of the Shahed-136 (Figure 13) is capable of launching five munitions in a short time. Concentrating the efforts of 10–50 such launchers (which do not all need to be located together but simply need to coordinate launch times, flight paths, and time over target) would create a swarm consisting of 50–250 loitering munitions. Allocating about 10 to 20 munitions per target would result in a loitering munition swarm over each high-value target attacked.

Some loitering munition systems have launchers with even higher mass-launch capability—up to 20 munitions per launcher. It is reasonable to assume that the Iranians will also work to enhance this capability in the future.

**Figure 13**. Shahed-136 Launcher Loaded with 5 Loitering Munitions

*Note*. Source: https://armyrecognition.com/

**What Can Be Done Against Loitering Munitions?**

Loitering munitions typically pass through several key phases in their operational life, as shown in Figure 19.

- **Development and Production Facility (Industry)**—A plant where the loitering munition and the weapon system that operates it are developed and mass-produced.
- **Logistics / Operational Storage Facility (Industry or Military)**—A logistical warehouse or base where the operational unit that launches the loitering munitions is located.
- **Operational Deployment in the Field**—An area where launchers are deployed and ready to fire, ranging from a single launcher carrying just one munition to a battery with multiple launchers.
- **Swarm in the Air**—Loitering munitions after launch, flying toward their targets—from a single munition to swarms of hundreds.

At each of these phases, it is possible to counter loitering munitions, but the further along the chain, the higher the cost of mitigation, as seen in Figure 19. Neutralizing or destroying a UAV swarm in the air is extremely difficult and significantly more expensive.

The Israeli Air Force plays a full role in the effort to neutralize loitering munitions launched against Israel:

- Using fighter jets to neutralize UAVs (likely at high and medium altitudes). Fighter jets have excellent radar for detecting UAVs, but using air-to-air missiles to destroy them is very costly.
- Using attack helicopters to neutralize UAVs (likely at medium and low altitudes). Helicopters have cannons whose shells are much cheaper than air-to-air missiles, but they lack radar.
- Using surface-to-air defense missiles (against aircraft) from Iron Dome and David's Sling ("Magic Wand") batteries.
- Using electronic warfare—broad GPS jamming.

In the past, the Israeli Air Force operated ground-based anti-aircraft artillery (gun-based air defense):

- L-70 system ("Super Fledermaus")—operated 40 mm cannons (see Figure 14).
- TCM-20 anti-aircraft guns—dual-barrel 20 mm cannons (see Figure 15).
- "Hovet" / "Machbet" system (see Figure 16)—operated 20 mm Vulcan cannons (a fast-firing gun that was also mounted on Phantom F-4 jets), with a radar rangefinder (in the Hovet system) and radar detection plus shoulder-launched missiles (in the Machbet system).
- Captured Soviet ZSU-23-4 Shilka Gundish system—based on four radar-guided 23 mm cannons (see Figure 17).

The Israeli Air Force abandoned gun-based air defense over 25 years ago and ceased using all of the above systems. However, given the emergence of loitering munitions, whose aerodynamic performance resembles World War II fighter planes, it may be worth reconsidering the use of gun-based air defense.

It is worth noting that the US Air Force has recently introduced 75 propeller-driven Skyraider II fighter aircraft (see Figure 18) for patrol and close air support missions. These aircraft—with performance similar to World War II fighter planes—could also be used to intercept loitering munitions, provided they are equipped with cannons and cheap 75 mm rocket-based armaments for intercepting UAVs. These fighter planes have five "hardpoints" for carrying weapons, and on at least one of these, it is certainly possible to install an existing pod with an air-to-air cannon.

**Figure 14**. L-70 Super Fledermaus Anti-Aircraft Gun

*Note*. Source: Bukvoed via wikipedia

**Figure 15**. TCM-20 Anti-Aircraft Gun System

*Note*. Source: Bukvoed via wikipedia

**Figure 16**. “Hovet” System with 6-Barrel VULCAN Cannon

*Note*. Source: Bukvoed via Wikipedia

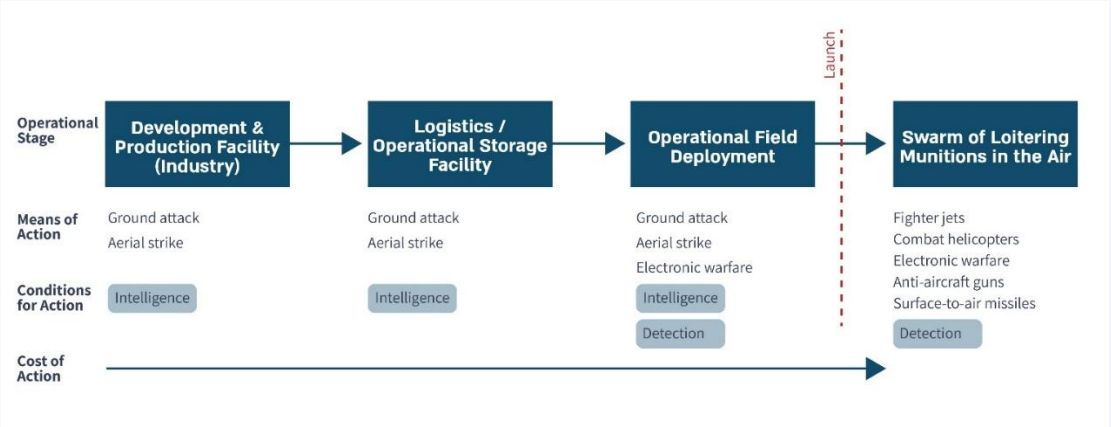
**Figure 17**. ZSU-23-4 Shilka


*Note*. Source: https://en.namu.wiki/w/ZSU-23-4%20%EC%89%B4%EC%B9%B4

**Figure 18**. Skyraider II aircraft

*Note*. Source: Staff Sgt. Natalie Fiorilli/Air Force

**Figure 19**. The Complexity of Combat Against Loitering Munitions




**What Did the Ukrainians Do?**

In the war with Russia, the Ukrainians effectively used old anti-aircraft guns to defend important targets. This appears to be a good solution for protecting point targets, but it is not a viable method for defending an entire country. In addition, there was extensive use of electronic warfare (EW) systems to disrupt GNSS-based navigation systems and the command-and-control communications of loitering munitions. According to their claims, they managed to neutralize over 70%–80% of the Russian loitering munitions launched against them (mainly Shahed-131 and Shahed-136. Large electronic warfare systems were mostly used to defend high-value assets, such as air defense systems or artillery batteries. It has been proven that the best way to counter Russian loitering munitions was through the use of electronic warfare.

In terms of Ukraine's enemy, a study by RUSI in Britain found that Russian electronic warfare units downed about 90% of Ukrainian UAVs in March–April 2022. Their greatest success was in jamming the GPS (and apparently also GLONASS) signals and the radio data link of the UAVs. That same study claimed that today, the Ukrainians dominate both the fields of UAVs and electronic warfare systems. The electronic warfare systems that particularly stood out in the Ukrainians' fight against Russian UAVs were:

- **B**ukovel—This system was developed by the Ukrainian company Proximus (see Figure 20). It detects UAVs from distances starting at 1,100 km and jams their communication systems and GNSS-based navigation systems (GPS, GLONASS, Galileo, and Beidou) from ranges of 15–20 km.

**Figure 20**. Bukovel System


*Note*. Source: https://militarnyi.com/

- Anklav—The system was developed by the Ukrainian company Ukrspetstechnika, and it jams the receivers of navigation systems that operate within the GPS and GLONASS frequency bands at ranges of up to 40 km. There is also a smaller version called "Anklav Maliuk" (Maliuk means "small" or "baby" in Ukrainian).

**Figure 21**. Anklav System

*Note*. Source: ust.com.ua

- Nota—The system was developed by the company Tritel (see Figure 22). It can jam all types of cellular networks operating in Ukraine, as well as electronic warfare systems and artillery radars. The system is capable of detecting UAVs at ranges over 20 km and neutralizing them at ranges of up to 15 km. Additionally, it can neutralize cellular communications at ranges of up to 1 km.

**Figure 22.** NOTA System

*Note*. Source: https://defence-blog.com/

- Gekata—An airborne ELINT (Electronic Intelligence) system mounted on a UAV, designed specifically for detecting the radars of air defense systems (see Figure 23). It is capable of detecting targets at ranges of up to 450 km.

**Figure 23**. Gekata System


*Note*. Source: Infozahyst

- Kulbaba—The system protects vehicles against drones operating in the 700–1,010 MHz frequency range (see Figure 24). Its operational range is 150 meters around the protected vehicle

**Figure 24**. Kulbaba System

*Note*. Source: https://revolt.in.ua/

- Parasol—A self-defense electronic warfare system against drones, available in two versions: one for defending fixed positions and one for defending equipment, with ranges of up to 200 meters (see Figure 25).

**Figure 25**. Parasol System

*Note*. Source: https://militarnyi.com/

**What Are the Americans Doing?**

Over the past ten years, the United States has developed a system against loitering munitions called Coyote (see Figure 26). The system is based on a detection radar (available in two versions operating in different frequency ranges) and an interceptor loitering munition. Three generations of the interceptor have been developed: the first and third generations use electric propulsion, while the second generation uses jet propulsion. The target price for each interceptor is $100,000, and the system has an effective range of 15 km. In addition to the United States, Ukraine and the United Arab Emirates have also acquired the Coyote system.

**Figure 26**. Coyote System

*Note*. Source: https://www.rtx.com

**Conclusion**

Without a doubt, loitering munitions present a complex challenge that requires preparation to address. Looking ahead, we are expected to face an even more threatening challenge in the form of swarm attacks composed of dozens or even hundreds of loitering munitions operating simultaneously.

To address this threat, it is necessary to develop and deploy detection and weapon systems specifically designed to identify, track, and destroy loitering munitions. A core requirement for such systems must be the ability to handle large swarms, and not just individual loitering munitions.

Addressing the loitering munitions challenge, several actions are required:

• Improve intelligence capabilities to detect and expose the procurement channels of the loitering munition industries in Iran and Yemen;
• Block those procurement channels;
• Improve intelligence capabilities to locate development and production sites for loitering munitions;
• Strike development, production, and storage facilities of loitering munitions;
• Improve detection systems—optical, radar, and ELINT (electronic intelligence)—especially against low-flying, slow aerial platforms;
• Expand and improve electronic warfare capabilities to target the sensitive components of loitering munition swarms:

- Data link systems for command-and-control;
- Ground-based and satellite cellular communication systems;
- All types of GNSS systems (GPS, GLONASS, Galileo, Beidou).

• Enhance the air defense array against the threat:

- Improve the capabilities of the Iron Dome;

- Consider acquiring an additional, lower-cost interceptor for the Iron Dome;
- Consider acquiring (or developing) dedicated anti-loitering munition systems, such as the American Coyote system, or integrating such capabilities into existing systems (for example, into the Iron Dome);
- Consider acquiring short-range air defense systems (radar guided or electro-optics guided anti-aircraft guns );
- Examine the use of propeller-driven fighter aircraft, such as the Skyraider II, after installing suitable cannons and radars;
- Accelerate the development and operationalization of laser-based air defense systems.

---

Editors of the series: Anat Kurtz, Eldad Shavit and Ela Greenberg