Loitering Munitions

In Focus

In the early history of unmanned aviation, the distinction between a drone and guided missile was not always well defined. The World War One-era Kettering Bug, regarded to be one of the first drones, was designed to deliver an explosive charge by crashing into its targets, more like a rocket than the reconnaissance and strike aircraft that we associate with the word "drone" today. But now an emerging field of unmanned aircraft, called loitering munitions, once again blurs the line between drone and missile.

A loitering munition is a type of unmanned aerial vehicle designed to engage beyond line-of-sight ground targets with an explosive warhead. Loitering munitions are often portable and many are meant to provide ground units such as infantry with a guided precision munition. They are equipped with high resolution electro-optical and infrared cameras that enable the targeter to locate, surveil, and guide the vehicle to the target. A defining characteristic of loitering munitions is the ability to "loiter" in the air for an extended period of time before striking, giving the targeter time to decide when and what to strike.

Early loitering munitions like the Israel Aerospace Industries Harpy, which was unveiled in the early 1990s, were intended to be used against radar installations or mobile missile launchers. Today, many loitering munitions are marketed for infantry use because they offer ground forces greater precision than, for example, a mortar. Unlike other types of drones of equivalent size and weight, a loitering munition is not meant to be recovered after the mission is over. Once armed and airborne, loitering munitions—which are also known as "suicide drones"—are meant to detonate on impact.

A growing number of countries are acquiring their own loitering munitions, which offer a unique set of new capabilities compared to traditional alternatives such as rockets and mortars. This document provides an overview of loitering munitions currently in use or development, and examines some unanswered questions relating to the potential benefits and dangers of the proliferation of this technology.

Note: Not all systems included in this tally are actively deployed. Some systems have yet to find a buyer, while others like the Fire Shadow were the result of military development programs that appear to be no longer active.

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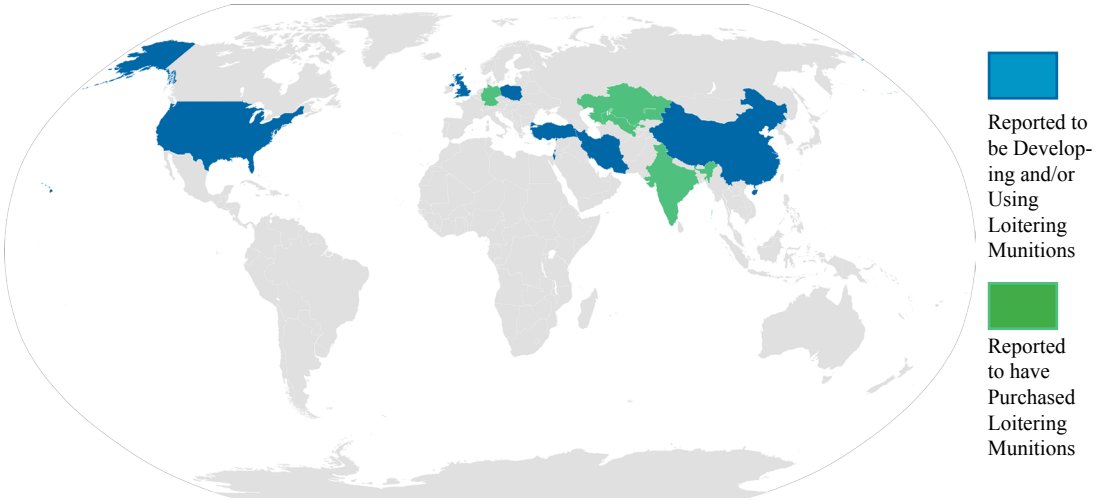
The Center for the Study of the Drone at Bard College is an interdisciplinary research institution that examines the novel and complex opportunities and challenges presented by unmanned systems technologies in both the military and civilian sphere.

Countries with Loitering Munitions



Reported Users

Country	Platform	Country	Platform	Country	Platform
Azerbaijan	Harpy/Harop	Germany	Harpy/Harop	South Korea	Harpy/Harop
Azerbaijan	Orbiter 1K	India	Harpy/Harop	Turkey	Harpy/Harop
China	Harpy/Harop	Israel	Harpy/Harop	USA	Coyote
China	CH-901	Kazakhstan	Harpy/Harop	USA	Switchblade
China	WS-43	South Korea	Devil Killer	Uzbekistan	Harpy/Harop

Date of Introduction

Battlehawk Squad-Level Loitering Munition
Country: USA
Textron Systems

Length	0.45 m	Endurance	0.5 hr
Weight	2.5 kg	Range	5 km
Warhead	40 mm	Introduced	2011

Source

CH-901

Country: China
CASC

Length	1.2 m	Endurance	2 hr
Weight	9.1 kg	Range	15 km
Warhead	2.7 kg	Introduced	2016

Source

Coyote

Country: USA
Raytheon

Length	0.9 m	Endurance	1 hr
Weight	5.9 kg	Range	
Payload	0.9 kg	Introduced	2004

Source

Cutlass

Country: USA
L3 Technologies

Length	0.8 m	Endurance	1 hr
Weight	6.8 kg	Range	56 km
Payload	1.4 kg	Introduced	2009

Source

Devil Killer

Country: South Korea
Korea Aerospace Industries

Length	1.5 m	Endurance	
Weight	25 kg	Range	40 km
Warhead	2 kg	Introduced	2012

Source

Dominator

Country: USA
Boeing

Length	0.8 m	Endurance	
Weight	27 kg	Range	
Payload		Introduced	2006

Source

Fire Shadow

Country: U.K.
MBDA

Length	4 m	Endurance	6 hr
Weight	200 kg	Range	100 km
Payload		Introduced	2007

Source

Green Dragon

Country: Israel
Israel Aerospace Industries

Length	1.7 m	Endurance	1.5 hr
Weight	15 kg	Range	40 km
Warhead	2.5 kg	Introduced	2016

Source

Harop

Country: Israel
Israel Aerospace Industries

Length	2.5 m	Endurance	6 hr
Weight		Range	1000 km
Warhead	23 kg	Introduced	2009

Source

Harpy

Country: Israel
Israel Aerospace Industries

Length	2.1 m	Endurance	2 hr
Weight	135 kg	Range	400 km
Warhead	32 kg	Introduced	1990

Source

Harpy NG

Country: Israel
Israel Aerospace Industries

Length	2.1 m	Endurance	9 hr
Weight	160 kg	Range	
Warhead	15 kg	Introduced	2016

Source

Hero 30

Country: Israel
UVision

Length		Endurance	1 hr
Weight	12.5 kg	Range	40 km
Warhead	3.5 kg	Introduced	2012

Source

Hero 70

Country: Israel
UVision

Length		Endurance	0.75 hr
Weight	7 kg	Range	40 km
Warhead	1.2 kg	Introduced	2015

Source

Hero 120

Country: Israel
UVision

Length		Endurance	1 hr
Weight	12.5	Range	40 km
Warhead	3.5 kg	Introduced	2012

Source

Hero 250

Country: Israel
UVision

Length		Endurance	3 hr
Weight	25 kg	Range	150 km
Warhead	5 kg	Introduced	2015

Source

Hero 400

Country: Israel
UVision

Length		Endurance	4 hr
Weight	40 kg	Range	150 km
Warhead	8 kg	Introduced	2013

Source

Hero 900

Country: Israel
UVision

Length	0.8 m	Endurance	7 hr
Weight	97 kg	Range	250 km
Warhead	20 kg	Introduced	2012

Source

Nemesis

Country: USA
Lockheed Martin

Length	1.2 m	Endurance	
Weight	14 kg	Range	12 km
Warhead	81 mm	Introduced	2011

Source

Orbiter 1K Kingfisher

Country: Israel
Aeronautics Defense

Length	1 m	Endurance	3 hr
Weight	6.5 kg	Range	
Warhead	2 kg	Introduced	2015

Source

Rotem L

Country: Israel
Israel Aerospace Industries

Length		Endurance	0.75 hr
Weight	4.5 kg	Range	10 km
Warhead	1 kg	Introduced	2016

Source

SkyStinger

Country: USA
Innovative Automation

Length	0.5 m	Endurance	
Weight	1.8 kg	Range	
Payload		Introduced	2007

Source

SkyStriker

Country: Israel
Elbit Systems

Length		Endurance	1-2 hr
Weight		Range	
Warhead	5-10 kg	Introduced	2016

Source

Terminator

Country: USA
Lockheed Martin

Length		Endurance	
Weight		Range	
Payload		Introduced	2014

Source

WS-43

Country: China
CASC

Length	3.4 m	Loiter	0.5 hr
Weight	220 kg	Range	60 km
Warhead	20 kg	Introduced	2014

Source

Other Loitering Munitions

Tactical Advanced Recce Strike (TARES)
Rheinmetall Defence Electronics GmbH
2004

Source

Tiger Moth
Lite Machines
2013

Source

Research Initiatives

There is growing concern within the U.S. military that the prominent unmanned aircraft of today—namely the Predator and the Reaper—are not suited for conflicts in contested airspace. These aircraft are slow and unwieldy, making them easy targets for air defenses. As such, the future of unmanned aircraft may be more in the realm of small, attritable drones that can be controlled independently or act autonomously in swarms.

Several U.S. defense programs are developing technologies for large swarms of drones equipped with a range of different payloads that can carry out a variety of missions, including lethal strikes. Some of these programs employ loitering munitions, like the AeroVironment Switchblade or Raytheon Coyote. In the future, drones similar to the loitering munitions featured in this guide could come to dominate the airspace far more than any single drone does today.

Sparrow

Country: Israel
EMIT

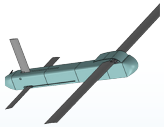
Length	2.4 m	Endurance	0.2 hr
Weight		Range	110 km
Payload	12 kg	Introduced	2003

Source

Unnamed "Suicide Drone"
Country: Iran

Length		Endurance	
Weight		Range	
Payload		Introduced	2016

Source



XQ-06 Fi

Country: Turkey
Karal Defense Technologies

Length		Endurance	0.2 hr
Weight	3.5 kg	Range	
Payload	0.75 kg	Introduced	2016

Source

Gremlins

Defense Advanced Research Projects Agency
Active

This program, initiated in 2016, seeks to develop enabling technologies for swarms of small drones that can be launched and recovered by manned aircraft. The program envisions modular drones that can be equipped with a range of different sensors for surveillance and reconnaissance, as well as warheads for attack missions.

Perdix Project

Strategic Capabilities Office
Active

Unveiled in 2016, the Perdix program is developing air-launched micro-drones that fly in autonomous coordinated swarms. These small aerial vehicles can be programmed to autonomously detect and track objects, and could be armed for strike missions.

Lethal Miniature Aerial Munition System (LMAMS)

U.S. Army
Active

Seeks a small loitering munition, weighing less than 3kg with maximum 0.3kg warhead, an endurance of 15 minutes or more, and a range of 10km or more. The loitering munition must have be effective against both "unprotected" personnel and soft-skinned vehicles, must be able to autonomously track targets in cluttered environments, and can be "waved off" if the operators decide that they no longer want to attack in mid-flight.

Switchblade

Country: USA
AeroVironment

Length	0.6 m	Endurance	0.2 hr
Weight	2.5 kg	Range	5 km
Warhead	40 mm	Introduced	2011

Source

Warmate

Country: Poland
WB Electronics

Length	1.1 m	Endurance	0.5 hr
Weight	4 kg	Range	
Warhead	0.3 kg	Introduced	2015

Source

Other Loitering Munitions

Low Cost Autonomous Attack System (LOCAAS)
Lockheed Martin
1998

Source

Surveiling Miniature Attack Cruise Missile (SMACM)
Lockheed Martin
2004

Source

Low-Cost UAV Swarming Technology (LOCUST)

U.S. Navy
Active

This program is developing systems that enable tube-launched drones to fly in large coordinated swarms. The research effort, which is currently based on the Raytheon Coyote platform, seeks to create swarms of drones that can autonomously conduct a range of missions, including attack operations.

Project Anubis

U.S. Air Force
Completed

This project, initiated in 2008, sought to develop a small loitering munition designed specifically for striking mobile high value individuals. Though it is known that the research phase of the project was completed, no information is available as to whether the system was produced or deployed.

Cluster UAS Smart Munition for Missile Deployment

U.S. Army
Active

A program to develop a "cluster payload" consisting of smart quadcopters that can place explosively formed penetrators (EFP) on targets, including tanks, fuel storage barrels, vehicles, and ammunition depots.The drones would be launched from a mobile missile launcher. They must be able to "identify potential targets" and land on targets without significant operator input.

Opportunities and Potential Benefits

- Use of loitering munitions could enable increased capacity to discriminate between combatants and noncombatants compared to equivalent weapons such as mortars, rockets, and small missiles. The loiter capability of these systems allows users to detect and track potential targets for extended periods of time before a strike.
- Loitering munitions could enable improved precision compared to equivalent weapons. For example, the AeroVironment Switchblade creates a forward-facing blast that makes the detonation more targeted than a grenade, which creates a 360-degree blast. Loitering munitions are steerable, whereas many equivalent munitions are not.
- Loitering munitions may be cheaper than some guided missiles that provide a similar level of precision. The AeroVironment Switchblade, for example, is estimated to cost around $70,000 a piece, roughly two-thirds the cost of the AGM-114 Hellfire, a missile used on several strike drones and gunships.
- Various loitering munition models feature a "wave off" feature that allows operators to cancel an attack in mid-flight and ditch the aircraft harmlessly. Traditional rockets, mortars, and missiles do not have this feature.

Challenges and Potential Concerns

- Some manufacturers of loitering munitions claim that their products can autonomously detect targets. Systems that can potentially carry out lethal actions without requiring "in the loop" or "on the loop" human control raise concerns relating to accountability, laws of armed conflict, and international humanitarian law. This international debate around the use of Lethal Autonomous Weapons Systems is ongoing and remains unresolved.
- Previous failed loitering munitions programs have demonstrated the tension between developing semi-autonomous drones that can operate in denied or contested environments and, at the same time, maintaining a degree of control over that system. The Low Cost Autonomous Attack System (LOCAAS) was a joint DARPA and Air Force program in the 1990's aimed at developing a small, autonomous loitering munition for targeting mobile missile launchers such as the "Scud." The LOCAAS program folded in the early 2000s after the Air Force determined that the lack of human oversight of the weapons was too great a risk. Future programs may encounter similar problems.
- Loitering munitions that identify targets autonomously rely on software, rather than human operators, to make targeting decisions. The field of target identification and tracking software remains developmental, and errors or shortcomings in this software in the battlefield could result in strikes that do not hit intended targets.
- If the potential concerns around the use of advanced, swarming loitering munitions prove to be real, existing counter-drone systems may need to evolve. Current counter-drone systems may not be equipped to deal with sophisticated loitering munitions. Although much of the counter-drone discussion has so far focused on "flying IEDs"—consumer drones modified to carry out lethal strikes—it is clear that more and more countries are developing and fielding loitering munitions, suggesting that the cheap, lethal drone threat will not only originate with non-state actors. Counter-drone systems will need to take into account advanced capabilities that are already appearing in today's loitering munitions such as semi-autonomous and swarming behavior.
- Advanced loitering munitions may not always be cheaper than the alternatives. The MBDA Fire Shadow program ran from the early 2000s to 2013 and cost the U.K. an estimated $300 million. It was intended to be upgraded version of the Israeli Harpy loitering munition, but it was eventually decided that the technology was not mature enough.

Credit: Azerbaijani armed forces Qarabag/ YouTube

Loitering Munitions in Nagarno-Karabakh

Footage published by the Azerbaijani Armed Forces on April 4, 2016 appears to show an Israeli-made Azerbaijani Harop loitering munition flying over Armenian targets in the disputed Nagarno-Karabakh region. In a statement, the Armenian Defence Ministry claimed that the drone attacked a bus filled with pro-Armenian volunteers, killing seven people. A second Azerbaijani drone, also matching the appearance of a Harop loitering munition, was reportedly shot down by pro-Armenian forces in Karabakh on April 7, 2016.

Although unconfirmed, the video and stories point to the potential implications of the rapid proliferation of loitering munitions. In addition to Israel and Azerbaijan, several other countries that have reportedly purchased the Harop and it's older relative the Harpy, including Kazakhstan, Turkey, Uzbekistan, South Korea, China, Germany, and India. A June 2015 press release by Israel Aerospace Industries claimed that "hundreds of HAROP systems have been sold to different customers."

The wreckage of a second Azerbaijani Harpy UAV reportedly shot down in April 2016. Credit: arsahk.zakaryan.98/Facebook

Azerbaijan has acquired several different types of drones from Israel besides the IAI Harop/Harpy. The Azerbaijani defense contractor Azad Systems Co. has an agreement with Israel's Aeronautics Defense to locally manufacture variants of the Orbiter 1K, another loitering munition, and the Aerostar surveillance drone. In September 2016, Azerbaijani President Ilham Aliyev visited the Azad Systems factory in Baku where these drones are assembled. Azerbaijan has also acquired the Israeli BlueBird Aero ThunderB, a reconnaissance drone. Armenian troops captured a ThunderB in Nagorno-Karabakh in early April 2016.