Violent Skies

How lethal drone technology is shaping contemporary warfare

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Colophon
August 2020

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Cover photo: Anatolii Stepanov/AFP

Cover photo: A Ukrainian serviceman fires at a military drone during night combat against Russia-backed separatists on the front line near Novolugansk in the Donetsk region on November 14, 2019.

This report was made possible with financial support from the Open Society Foundations.

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Executive summary

Aerial access has proven to be a decisive component in conducting military operations. From the reconnaissance planes of the First World War to super-high resolution satellite imagery, many aspects of operational planning are dependent on the level of situational awareness and information-gathering. Unsurprisingly, the use of uncrewed aerial vehicles for intelligence, surveillance and reconnaissance (ISR), as well as targeting, have increasingly become an elementary asset in conflicts over the last two decades. Taking the conflicts in Yemen and the Ukraine as an example, this report demonstrates that both state and non-state actors have heavily invested in the use and development of drone and counter-drone technology in recent years. This has led to a steep increase in easily accessible drone technologies and a blurring distinction between the commercial and the military market.

Our analysis on the basis of open-source investigations and public reporting on drone use found that at least **40 different types of drones,** varying from small commercial off-the-shelf type to large military drones, from **12 different countries**. Their use by armed forces and non-state armed groups varied from propaganda purposes and reconnaissance and intelligence collection to support of artillery targeting, to direct drone strikes with military and civilian weaponized drones and explosive-laden kamikaze drones on critical infrastructure. Our analysis points out that the increased use of all types of drones in armed conflicts have significantly boosted **Situational Awareness and Targeting Support**, improved **Payload and Precision** with drone attacks and have provided military actors with novel means for **Force Projection**.

As a consequence of rapid development and proliferation of drones, the current international framework on the regulations and use of drone technology have not been adequate enough to ensure compliance with existing legal principles and human rights standards. The drone dynamics sketched in this report show a highly complex environment in which all actors try to outperform each other, leading to situations where the security of civilians is often compromised. To stop a further escalation of today's drone and counter-drone competition, this report outlines a set of recommendations for States and the United Nations to look ahead and ensure proper policies and norms are put in place that prevent and limit the risk of escalation of drone use and proliferation that could result violation of human rights, international humanitarian law, and endanger regional peace and security.

1. Introduction

The world is witnessing an explosive growth of all kinds of military and civilian drones, that is changing the nature of war, armed conflict and insurgency. While the United States has long held a monopoly on the use and proliferation of uncrewed aerial vehicles (UAVs), this theatre of war is no longer dominated by the iconic Predator and Reaper drones. In places like Libya, referred to as 'the biggest drone war theatre in the world',[1] the use of military drones has been the most appealing means of intervention and resulted in the deployment of Chinese-made Wing Loong drones; Turkish Bayraktar TB2 drones; Russian Orlan-10 drones; UAE Yabhon drones; Iranian Mohajer drones; and Israeli Orbiter drones, as well as smaller commercial hobby drones. Drones are not only used by the states producing them, but also by purchasers like Italy and France. These conflicts in which states deploy various military drones in support of armed groups under murky agreements, results in lack of accountablity on the use of lethal force, while civilians bear the consequences. The summer 2019 drone strikes on Saudi Arabia's oil infrastructure by Iran[2] and Yemen's Houthis[3] further underscored that state and non-state actors around the world are increasingly developing and deploying their own drone and counter-drone technology. The resulting competition has led to the rapid proliferation of drones and their deployment in novel capacities in conflicts around the world.

On multiple levels, drones are shaping military strategies and tactics, including counterinsurgency and counterterrorism operations. Their unique advantages, from sustained loitering to absence of risk to pilots and relatively low costs, have made them very popular. These characteristics make drones ideal for modern battlegrounds, which can take place in areas without proper government control, with examples such Yemen and Pakistan, or involve long-range targeting of civilian infrastructure. Moreover, their tracking and loitering capabilities are increasingly used for improved intelligence collection, targeted killings and long distance precision strikes. The battlefield has expanded beyond traditional boundaries.

This report will explore how these developments have resulted in novel military tactics and strategies in two ongoing conflicts: Yemen and eastern Ukraine. Our analysis shows a rapid increase in drone use from all military actors involved in these conflicts. Moreover, this growth comes with a steep learning curve in deploying both drones and counter-drone measures in military operations. These developments are spurred by booming civilian and military drone markets, while growing expertise on drone development and production facilitates novel uses. The outcomes raise profound questions over the risks and responsibilities in the use and production of drones, as this can directly impact protection of civilians, legal frameworks around the use of lethal force, and regional security.

First, the report outlines the current state of affairs, demonstrating a growing market and changing use of drone technology by all actors, including increased deployment of drones by non-state actors. The report then examines further challenges of drone warfare and the implications for civilian harm, regional security, and military tactics and strategy. To illustrate these developments, the second part analyses two cases, the conflicts in Yemen and Ukraine, demonstrating how lethal drone use has shifted and contributed to reshaping modern warfare. The consequences of those changes will pose new questions and challenges relating to regional power balances, protection of civilians and critical infrastructure, and arms export control.

Rise of the Drones

The multi-billion dollar drone industry has produced an estimated 30,000 drones in current use for military service alone. [4] While the US, Israel and China have the longest track records of developing and exporting military drones, there is a growing list of drone-producing and -exporting states looking for new markets.[5] According to the Bard Center for the Study of the Drone, 79 countries operate 'at least one active drone type' made in the US, Israel or China.[6]

The US and Israel have been at the forefront of developing and using armed drones, but other states have stepped up their efforts. Weaponized drones made in China have appeared on various battlefields and in armed forces across the world, from Sudan to Syria, Venezuela, Myanmar and Turkmenistan,[7] while other countries like Turkey, Pakistan and Iran have started to manufacture their own armed drones. Other upcoming drone producers, such as South Korea and Ukraine, are in the process of developing their own military drones.[8]

Beyond the growth in military drone production, the number of commercial drone companies is growing extensively each year. The US Federal Aviation Administration (FAA) has predicted that total drone production worldwide will increase from 600,000 units annually in 2016 to 4.7 million by 2020.[9] This makes inexpensive commercial off-the-shelf (COTS) drone technologies widely available for both states and non-state armed groups.[10]

U.S. Marine Corps Lance Cpl. Ryan Skinner, assistant patrol leader, with Company Bravo, 1st Battalion, 6th Marine Regiment prepares to fly the Mark-2 Instant Eye during the Infantry Platoon Battle Course as part of a Deployment for Training (DFT) in Fort Pickett, VA., August 15, 2017.

The accelerating use and proliferation of drones has created a number of controversies and legal, ethical and political questions. Though drones offer unprecedented possibilities to wage war from a distance and significantly reduce financial costs and physical risks for militaries, critics have argued that drones also lower the threshold for the use of force and provide a solely military-technical answer to complex social and political problems.[11] Technology can be mistaken for strategy, while questions as to the legal rationale remain unanswered. Can drones legitimately be used for targeted killings of suspected terrorists? Can they be deployed outside recognized areas of armed conflicts? States using armed drones have challenged existing legal frameworks, particularly international humanitarian law and international human rights law, with multiple or even contradicting interpretations. These practices have so far been met with deafening silence by armed drone users, who have regularly failed to provide adequate information to justify the strikes on legal grounds, while defending the lack of transparency under the pretext of 'national security in an age of terrorism.'[12]

Though drones were initially developed to increase intelligence, surveillance and reconnaissance at the end of the 20th century, the September 11, 2001 terrorist attacks spurred newfound interest in arming them. The rapid development of armed drones that followed resulted in a growing number of operations using drones in non-contested airspace by intelligence agencies, particularly clandestine counterterrorism operations against suspected terrorists in Pakistan, Yemen and Somalia. Drones were also used for substantial counterinsurgency operations in Iraq and Afghanistan, as well as for targeted strikes in the Gaza Strip by Israel.

Despite the glorification of drones by the US government as a tool against terrorist groups, the effectiveness of drones as a counterterrorism tool is highly disputed, both by think tanks and human rights organisations active in areas where they are deployed. Analyses by both academics and institutions such as the RAND Corporation have found that drone strikes 'do not appear to meaningfully disrupt and degrade militants' ability to produce propaganda.'[13] The effects of the strikes are often temporary, 'fading to statistical insignificance within six months.' Drone strikes can even be counterproductive; even successful targeted strikes can still result in unfavorable consequences such as growing support for the armed groups and civilian casualties that lower public support for such operations. [14]

An MQ-9 Reaper flies over the Nevada Test and Training Range, Jan. 14, 2020.

International and local human rights groups who operate in the affected areas have come to similar conclusions. In 2013, for example, Amnesty International refuted the US government's claim of conducting surgically precise drone attacks in Pakistan and Yemen based on reliable intelligence. The human rights organization explained that drone strikes had resulted in hundreds of civilian deaths, stating that some of them 'may amount to extrajudicial executions or war crimes.' [15]

In addition to the loss of civilian lives, the uncertainty of why certain strikes took place and the lack of accountability has left affected communities and individuals with 'a sense of indignation and constant anxiety over the next drone strike', according to field interviews from civilians affected by drone strikes in Yemen.[16] These feelings are amplified by the ability of drones to hover over communities for a long time. Findings based on fieldwork in Yemen show that the constant presence of drones has resulted in 'an overwhelming majority of adult respondents (…) suffering from numerous drone-inflicted symptoms of PTSD, which are even more prevalent amongst children.' [17]

Anger over the death and destruction caused by drone strikes has resulted in severe blowback against counterrorism operations conducted by the US, who often operate in secret agreement with local authorities.[18] Armed groups on the receiving end, meanwhile, have begun to adapt, not only with new evasive techniques but by adopting similar drone technologies in their own operations.[19]

Adapting Strategies

The alarming number of novel applications and lethal incidents with drone use are turning into structural patterns, which signifies a dark omen of drones in future warfare. Over the last three decades, various armed groups, from Aum Shinrikyo's attempts to use drones with nerve gas in Japan to Hezbollah's growing drone inventory in Lebanon used for cross-border operations against Israel, have explored the potential uses of armed drone technology. While early attempts by Hezbollah and Hamas largely utilized Iranian drones and commercial off-the-shelf systems, the rise of the so-called Islamic State (IS) revolutionized non-state armed groups' (NSAGs) drone capabilities.[20] Initially, IS used drones for propaganda purposes to film their operations and scout enemy positions, but soon switched to IED-equipped drones and later drones with small ammunitions dropped with makeshift systems. They established the "Unmanned Aircraft of the Mujahideen" unit in the beginning of 2017. This separate drone unit traffics in commercial drone technology and equips drones like the Chinese DJI quadcopter with kinetic payloads such as small bomblets, as well as using them as flying boobytraps.[21]

The pace of technological development, combined with the expanding global tech market and internet economies which make the same technologies easily accessible, has led to the present blurred distinction between military and civilian drones. Easy-to-build and/or -acquire platforms combined with a range of payloads, ranging from lethal and less-lethal weaponry to sophisticated camera and sensor systems, as well as 3D-printed bomb-kits, enabled non-state drone warfare to proliferate on the battlefield.

Other non-state groups have received critical components from state allies that have enabled them to assemble increasingly sophisticated domestic drones. The Qasef-1 drone, for instance, is commonly deployed by Houthi rebels in Yemen and is suspected to be manufactured with material

sourced from Iran and China, owing to its strong similarities with the Iranian Ababil-2/T, and use of the Chinese Skywalker 8-X drones.[22] This form of 'proxy' drone warfare is not unique. Other cases include the Kurdish Peshmerga's use of US-made drones in the battle for Mosul; the Iraqi police using commercial UAVs equipped with bomblets; the Iranian-made drones operated by Hamas; the use of Russian-made drones by the Donetsk People's Republic in the Ukraine; and drones used by Libyan general Khalifa Haftar, in his UAE/Saudi/Egypt-backed fight against the Turkey/Qatar-supported Government of National Accord.

The developments of the last decade have also led to a 'counter-drone dynamic,' in which states no longer have a monopoly on drone use, but are instead forced to respond to the possible threat of drone attacks by non-state actors. In addition to sponsoring non-state actors, many states are investing heavily in the development of counter-drone technology. Examples include radar-based detection systems, such as the United Kingdom's Obsidian system;[26] anti-drone laser guns, like the American Compact Laser Weapon Systems (CLWSs) or the British Dragonfire;[27] electronic countermeasures, such as the Russian-made Avtobaza 'jammer' that can disrupt the radio connection between a UAV and its operator;[28] and the drone interceptors, such as the the Australian DroneShield[29] or the Turkish iHTAR.[30] The size of the counter-drone market is estimated to reach $4.5 billion by 2026.[31] The Center for the Study of the Drone at Bard College (who released an extensive study on counter-drone technology in 2019) predicts that these systems 'will become ubiquitous in all future conflicts.'[32]

Sadly, civilians both inside and outside conflict zones continue to suffer the consequences of military drone usage. The implications for civilians of the competitive drone dynamics between adversaries are profound due to the lowering threshold of the use of lethal force and expansion of areas where they will be deployed against a wide range of targets, including critical infrastructure and populated areas, and will only intensify as long as international rules and regulations on the use and proliferation of unmanned aerial vehicles remain outmoded and inadequate. The advances in drone technology and availability warrant new approaches for constraining and controlling them. Even more important is the strengthening of norms on the use of lethal force to push back against attempts to undermine existing legal principles that guide military actions, a practice that is currently widespread.

2. International rules and regulations

Following the initial emergence of drone technology in the 1990s, no specific multilateral mechanisms came into place to regulate the sale, transfer, or use of drones. Preexisting arms control regimes nevertheless set some guidelines. One such agreement is the **Missile Technology Control Regime** (MTCR), established in 1987 with the aim to prevent or limit the proliferation of delivery vehicles that could carry chemical, biological, or nuclear weapons, as well as the technology, software or services that could be used for missile production. The MTCR puts UAVs in two categories: Category I, 'complete unmanned aerial vehicle systems (including cruise missiles, target drones and reconnaissance drones) capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km', as this was estimated as the minimum capability a missile with a nuclear payload will need. Smaller drones also are covered under Category II but with less restrictions to export them. Due to its voluntary character, however, the MTCR does not impose any legally binding restrictions on its 35 member countries.[33] There are ongoing attempts by the US to change armed drones from Category I to Category II, making it easier to export more drones.[34]

In 1996, the **Wassenaar Arrangement** was established to promote transparency and greater responsibility in the transfers of arms and dual-use technologies.[35] States adhering to the agreement promised 'to ensure that transfers of arms and dual-use goods and technologies do not contribute to the development or enhancement of military capabilities that undermine international and regional security and stability and are not diverted to support such capabilities.'[36] Using the same control lists agreed under the Wassenaar Arrangement and building on policy initiatives from the 1990s, the **EU Common Position on Arms Exports** was established in 2008 and obliges all EU member states to regulate the export of military goods, including drones. As part of their export licence assessment, the Common Position obliges EU members to take the behaviour of importing states into account.[37] Separately, the EU's dual-use regulations set out a control mechanism for dual-use goods, including certain technologies for uncrewed systems, be it for air, land or water use, as defined through the Wassenaar Arrangement's list of dual-use goods.[38]

The **Arms Trade Treaty** (ATT), adopted in 2013, was the first international treaty to set legally binding standards aimed at increasing transparency and accountability in the global trade in conventional weapons. Though drones are not explicitly referenced in the treaty text, they are covered under one of the eight weapon categories captured in the treaty's scope, as it refers to the UN Registry of

Conventional Arms definition, namely 'combat aircraft and unmanned combat aerial vehicles (UCAV).'[39] Nonetheless, the effectiveness of all the above-mentioned agreements is complicated by the fact that they all highlight different aspects and often only implicitly include the transfer or use of drones. As outlined by the Stimson Centre, this can result in confusion over which regulation to apply when, for both importing and exporting states.[40]

It is worth noting, however, that key drone manufacturers and exporters are not active participants in several of these agreements. For example, China only recently signed the ATT[41] but has not acceded to it yet, and questions remain on its commitment,[42] considering its track record of arms sales to brutal regimes. The US has signed but not ratified the ATT, and China and Israel are not part of the MTCR, although Israel holds observer status.

Recognizing, at least to some extent, that drones present unique challenges when it comes to the transfer and use of conventional weapons, the Obama administration established a national policy on the use and proliferation of drones in February 2015 through a presidential memorandum.[43] This included boundaries on how recipient states of American drones were permitted to use them (only in accordance with international law, including IHL and IHRL). A year later, the US together with 53 states released a Joint Declaration on the export and subsequent use of armed drones -- which echoed the 2015 U.S. drone export policy. Those who signed the the document stated that they recognized that armed drones could be misused and fuel conflicts, instability and terrorism, and aimed to promote "responsible export and subsequent use" of armed drones.[44]

Ironically, the declaration that sought to increase transparency has been criticized by civil society for not being a transparent and inclusive process. Moreover, the declaration contains ambiguous, weak, and non-binding language that 'risks setting standards that are too low, and will not adequately address the full range of risks and harm associated with the use of drones', according to a joint statement released by eighteen organizations (including PAX).[45]

Despite these and other concerns, the Trump administration maintained US efforts initiated by the Joint Declaration process and even revised the United States' drone export policy in 2018, effectively loosening the previously set domestic regulations on drone exports. Reports indicate that the US drone export policy was revised in response to Chinese and Israeli drone manufacturers, who can sell their technologies with less restrictions. [46]

Since then, the US, together with a small group of countries -- including the United Kingdom, the Netherlands, Germany, Italy, and Japan -- have worked to develop the '**International Standards for Export & Subsequent Use of Armed Unmanned Aerial Vehicles'**, a political declaration that at the time of writing has not been published, yet has been discussed at various public meetings by officials since 2017, and during parliamentary debate in the Netherlands in 2019.[47]

Even though the US itself appears to operate outside their previously set parameters on export regulations, they have concerns over the risks of armed drones in the hands of non-state actors. Together with Germany, the US led an initiative to counter unmanned aerial threats. **The Berlin Memorandum on Good Practices for Countering Terrorist Use of Unmanned Aerial Systems (UAS)** identifies 26 practices that intend to inform and guide states, multilateral organizations, private industry and law enforcement agencies 'in identifying, developing, and refining policies, practices, guidelines, regulations, programs, and approaches for countering the terrorist use of UAS.'[48] This

memorandum too is non-binding and does not address the core issue: the lack of strong regulations that could have prevented the rapid spread and use of drones that we see now.

An inclusive international response is therefore necessary to effectively restructure and improve the current framework that has thus far failed to guide the rapidly changing norms of military drone use through sound legal, ethical and military guidelines on the use of lethal force. The urgency of this issue becomes clear when examining the two case studies of Yemen and eastern Ukraine.

Parade of Iranian Saeqeh drones, May 2019

3. Conflict case-studies: Yemen and Ukraine

To understand what the expanding deployment of drones by both state and non-state actors holds for future conflicts, we will look at the current pattern of use and how groups adapted their operations and tactics to available drone technologies. Taking into account technological developments, we try to understand the future challenges of drone warfare and define the necessary boundaries in the expanding use of remote-controlled violence. For this paper, we analyzed the dynamics of drone use in Yemen and Ukraine, as these two countries have seen unique patterns of drone use and counter-drone measures that can teach us valuable lessons about the adaptation of drone technology and the driving forces behind those developments.

Methodology

To understand the scale and use of drones in both case studies, open-source information was collected through credible social and regular media sources containing information on the different uses and sightings of drones by all actors deploying military force in Yemen since 2002 and in Ukraine since 2014. For this research we utilized a classification of drones based on weight and endurance, ranging from class I to III used by NATO.

Class I: uncrewed aerial vehicles with a maximum takeoff weight (MTW) less than 150 kilograms. Typically, these drones are deployed for reconnaissance and surveillance purposes and often have a maximum endurance of three hours and 80 kilometers range. Examples are the Hermes 90, Raven, and the Black Widow.

Class II: also mostly unarmed but do have the capacity to carry lightweight missiles and are referred to by NATO as the tactical category. The MTW is between 150 and 600 kilograms, with an endurance of approximately 10 hours with a range between 100 and 200 kilometers. Examples are the Sperwer, Hermes 450, and the Ranger.

Class III: the third class refers to UAVs that are often defined as Medium-Altitude Long-Endurance (MALE) or High-Altitude Long-Endurance (HALE) drones. They can carry an additional payload of more than 600 kilograms, including extra sensors, fuel tanks or a variety of weapons, have an endurance of 24 hours or more, and are able to cover 300 kilometers per hour. Examples are the Global Hawk, the Predator A and B, and the Heron/TP.

NATO UAS CLASSIFICATION

Class	Category	Normal Employment	Normal Operating Atitude	Normal Mission Radius	Primary Supported Commander	Example Platform
Class III (> 600kg)	Strike/ Combat *	Strategic/ National	Up to 65,000ft MSL	Unlimited (BLOS)	Theatre	Rasper
	HALE	Strategic/ National	Up to 65,000ft MSL	Unlimited (BLOS)	Theatre	Global Hawk
	MALE	Operational/ Theatre	Up to 45,000ft MSL	Unlimited (BLOS)	JTF	Heron
Class II (150-600kg)	Tactical	Tactical Formation	Up to 18,000ft AGL	200km (LOS)	Division, Brigade	Watchkeeper
Class I (< 150kg)	Small (>15kg)	Tactical Unit	Up to 5,000ft AGL	80km (LOS)	Battalion, Regiment	Scan Eagle
	Mini (<15kg)	Tactical Sub-unit (manual or hand launch)	Up to 3,000ft AGL	Up to 25km (LOS)	Company, Platoon, Squad	Skylark
	Micro ** (<66J)	Tactical Sub-unit (manual or hand launch)	Up to 200ft AGL	Up to 5km (LOS)	Platoon, Squad	Black Widow

NATO Classification from STANAG 4670

The fact that our database, included as an annex, is based on open source material means that only part of reality on the ground is reflected in this report. Nonetheless, the publicly available data gives valuable insights in the situation in the ground, how armed forces and non-state armed groups operate and what role drones play in their operations.

Yemen

Yemen is the birthplace of clandestine drone killings, as the first-ever drone strike outside a recognized armed conflict took place in Yemen on November 3, 2002, when six suspected al-Qaeda members travelling by car were struck by a missile fired from a CIA-operated MQ-1 Predator.[50] The continued presence and use of US drones over Yemen, flying mostly from US bases in Djibouti, have had a profound impact on local populations, who say they fear the 'death machines' referring to the drones flying overhead, that can strike at any time. Faced with US drones tracking and targeting their movements, al-Qaeda soon learned to adapt to US drone surveillance and disseminated instructions on how to avoid detection by US drones in Yemen, while these instructions were also distributed to al-Qaeda groups in Mali. These kinds of adaptive techniques, which also include camouflage and

materials to cloak body heat signatures, will likely develop and improve in the future. They also put civilians at risk - armed groups often move operations into civilian areas, or use civilian infrastructure as a shield to protect themselves from being targeted.

A new era of drone warfare emerged with the Houthis rising to power, taking over the northwestern parts of the country, and expelling the government of President Abdrabbuh Mansour Hadi from the capital Sanaa in 2014. The Hadi government requested support from Saudi Arabia, and a new coalition of nine countries (supported by the US and UK with weapons, intelligence and logistics) intervened militarily against the Houthis in 2015. This intervention proved to be a testing ground for all types of drones in various operations.

Satellite image showing five MQ-9 Reaper drones at the Chabelly Airfield, the CIA drone base in Djibouti, June 2020

The following is an overview organized by actor, type of drone operation, and drones deployed.

United States (2002-today)

The United States has been deploying its three primary models of armed drones over Yemen since 2002: the MQ-1 Predator, the MQ-1C Grey Eagle and the MQ-9 Reaper. From the first drone strike in 2002 until August 2019, at least 329 confirmed drone strikes have been conducted, resulting in an estimated range of 174-225 civilians killed and many more wounded according to the Bureau of Investigative Journalism (an independent organization that tracks US drones strikes).[54] Researchers from the New America Foundation have found a slightly lower number of confirmed strikes (roughly 280), due to a different methodology. They also report a high number of civilian casualties, between 115 and 149 deaths.[55] Also, there are confirmed reports, satellite images and video footage from US drones downed by Houthi fighters, with likely support of Iranian expertise using surface-to-air-missiles, or mechanical failures.

The US drone fleet operating in Yemen is based in Djibouti, initially flying from Camp Lemonnier and later moved to Chabelley Airfield. The drones are flown by both the CIA and the Joint Special

Operations Command. While the latter falls under the direct responsibility of the Pentagon and thus needs to be more transparent over their military operations, the CIA operates with less oversight from Congress due to the clandestine nature of their work, posing a challenge to effective oversight and accountability. US drones remain operational over Yemen today, continuing to strike suspected al-Qaeda and IS targets, as asserted by Yemeni human rights groups in 2019.[56] Aside form direct attacks, US drones are said to be supporting the Saudi-led coalition by providing intelligence on Houthi operations.[57] Yemen has proven to be a key training ground for US drone warfare, utilizing new means of tracing, tracking, surveilling and targeting suspected militants.

A Yemeni walks past graffiti protesting a US forces alleged raid against al-Qaeda's Yemen branch, in Sana'a, Yemen, 23 May 2017.

Houthi rebels (2014-2019)

Following their capture of Sanaa in 2014, the Houthis managed to quickly grasp the potential of drones in their operations, boosting their intelligence, surveillance and reconnaissance (ISR) abilities and slowly developing substantial capabilities that have proven to pose a significant threat on the battlefield and beyond. We have identified eight different drone types actively used by the armed group. Houthi drones have targeted Saudi military bases, water infrastructure and oil facilities. Most of these drones have been intercepted, but a hit to the water filtration plants or large oil refineries could have serious ramifications for access to clean water, or cause a local environmental catastrophe.[58] Other drones are claimed to be used against airports in the United Arab Emirates.[59] The Houthis initially claimed the September 2019 drone and missile strike against Saudi Arabia's largest oil processing facilities in Khurais and Abqaiq, but this later was confirmed to be an operation carried out by Iran.[60]

Various drones and long-range missiles presented by the Houthis at a press event, July 7, 2019

The first recorded use of drones by the Houthis was in 2015, using a commercial DJI Phantom quadcopter for intelligence collection. In the year that followed, more open source reporting indicated a variety of commercial drones used by the group for scouting enemy positions and propaganda purposes, as the footage was used in promotional videos by the group. The Houthis seem to have drawn from similar tactics applied by the Islamic State, which significantly stepped up the use of commercial drones in their operations from 2014 onwards and proved the utility of access and use of commercial drone technology. Chinese commercial drones such as the Skywalker X8 are frequently seen in online footage and social media postings from Yemen, and have been rebranded as 'Rased' models by the Houthis, mainly being used for ISR missions. In 2019, there were also reports that commercial drones were used by the Houthis for scouting and guiding ballistic missile strikes against various targets in Yemen, particulary against Saudi supported forces in Marib province. Though unconfirmed, this seems to be a plausible application of drones for targeting purposes to amplify military effectiveness.

Soon new types of more sophisticated drones were deployed by the Houthis. The designs were clear copies of various types of Iranian drones, indicating state support from Iran in improving Houthi drone capabilities. The Iranian Ababil-T drone design was exported to Yemen and renamed by the Houthis as Qasef-1, and frequently used for strikes, as was its upgraded version (Qasef-2k) that proved particularly deadly as they were used in strikes against military bases but also individuals.[63] These drones have a range of 100-150km and have a 30-45kg explosive payload. While materials for construction of the Qasef-1, such as the platform itself and the technology to make it fly, were likely smuggled in from Iran, experts assert that the Qasef-2k is produced domestically in drone workshops.[64]

The Yemeni Armed Forces, a Saudi and UAE-backed armed group, claimed to have shot down an Houthi Skywalker X-8, also known as 'Rased' drone, March 27, 2019.

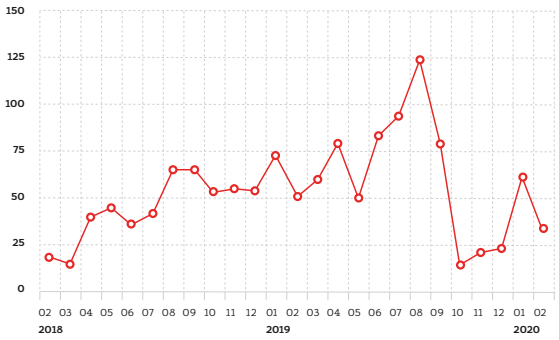
The Houthis have also developed (with the likely aid of Iranian engineers) long-range 'suicide drones', with a 1500km range and a 16kg explosive payload, able to strike targets deep in Saudi Arabia and the UAE. Known as the UAV-X or Samad type drone,[65] over the last two years the Houthis have used these drones for attacks on military commanders [66] and parades, [67] military and civilian airports, anti-aircraft systems, air defence radars and oil refineries. [68] According to the Saudi military, over 258 Houthi drones

have been intercepted by Saudi air defences in this period.[69] Military experts from Osprey Flight Solutions, who monitor air strike incidents, have stated that since 2015, 450 surface-to-surface missiles (SSMs) and suicide drones have been fired by the Houthis, with 160 intercepted by Saudi Arabia, and 100 of these interceptions taking place inside Saudi Arabia itself. These numbers were not divided by type of weapons, so it is not clear how many of those 450 objects were drones and SSMs.[70] A disclaimer should be made that these media reports are not verified events, though a substantial increase in reported events provided already a clear indication of an trend.

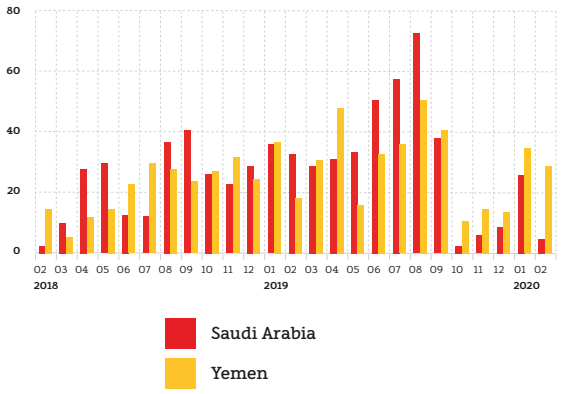
The data, based on monitoring of reported events in various media, shows a steep rise in the use of drones and SSMs in 2018 and 2019, particularly against targets such as airports and oil refineries. This enabled the Houthis to use their drone capability as force projection, and force the Saudi/UAE Coalition to readjust its defences. This, combined with a small number of successful shoot-downs of both jet fighters and drones flown by both the Saudi-led coalition and US,[71] underscores the emerging capabilities by non-state armed groups such as the Houthis, albeit with likely state sponsorship, to develop and actively deploy drone technology in all their operations, significantly boosting their military capabilities.

Osprey Flight Solutions Data

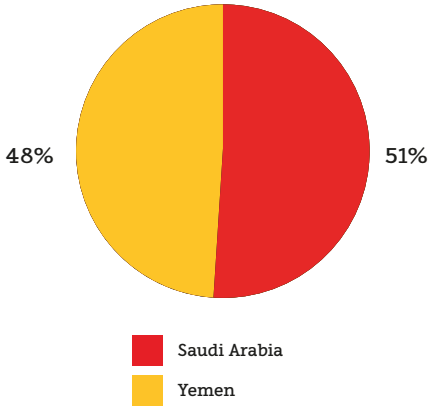
Total Pings



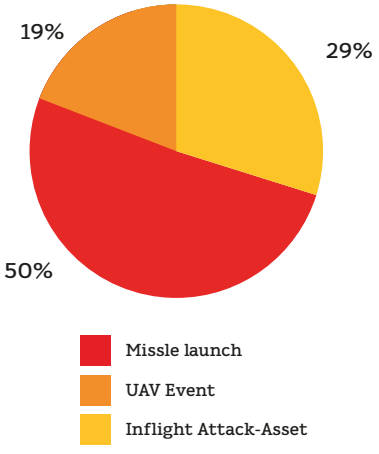
Total Pings by Country



Pings by Country



Pings by Type



Ping: *Reported event in media*
In Flight Attack Asset: *An aircraft, drone, helicopter or missile being engaged/shot down*
GPS Jamming: *Application of Electronic Warfare means*

Saudi-UAE-led Coalition (2015-today)

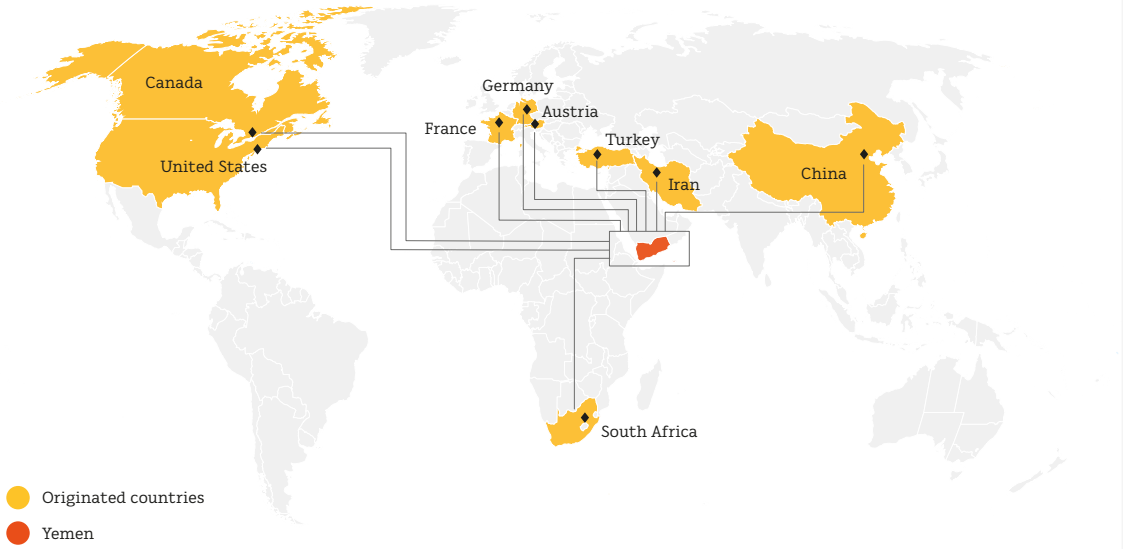
The Saudi/UAE-led coalition intervention against the Houthis witnessed a growth in UAV use over Yemen. Visual evidence collected by our researchers has confirmed 10 different types of drones used by the coalition in Yemen, sourced from Austria, Germany, China, the US, Canada, Turkey and South Africa.

Houthi fighters next to a crashed Wing Loong II drone, Yemen, November 2019

Coalition use of drones in Yemen has been primarily for ISR purposes, while Class III drones are instrumental for target designation in airstrikes by crewed aircraft. The UAE's Predator X is unarmed, while the Wing Loong II and CH-4 drones operated by the UAE and Saudi Arabia carry smaller types of missiles. Based on the number of reported airstrikes and heavy munitions use, the strikes indicated the jet fighters are responsible for the majority of the reported attacks in Yemen and the drones play an ISTAR role. Saudi Arabia and the UAE are the largest users of drones in the ongoing conflict, and the UAE has deployed its Chinese-origin Wing Loong II drones for targeted killings of Houthi leaders.[72] Smaller drones from Germany, Austria and South Africa have been visually identified, either shot down or crashed. Most open source reports of crashed Class I and II drones appeared in the early onset of this conflict in 2015. This could indicate that the coalition deployed drones available in their stockpiles at that moment, before later acquiring more capable Class III drones with increased payload and endurance such as the CH-4, the Wing Loong II and Predator XP. These proved vulnerable to counter-drone measures, however, as the Houthis, with likely expertise and materials from Iran, managed to use missiles from the former government's military stockpiles against Class III drones, resulting in the shooting down of various Reapers and Wing Loongs that were targeted with ground-to-air missiles.[73] This showed serious limitations on armed drone use over Yemen and could make a difference for future deployment of Class III drones if non-state armed groups have access to materials and expertise on surface-to-air defence systems.

In total, **22 different drone types** from **nine different countries** are in use by at least **six different actors** that have been deployed throughout the last 18 years in Yemen. A total overview of the type of drones and countries of origin can be found in the Annex.

Origin drones and drone technology



Actors

- Saudi Arabia
- United Arab Emirates
- Houthi rebels
- Yemenite government
- United States
- Iran
- Turkey

Drone types

- Commercial drones
- Loitering munitions
- DIY military grade drones
- Military armed drones
- Long endurance drones

Yemen: drone warfare testing ground

Yemen has showcased how drones have shaped the use of lethal force with remote violence. From targeted killings by the US MQ-1 Predator in 2002, drone usage in the country has expanded to large-scale kamikaze drone attacks by Houthi forces against Saudi and Emirati critical infrastructure. Both states and non-state actors have honed their strategies around the use of drones, especially in the past five years of the Yemen conflict. Aerial surveillance of individuals, troop movements and military sites has expanded to targeting with lethal force, either directly from drones themselves or using the reconnaissance they provide. Drones have reshaped aerial defenses and military movements, and contributed to putting pressure on the Saudi/UAE-led coalition due to force projection. Yemen also became a testbed by all warring parties for both military and civilian drones, based on the

various types that have been found on the battlefields. The abundance of drone use, from short-range tactical ISR drones to long-range armed drones, demonstrates the perceived need by armed actors to have direct access to ISR info with small commercial drones, while on a larger level, the ability to hit distant targets with lethal payloads has proved to be effective in terms of force projection.

Ukraine

The 2014 Maidan revolution provided an opportunity for Russia-backed separatists to take over a large part of eastern Ukraine, the start of a conflict which continues today. The ill-equipped Ukrainian armed forces, supported by volunteers, fought against the Donbas separatists, who received direct military assistance from Russia's armed forces, including both weapons and military personnel that joined the separatists on the battlefield. With this support, the separatists managed to capture a large part of the Donbas by mid-2014, but fierce resistance by the Ukrainian army and volunteer brigades created a stalemate. Internationally mediated negotiations resulted in a ceasefire agreement, the Minsk Protocol, which collapsed under repeated fighting and renewed offensives in January 2015. This led to another round of negotiations and the Minsk II protocol in February 2015. Daily exchanges of fire and sporadic fights continue, however, and since the beginning of the conflict in 2014, thousands of civilians killed[74] and many more wounded, alongside damage to critical civilian infrastructure and environmental problems resulting from the targeting of industrial areas.[75] The Organisation for Cooperation and Security in Europe (OSCE) has acted as a monitor for the ceasefire since the first Minsk Protocol in 2014.

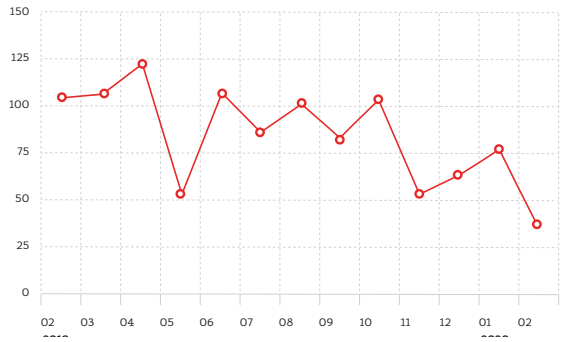
Drones and counter-drone measures have become common military tools in the Donbas. Particularly on the Ukrainian side, do-it-yourself (DIY) drone builders laid the foundation for ISR operations in the absence of military drones, while the Russian-backed separatists used commercial drones to carry out attacks on munitions depots, as well as using jamming and electronic warfare systems to disrupt both Ukrainian and OSCE monitoring drones.

A Ukrainian commander launches a drone into the air

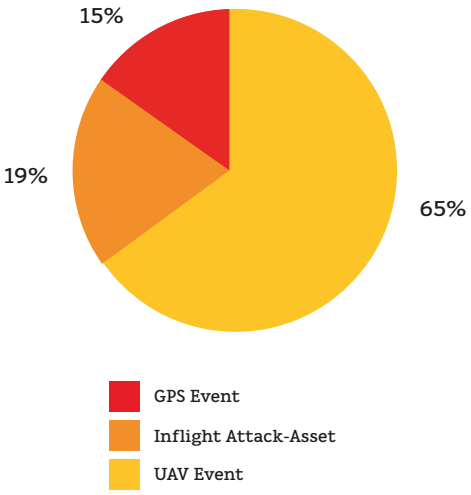
Open source data collection shows the frequency of drone-related events, as in the period 2014-2019, 468 incidents were reported in news articles about the Donbas, as shown in analysis from Osprey Flight Solutions below.

Osprey Flight Solutions Data

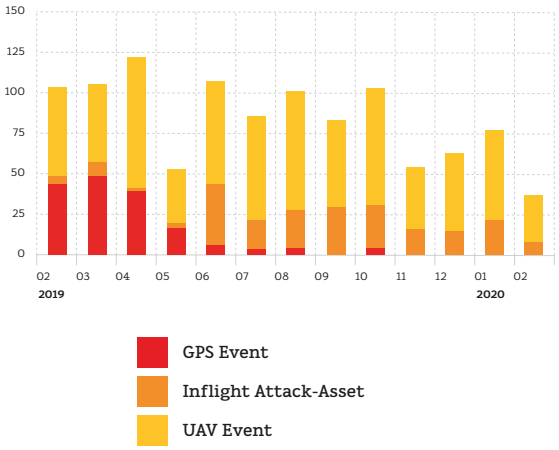
Total Pings



Pings by Type



Total Pings by Ping type



Ping: *Reported event in media*

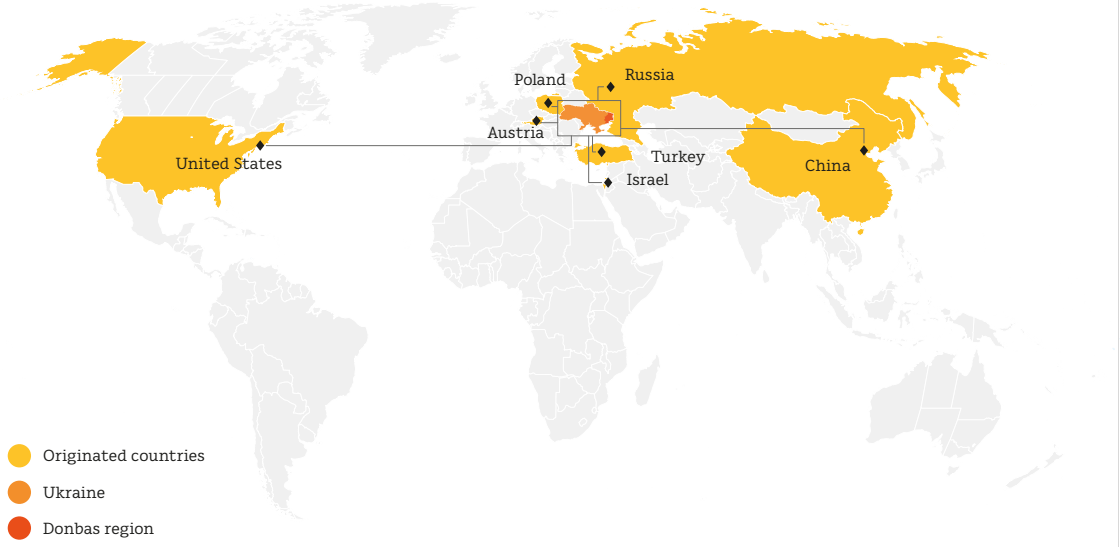
In Flight Attack Asset: *An aircraft, drone, helicopter or missile being engaged/shot down*

GPS Jamming: *Application of Electronic Warfare means*

This proliferation serves as an indicator of the increasing importance of drone usage on the battlefield. The evolving dynamics of drone warfare in Donbas also demonstrate the potential of commercial drone technology. Parts, components and inventive application of other materials e.g. composite materials and 3D printed munitions, all contributed to novel insights in tactics, and strategies for deploying them, but also how to counter both drones and drone units. The following section provides an overview of the types and usage of drones in Donbas. Though there are no clear numbers of how many drones exactly have been deployed, nor how frequently, by all the warring parties, the following section functions as an indicator of the intensity of drone use by identifying the models and origins.

Open source research undertaken for this report identified **23 different models** of drones produced in **eight countries** that are operated by at least **six actors** in eastern Ukraine. The total number of drone types is likely higher, considering the diverse types developed domestically by the Ukrainian defence industry, that, as referenced earlier, is stated to have developed over 30 different types.

Origin drones and drone technology



Actors

- Ukrainian militias
- Ukrainian government
- Ukrainian seperatists
- Russia
- OSCE
- United States

Drone types

- Commercial drones
- Loitering munitions
- DIY military grade drones
- Military armed drones
- Long endurance drones

Ukrainian armed forces and pro-government paramilitary groups (2014-today)

At the conflict's start, the only drones available to the Ukrainian army were a handful of old and slow Soviet-era Tupolev T-141/143 reconnaissance drones, of which several crashed or were shot down.[77] This initial lack of resources resulted in the Ukrainian armed forces and paramilitary volunteer groups relying largely on commercial drones,[78] as there were financial and import restrictions on acquiring military drones, before developing the capability to produce the domestically developed PD-1 fixed-wing UAV in 2016 and more recently the AS-1 Furia tactical UAV. These drones can host ISR equipment, such as night vision systems and laser designation systems, and are mostly used for scouting enemy positions, movements and target acquisition. Other novel uses include deploying the domestically produced Sparrow LE drones to drop leaflets on Ukrainian Independence Day over separatist-controlled territory in 2016. According to a 2017 overview made public by the Ukrainian defense industry UkroBoronProm, they offer 24 military-use drone models with 15 more models under development,[79] a number that is likely higher today.

The initial drivers of Ukraine's drone development were the DIY drone builders, volunteers and engineers who modified both commercial drones such as the Chinese DJI Phantom II and the Skywalker X-8 with additional cameras for ISR purposes as well as designing and engineering their own drones. This grew into a booming domestic drone industry, with companies designing and producing various types of fixed-wing and rotary drones in order to meet the needs of the Ukrainian armed forces and the paramilitary volunteer brigades in the field and they have been actively using those, according to public reports. [80] [81] The Ukrainian Ministry of Defence has claimed that 30 different types of drones are used by Ukraine's armed forces, corresponding with the Ukroboronprom numbers provided earlier.[82]

Ukrainian policemen, who will serve at the eastern Ukrainian war zone, practice with a drone during their training near Mariupol, Ukraine, 03 July 2016.

Armed drones have not yet been deployed, though Ukroboronprom did in 2016 reveal the BK-1 Horlytsia drone, which is capable of carrying missiles.[83] Ukraine obtained Turkish Bayraktar TB-2 armed drones in 2019, but these have not seen action. In 2015, the Ministry of Defence bought an undisclosed number of Polish Warmates, a loitering munition (better known as a suicide drone). [84] Similar types of drones include the Yatagan-2, an indigenous suicide drone developed by a consortium of Ukrainian manufactors in 2016, but no use of them has ever been reported, [85] and there are current trials with the RAM UAV [86] and the Hrim (Thunder) kamikaze drone. [87] The US has also donated $12 million worth of RQ-11B Raven Class I ISR drones, but they prove to be highly vulnerable to jamming and interception of video feeds, due to the use of analog control in the older models donated by the US. As a result, they were removed from service in 2016 and the army began looking for less vulnerable systems.[88]

Russian-Backed Separatists (2014-today)

With support from Russia, the separatists managed to rapidly collect intelligence on Ukranian military troop movements and positions as Russia had available functional drone capacity, both from domestically produced drones as well as Israeli ones. They had access to Granat-type drones falling in the CLASS I category, which are small drones used for ISR purposes. They are domestically produced in Russia and the Granat-1, 2 and 4 models were all identified to be used in the Donbas, as well the Russian Orlan-10, a Class I drone. The Russian Forpost, a Category II drone, was also spotted and shot down, and this drone is based on the Israeli IAI Searcher, an old UAV model built in the 1980s for ISR purposes and later exported to Russia. These types of drones are likely to be operated by Russian forces, as this requires training and expertise. Russian Tachion UAVs (small ISR drones) were also found to be used and even though domestically produced in Russia, these drones relied on technology imported from all over the world, with parts and components coming from Japan, Sweden, Germany, China and Israel.[89] In sum, open source information indicates that the military grade drones are likely operated by Russian forces supporting the separatists, considering the level of training and expertise needed.

Commercial drones such as the DJI Phantom have also been used by the separatists, for both scouting enemy positions and in attacks with commercial drones equipped with small 3D printed grenades and regular fragmentation grenades. According to an Army spokesperson, these attacks can take place up to three times a day. The scale of separatist drone use was underscored by a comment from a Ukrainian military attache in 2019 stating that on some occasions 10 drones are launched per day from the separatist side, and in 2018 alone, 741 separatist drone flights were reported across the frontline.[93]

Beyond the direct support given with drones, Russia is also involved in active drone countermeasures through electronic warfare means. Specialised units using cellular and satellite communication systems have been deployed along the frontlines, blocking both drone flights from the Ukrainian armed forces and from the OSCE, the latter of which has frequently protested against this practice.[94] Russian electronic warfare specialists also monitor and trace the signals from Ukrainian drones to locate their operators. This has resulted in some reported incidents of Ukrainian soldiers being killed by strikes against drone operators. [95] Spoofing (i.e. disguising a communication from an unknown source as being from a known, trusted source), jamming and hacking by taking over controls, particularly of the civilian type of drones with little or no encryption and vulnerable software systems has occurred frequently. [96] This adds another relevant dynamic to drone warfare, as states and non-state actors should consider adapting their strategies to an opponent with more airborne means such as drones to trace, track and target; while at the same time, those means can be used to retrace units deploying drones.

OSCE and the United States

Both the OSCE and the US have been monitoring ongoing developments in the Donbas with drones. As part of the Minsk agreements, the OSCE was provided with 12 Class I drones, including the Chinese Y-6 hexacopter, and 10 mid-range Austrian Schiebel S-100 drones for surveillance purposes.[97] On various occasions, these drones were shot down with surface-to-air missiles, [98] small arms fire and jammings systems, deployed by both the Russia-backed separatists and the Ukrainian army in order to prevent the OSCE from reporting on use and placement of specific weapons forbidden under the Minsk agreements. [99] The US also continues to deploy their largest drone, the RQ-4 Global Hawk, over Ukraine for monitoring the situation. [100] The RQ-4 is based in Sigonella, Italy and has flown ISR missions for EUCOM, AFRICOM and CENTCOM since 2011. [101]

A member of the Organization for Security and Co-operation in Europe (OSCE) mission to Ukraine watches a drone take off during a test flight near the town of Mariupol, eastern Ukraine. Germany and France say it appears that Russian-backed separatists in Ukraine downed a drone being used by neutral European observers and are demanding accountability

Donbas and drone warfare

State and non-state actors have made substantial progress in the Donbas with the incorporation of drones and counter-drone systems in their military tactics and strategies. The main lesson learned from drone warfare in Ukraine is the significance of having ISR capabilities on both sides for identification and targeting of enemy positions. Adapting to modern battlefield dynamics, the Ukrainian Armed forces and associated paramilitary groups were quick to boost their own ISR capacity with both commercial drones and domestically built drones with imported parts and components. Only in the last two years, more military grade systems, both armed drones from Turkey and loitering munitions from Poland, have been acquired but not yet fielded. On the other side, the Russia-backed separatists made significant use of Russian military drones, some of Israeli origin, and electronic warfare means to counter Ukrainian drones and block monitoring by the OSCE. We also witnessed drone sabotage actions through the use of commercial drones equipped with thermite grenades to target munitions depots in Ukraine. The Ukrainian developments demonstrated the relative ease for assembling and deploying small and medium military-grade drones based on imported parts and components.

The Russian involvement and application of counter-drone tactics also showed the vulnerability of the low-tech drones systems built by Ukraine, as electronic signals could be traced, leading to the drone operators being targets. Other tactics, such as flying a drone on a low altitude to attract fire, which could then be traced by a drone flyer at a higher altitude, demonstrate new security challenges posed by drones for armed forces. As evidenced by their extensive usage by all sides, drones have become an integral part of the conflict in eastern Ukraine.

Wreckage of a Russian Forpost, based on the Israeli Mk II Searcher drone, shot down by the Ukrainian Army on May 19th, 2015.

4. The shape of drone warfare to come

How will drones reshape tactics and strategies used by armed forces and non-state armed groups, and what are the implications for the way wars are fought? These questions are relevant in order to address the challenges posed by the enormous increase of the use of UAVs both on the battlefield and beyond it, as well as challenges around export control mechanisms for related drone technologies. Drones enable lethal force to be applied to targets far beyond the frontlines, particularly by non-state actors, posing significant security challenges. The clandestine targeted killing campaign with armed drones, initiated by the US in Yemen, Pakistan and Somalia, demonstrated the added uniqueness of drone capabilities. While drone use for ISR purposes was already growing prior to US drone killings, the rapid increase of military UAVs on and off the battlefield spurred interest the applications of drones for a wide array of military operations. The defence industry jumped on the bandwagon of this new opportunity to develop, produce and export drones.

The military advantage to have these additional 'eyes in the sky' for tactical and strategic means resulted in a rapid increase of acquisition and use by armed forces worldwide. This includes lethal applications with various types of larger and smaller drones, and for operations they would likely not carry out with crewed aircraft due to physical and political risks involved. The ongoing armed conflicts in the Middle East and North Africa are a cautionary tale of how drones could facilitate more use of lethal force against opponents or groups on and off the battlefield with relatively cheap methods. This type of drone use, be it clandestine targeting killings of individuals to strikes against civilian infrastructures risks eroding international legal principles around the use of force without any accountability or justice given to civilian casualties. In the same vein, cross-border incidents involving drones have risked force escalation from retaliatory strikes, endangering regional security. Moreover, drones provide states and non-state armed groups with the means to attack a wide range of targets outside the battlefield, such as critical infrastructure like airports, water filtration stations or oil facilities in Saudi Arabia by the Houthis and Iran.

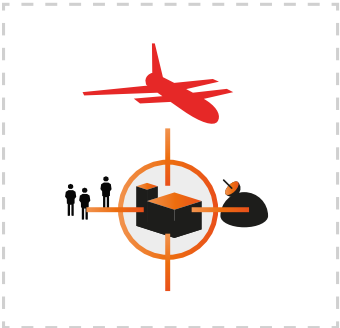
The growing commercial drone market and related technologies that enable platforms to fly or be equipped with payloads that facilitate ISR or targeting will provide more room for armed forces and militants to develop domestic drone capabilities. State-sponsored aviation expertise and engineers can facilitate the rapid development of these capabilities, as we have witnessed in Yemen, or with commercial tools and knowledge, as is clear from the thriving drone industry in

Ukraine. The defining capabilities of drones based on the current conflict-theatres where they have been deployed can be outlined as follows:

Situational Awareness and Targeting Support

Both state and non-state armed groups benefit significantly from improved information on troop movements, enemy positions and general awareness of the environment they operate in. Armed groups in Ukraine and Yemen clearly demonstrated the advantage of improved ISR, and also how these helped improve targeting with other means, particularly in Ukraine. Increased data collection and real-time tracking can be a decisive element in the battle, and to some extent levelled the playing field in conflicts like in Yemen and the Ukraine. As one drone operator in Ukraine stated: "He who sees the enemy first wins".[102] Logically, state and non-state groups try to act invisibly, for instance by operating 'off the air' as much as possible, [103] or hiding among civilians. This tactical evolution blurs the boundaries of conflict zones and puts civilians at extra risk. Considering the reports of hundreds of incidents with drones on an annual basis along the Donbas frontlines, we are entering the future normal in conflicts, namely widespread use of small drones, either lethal drones or in support of other lethal weapon systems, against a range of civilian and military sensitive targets.

Payload and Precision

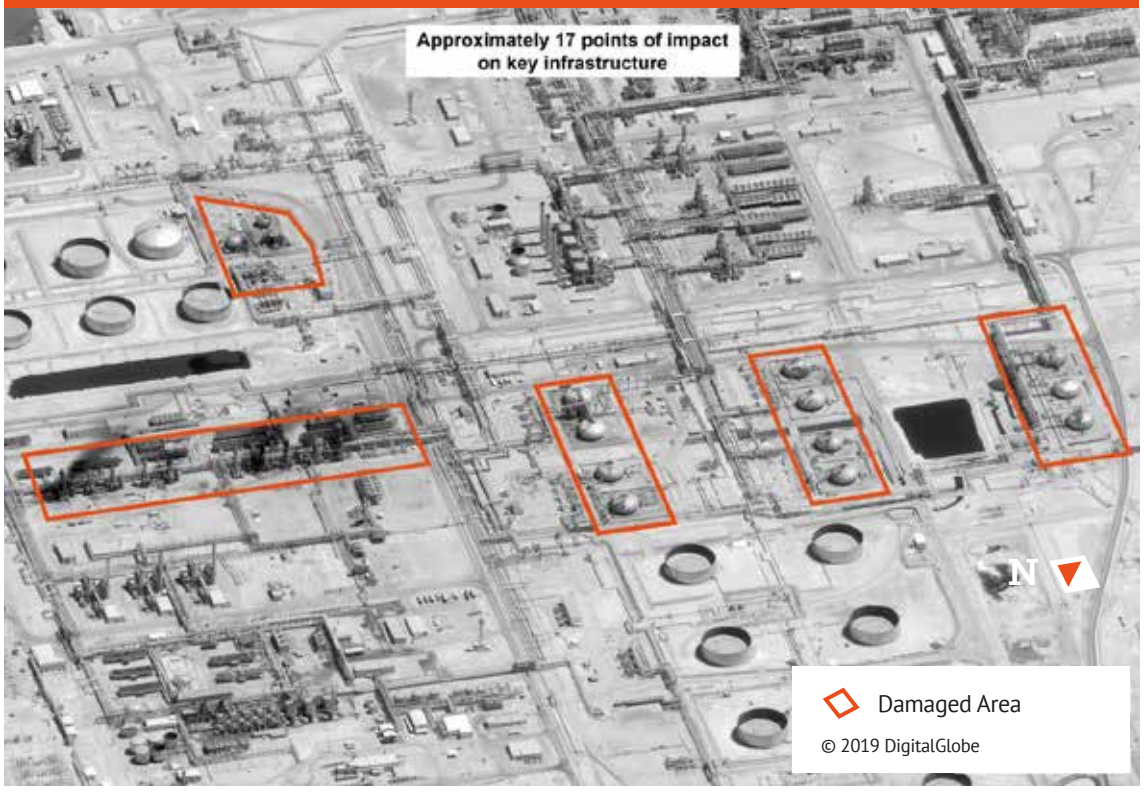


Whereas the use of armed drones by states has provided them with means to carry out strikes against individuals or targets with limited collateral damage, armed groups have taken the opportunity to acquire and develop such systems to carry out strikes against sensitive economic and military targets, both inside and outside the conflict theatre. Smaller drones in particular have proved able to avoid radar detection and air defences due to their size or quantity, demonstrated by the hundreds of attacks with drones undertaken by the Houthis in Yemen and Saudi Arabia. The demand for military grade loitering munitions/kamikaze drones, as already deployed in Syria by the US,[104] will likely also spill over into other markets, with Poland, Turkey and the Ukraine following suit in terms of development and sales. The ability to precisely deliver lethal payloads with (semi) remote-controlled platforms, [105] at both short and long distances, greatly increases the number of potential targets. Commercially available parts and components, together with blueprints of military drone platforms as used by the Houthis in Yemen, that can be reproduced domestically, risk the proliferation and increased use of drones against a wider array of targets, by both states and armed groups.

Force Projection

All actors currently deploying drones in combat have made use of the ability for persistence surveillance or striking targets. Both states and non-state armed groups are keen to showcase their drone capabilities during parades and press events. Initially, drone footage for propaganda purposes was shared with the media to show the precision of modern warfare. Examples are US drone footage released during their military interventions in the Middle East (Afghanistan, Iraq, Syria), and Israel deploying drones over Gaza during their military operations, ranging from targeted killing operations of militants from various groups to full out military interventions in 2008 and 2014. This took another turn when IS started to use drone footage to boast about their military strength in propaganda videos.[106] Other groups and States followed, with Turkey showing strikes against Kurdish militants in Iraq, rebel groups in northern Syria filming suicide attacks and Iranian drones used in Syria to film strikes and bombing campaigns. The Houthis took this to the next level, both filming sensitive locations inside Saudi Arabia with drones and posting this, combined with long-range strikes against airports and oil facilities. Even though the physical damage of those strikes was limited, albeit with far-ranging geopolitical consequences, the message was clear: we can target you where we want.

Damage to Oil/Gas Infrastructure at Abqaiq **15 Sep 2019**



Satellite imagery released by the US government shows damage of the strike with drones and missiles against the Abqaiq oil faciliy in Saudi-Arabia, September 15, 2019. (Edited for content purposes)

5. Conclusion: Technology and proliferation

We are witnessing a far-reaching shift towards increased use of drones for military purposes on and beyond the battlefield. The unique capabilities of drones have provided those deploying them with novel means of information collection and targeting, and this has already shifted tactics by all conflict parties. The horizontal diffusion of power with drones has enabled novel ways of hybrid warfare, combining force projection with deterrence. Drone technology has forced militaries to bolster defensive measures against groups and states deploying these systems, while at the same time, armed groups with state support have found ways to neutralize drones that have been tracing and targeting them, using both kinetic and electronic warfare means.

This increase of drone use against a wider array of targets, both on and beyond the battlefield could not only risk more civilian lives, but also have a destabilising effect on regional security; the temptation of using low-cost drones in lethal cross-border operations, though perceived as precise, risks escalation of conflicts, and in result would bring more civilian harm.[107] Moreover, the fall-out from damaged water infrastructure, pollution from oil, collapsed economic activities, or the mere psychological fear of aerial attacks with swarms of drones or retaliatory strikes will pose significant dangers to civilians and peace.

Without denying the abundance of positive applications of civilian drones, drones also bring into question how to properly control their use, restrict access to those capable and trusted to utilize them and place their use in a clear policy framework that prevents misuse. The rapid developments in the field of artificial intelligence, the miniaturization of technologies, and sophistication of payloads contribute to a booming business for drone developments. The skies have turned violent, and civilians are at risk of bearing the brunt from novel uses of lethal emerging technologies that dictate destructive tactics and strategies. Taken together, this leads to the following recommendations.

6. Recommendations

To address the challenges posed by drone use and proliferation, PAX has the following recommendations.

To states:

- **Formulate clear and strict legal policies on the use of lethal force with drones.** There is an urgent need to counter current practice by some states of using either armed drones in support of foreign armed groups or in counterterrorism operations, which has resulted in high numbers of civilian casualties. These types of use risk undermining existing interpretations of the use of lethal force under international law. By addressing legal positions publicly, states will contribute to norms of greater transparency and accountability over lethal force in military operations.

- **Actively engage in multilateral forums on drone-related debates.** States should address concerns over the growing (mis)use of drones and proliferation risks in debates at the UN General Assembly, the UN Security Council, the Human Rights Council and in regional and bilateral engagements with States. Previous discussions led by UNODA and UNIDIR have demonstrated the necessity of assessing the impacts of these technologies on the conduct of military operations and have furthered the debate on how to properly work towards improving norms and standards around drone use.

- **Update control lists and improve risk assessments in existing export control regimes.** States should expand their considerations of what types of drones or related technologies might be misused or diverted to unwanted end-users, and assess the potential for exported drones to be put toward misuse within the regional security context of the importing state. A broader discussion on the opportunities and limitations for civilian drone technology and export controls should also be encouraged. As a whole, and at a minimum, these measures and discussions serve as an educational tool for participating states dealing with export limitations for drones. Such measures should be addressed in the context of relevant arms export control regimes such as the Arms Trade Treaty, the Missile Technology Control Regime and the Wassenaar Arrangement. Ensuring wider engagement beyond these international agreements with often limited participation and on a voluntary basis, requires a broader international effort to ensure that developments around civilian and military drones technologies in all facets are addressed through proper legal binding export control agreements.

To the United Nations:

- **Support comprehensive and inclusive multilateral discussions on the use and proliferation of dual-use and military drones.** Uncrewed systems might have added value for civilian and military environments, yet emerging technologies with a set of unique features also pose novel risks that could undermine peace and stability. Moreover, current practices of illegal targeted killings risk further undermining existing legal principles for the use of lethal force in and outside armed conflicts. These issues should be subject to ongoing discussions at a multilateral level.

- **Establish a monitoring mechanism on drone warfare.** Regular reporting on the state-of-play regarding the domain of increased drone use helps to understand how this is shaping conflicts through trends and patterns. Such a monitoring mechanism would function as an accountability mechanism and can foster dialogue on contested use. Recent reporting on drone use in reports by UN experts on both Libya and Yemen provided crucial insights in technological developments and use cases.

7. Annex

Yemen

Type of Drone	Country or Origin	User
Qasef-1	Iran / Yemen	Houthis
Qasef-2	Iran / Yemen	Houthis
Samad-1	Iran / Yemen	Houthis
Samad-2	Iran / Yemen	Houthis
Samad-3 / UAV-X	Iran / Yemen	Houthis
Hudhud-1	Unknown	Houthis
Wing Loong 1	China	Saudi Arabia
WIng Loong 2	China	United Arab Emirates
CH-4	China	Saudi Arabia
Seeker 200	South Africa	Saudi Arabia
Luna X-2000	Germany	Saudi Arabia
DJI Phantom	China	Houthis
Tracker (DRAC)	France	Saudi Arabia
MQ-1 Predator	United States	United States
MQ-1c Grey Eagle	United States	United States
MQ-9 Reaper	United States	United States
Predator XP	United States	United Arab Emirates
Ayeron Scout	Canada	Saudi Arabia (unconfirmed)
Vetel Karayel	Turkey	Saudi Arabia
Schiebel-100	Austria	Saudi Arabia
Scan Eagle	United States	Saudi Arabia (unconfirmed)
RQ-20 Puma	United States	Saudi Arabia

Ukraine

Type of Drone	Country or Origin	User
DJI Phantom	China	Ukraine / Seperatists
DJI Mavic	China	Ukraine
UAV-X Talon	China	Ukraine
Skywalker X-8	China	Ukraine
Leleka-100	Ukraine	Ukraine
A1-s Furia	Ukraine	Ukraine
Bayraktar TB-2	Turkey	Ukraine
Bird Eya 400	Israel	Russia / Seperatists
Eleron-3SV	Russia	Russia / Seperatists
Granat-1	Russia	Russia / Seperatists
Granat-2	Russia	Russia / Seperatists
Granat-4	Russia	Russia / Seperatists
Orlan--10	Russia	Russia / Seperatists
PD-1	Ukraine	Ukraine
Ptero-5E	Russia	Russia / Seperatists
Raybird-3	Ukraine	Ukraine
Searcher Mkll / Forpost	Israel	Russia
Sparrow LE	Ukraine	Ukraine
ZALA-421-04M	Russia	Russia / Seperatists
Schiebel-100	Austria	OSCE
SkyEye Y-6	China	OSCE
RQ-4 Global Hawk	United States	United States

8. Endnotes

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