A Comparative Study of Non-State Violent Drone use in the Middle East

Yannick Veilleux-Lepage and
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ICCT International Centre for Counter-Terrorism

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Executive Summary

This report examines the drone programs of five non-state groups operating in the Middle East: Hezbollah, Hamas, the Houthi Movement, Islamic State (IS), and the Kurdish Workers' Party (PKK). In contrast to other violent non-state actors, these five groups have shown that they are willing to engage in tactical and/or technical innovation in the use of drones, have sustained a long-term engagement with drone technology and demonstrated the capacity to develop drone infrastructure. The development of drone programs by these five different groups is different in terms of timescales, methods, strategies, and tactics. Therefore, the report rejects the notion that all non-state groups' drone programs follow a similar course of development. Instead, it argues that a terrorist group's use of drones needs to be situated within the context of that group's overarching strategic goals. Because of this, we argue that states and militaries that are going up against these groups need to first understand what a specific group hopes to accomplish with drones in order to fully comprehend the specific threat, and secondly understand the specific challenges presented by innovation within drone programs (as opposed to episodic drone use). This report outlines offers a framework for the study of drone innovation which is not limited to these groups, but which could also apply to other groups in the future. It does this by describing five different routes that non-state actors have taken to develop drone technology.

This paper has made three important additions to the body of knowledge on this topic through systematic empirical data collection and analysis.

First of all, the findings suggest that there is a need to refocus attention away from the most high-profile threat — that of drone-deployed WMDs — and toward the more common and empirically demonstrated methods that groups use when employing drones. We have found no evidence of a non-state group seriously attempting to deliver WMDs by drone. While there are indications that Islamic State (IS) pursued both WMD programs and drone programs in parallel, there is no evidence that they are sought to integrate the two. Security professionals, as such, should focus their attention on the empirically-demonstrated uses of drones by armed non-state groups, and on the plurality of means through which drones can enhance these groups' activities.

Second, scholarship and security planning must concentrate on the particular danger posed by drone programs (as opposed to the occasional use of drones) and the potential for innovation in drone use. When fighting drone programs, nations and armies need to retain a focus on innovation and adaptation, and they must understand how organizations grow tactically, strategically, and technically. Drone development is neither linear nor static.

Finally, this report demonstrates that there is no single route of development for the use of drones by non-state entities, nor is there a pattern that these groups want to follow in order to expand their capabilities. Each organization uses drones in a manner that is unique to its own set of logistical, political, and strategic parameters; hence, drone programs need to be positioned within the larger context of the organization's military means and operations. Therefore, militaries and states that are confronting drone programs need to maintain a holistic approach. While they may draw on existing practices that have had varying degrees of success in countering drone threats and engage in preventive action to mitigate the scope of drone programs, approaches should consider drone programs not only as a distinct, isolated threat, but also as part of broader military operations, strategies, and conflict processes.

Acknowledgement

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Chapter 1: Introduction

Five years have elapsed since American Special Forces commander Raymond Thomas declared that the Islamic State's (IS) use of small, armed drones constituted the "most daunting problem" for the forces of the US-led coalition against IS engaged in the battle for Mosul. This problem was compounded by an "adaptive enemy" who exploited innovation to gain tactical advantages.[1] In many ways, the problem has only grown more pressing since then. Thomas identified four main characteristics which explained the salience of this threat. First, IS' drones operated below the altitude of American air power, challenging American efforts to establish air superiority. Second, IS developed new tactics, adapting to the US' way of warfare and exploiting asymmetric strengths, forcing changes in American tactics. Third, IS achieved strength in numbers, at one time being able to fly seventy drones within a twenty-four-hour period. Fourth, the US and coalition forces found themselves incapable of fielding countermeasures, as the "only available response was small arms fire."[2]

In the years since Thomas' warning, non-state actors' violent use of drones has grown in scope and complexity. Houthi rebels in Yemen have managed to launch major attacks with concerning regularity, notably targeting the Yemeni army intelligence commander with an explosive drone in January 2019. Eight months later, Houthi drones (or possibly those of allied groups in Iraq) struck an Aramco oil field in Saudi Arabia, temporarily suspending 6 percent of the world's oil production capacity.[3] Increasing drone activity by non-state groups in the Middle East has seen innovations in tactics, techniques, supply chains, and tactical and strategic objectives, as well as proliferation to new actors. This report provides an empirically based overview of such drone use and accompanying innovations, through a comparative study of five violent non-state groups that have employed drones in the Middle East.

Report Overview

This project is facilitated by a grant from the Mobilizing Insights in National Defence and Security program from the Canadian Department of National Defence. It seeks to address dynamics of innovation and learning among violent non-state groups, with a particular focus on the development of drone programs among such groups. While many individual or group actors have experimented or dabbled in violent drone use, we concentrate on five groups that have established drone programs – that is, ongoing efforts to develop new techniques and tactics of drone use – and whose drone use constitutes a significant and sustained part of their activities. By concentrating on these established programs, we uncover not only how such groups use drones, but also how they learn and innovate and learn to improve, how drone use contributes to their broader strategic and operational objectives, and how drone use reflects broader geostrategic dynamics.

This project is guided by four principal research questions:

1) How do various non-state groups employ drones violently?

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1 David B. Larter, 'SOCOM Commander: Armed ISIS Drones Were 2016's "Most Daunting Problem"', Defense News, 8 August 2017, https://www.defensenews.com/digital-show-dailies/sofic/2017/05/16/socom-commander-armed-isis-drones-were-2016s-most-daunting-problem/.
2 Larter.
3 Associated Press, 'Major Saudi Arabia Oil Facilities Hit by Houthi Drone Strikes', The Guardian, 14 September 2019, https://www.theguardian.com/world/2019/sep/14/major-saudi-arabia-oil-facilities-hit-by-drone-strikes ; Kareem Fahim and Steven Mufson, 'Saudi Arabia Oil Output Takes Major Hit after Apparent Drone Attacks Claimed by Yemen Rebels', Washington Post, 14 September 2019, https://www.washingtonpost.com/world/drone-attacks-on-saudi-oil-facilities-spark-explosions-and-fires/2019/09/14/b6fab6d0-d6b9-11e9-ab26-e6dbebac45d3_story.html.

2) How do non-state groups develop drone technology programs?

3) What factors influence the decision by non-state groups to employ drones violently?

4) What new challenges does the proliferation of non-state violent drone programs present to military forces engaged in security operations?

These research questions provide the foundation for an empirically based evaluation of non-state violent drone use which can offer guidance to the Canadian Armed Forces and other NATO militaries operating in these theatres. Canada's defence policy Strong, Secure, Engaged notes critical issues presented by global terrorism, weapons proliferation and "the changing nature of peacekeeping operations", as well as "growing complexity."[4] Innovation by non-state actors in the employment of armed drones presents pressing concerns relating to all these themes, as Raymond Thomas' quote above suggests. In particular, the combination of these themes – increasingly complex operations in environments defined by global terrorist groups having access to new weapons – raises the prospect of challenges requiring significant tactical, technical, and strategic adaptation on the part of Canada's Armed Forces. This report contributes to outlining the empirical and theoretical foundations upon which this adaptation may take place.

Findings

This report makes three substantial contributions to knowledge in this area. First, it revises our understanding of the common uses of drones by armed non-state actors, and suggests a need to refocus planning against these threats. In particular, one of the threats most commonly highlighted in the literature – that of drone-delivered weapons of mass destruction (WMDs) – is not substantiated by our survey of these five non-state drone programs. Rather, the groups under study have focused on developing means for conventional attacks of different kinds. For some groups, drones are primarily used in combination with other means of attack, as platforms for intelligence gathering and coordination. In the case of other groups, such as Hezbollah, concerns centre on the possibility of a mass attack which may overwhelm air defences, though there is limited evidence to substantiate this threat.

Second, this report calls for increased attention to the problem of drone programs specifically. The groups considered in this report do not present distinct threats merely due to the volume or style of their drone use, but rather through their capacity for innovation, adaptation, and development over time. All of these groups have shown progress in their employment of drones, and this capacity for adaptation presents an additional challenge for states seeking to counter these threats. Similarly, groups that associate with state patrons do not remain constant in their affiliation to these patrons: relationships and technology transfer patterns evolve over time, and such groups complement state patronage with other sources of supply and innovation.

Finally, this report rejects the idea of a single pathway of development for drone programs, and calls for more granular, empirically based analysis of drone use and development. Not all drones are created equal, and non-state groups do not seek to follow a particular successful blueprint. While there is certainly an element of symmetry with state drone use, non-state groups diverge from the state model and forge their own practices based on their specific situations and interests. In appraising drone programs, states and militaries should avoid subscribing to prescriptive models and expectations; nor can drones be considered separately from other facets of non-state groups' military power.

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4 'Strong, Secure, Engaged - Canada's Defence Policy.' (Canadian Department of National Defence, 2017), https://www.canada.ca/content/dam/dnd-mdn/documents/reports/2018/strong-secure-engaged/canada-defence-policy-report.pdf.

This report discusses techniques employed to counter the drone threats posed by the five groups under study, and, as such, provides a resource for states and militaries seeking to confront the threat of non-state drone activity. However, the techniques discussed here are not exhaustive, and at present there is no dominant way to neutralize the threat of drone programs distinct from the conflicts in which they are embedded. Nevertheless, in considering preventive action, states – including countries not directly impacted by drone violence – can explore ways to restrict access to drone capabilities and technologies. Although non-state drone programs leave room for improvisation and ad hoc assembly, they nonetheless represent complex enterprises requiring a combination of technical knowledge, tactical and strategic planning, and financial and technical resources, all of which can be impacted by state action.

Methodology

This report is based on the collection and systematic review of incidents of drone use by violent non-state actors in the Middle East. While useful, existing databases such as the Global Terrorism Database[5] (GTD) and the Armed Conflict Location & Event Data Project[6] (ACLED) are inadequate for the task at hand, for two reasons. First, existing datasets are incomplete. For example, in his review of hijacking incidents, Veilleux-Lepage found that nearly 75 percent of politically motivated airplane hijackings between 1931 and 2001 were omitted from the GTD.[7] A second factor is that a large amount of data on terrorist drone use is not openly accessible and therefore impossible to validate. As the main goal of this report is to provide a comprehensive overview of violent non-state actors' use of drones in the Middle East, the creation of a new dataset was necessary.

In order to construct our database of violent non-state drone use in the Middle East, we used a formalized codebook. Each incident of drone use by the five groups under study and taking place in the Middle East was coded, including the following elements:

- Date and Location of the event

- Incident summary

- Make and model of the unmanned aerial vehicle (UAV)

- Incident type

- Target

- Experimental use (yes/no)

- Impact

- Information relevant to the internal decision-making process

- Provenance of the UAV

- Sub-group responsible

- Additional relevant information

5 'Global Terrorism Database', National Consortium for the Study of Terrorism and Responses to Terrorism (START), 2021, https://www.start.umd.edu/gtd.
6 Clionadh Raleigh et al., 'Introducing ACLED: An Armed Conflict Location and Event Dataset: Special Data Feature', Journal of Peace Research 47, no. 5 (1 September 2010): 651–60, https://doi.org/10.1177/0022343310378914.
7 Yannick Veilleux-Lepage, How Terror Evolves: The Emergence and Spread of Terrorist Techniques (Lanham: Rowman & Littlefield Publishers, 2020).

Date	Year	Location	Country	Incident summary	Make / Model of UAV	Incident Type (According to Typology)	Target	Experimental Use	Impact	Simplified Impact	Information on Internal Decision Making	How Drone was Obtained	Sub-Group Responsible	Any other relevant information	Info source(s)
2016/03/16	2016	North of Iraq	Iraq	ISIS used drones to carry out an attacked against US and Iraqi military base.	DJ Phantom	Weaponize - Explosive Delivery	US and Iraqi Military base	No	One of the US marines was killed in the ISIS strike.	Major damage	-	-	-	-	نظم دفاع جوي وظائرات مسيرة: تنظيم الدولة يعزز ترسانة أسلحته – إضاءات ida2at.c)om)

Figure 1: Sample dataset entry

We conducted a systematic search of articles published in English, French, Arabic, Hebrew and Turkish language newspapers.[8] In addition, this report also makes use of available primary information contained in newspapers, propaganda videos, training manuals, and social media posts produced by violent non-state actors. This wide variety of languages and source types enables a better understanding of the political, cultural, and technological contexts in which violent non-state actors use drones.

To find official sources concerning the use of drones by violent non-state actors, we also conducted systematic thematic searches of the websites of government bodies, both those located in the Middle East and those with strong geopolitical interests in the region. Lastly, the database was further informed by major academic and governmental reports, as well as reports from various conflicts and from armament watchdog associations (which monitor the proliferation of emerging technologies in conflict zones).

While this approach contains inherent limitations, it also mitigates problems of unreliable source data in significant ways. Researchers working with published reports have little control over the data on which their analyses depend, instead relying largely on journalistic and editorial decisions regarding which version of an event will ultimately be available for research purposes. As a result, such research data is subject to biases and unreliability.[9] With regard to the current database, data sources range from extremely credible – such as reports by UN Security Council-mandated Panels of Experts – to less inherently trustworthy sources, such as online reports from various media organizations. This multiplicity of sources, however, is appropriate to the structure of our research, which seeks to obtain a coherent overview of each group's employment of drones, rather than granular data about individual incidents. Due to the systematic nature of the search conducted, our analysis does not depend on the credibility of any specific source or incident, but on the coherence of the dataset as a whole. Furthermore, we are mindful that when reports are unconfirmed, this may represent limitations in the availability of information (or of journalistic organizations) rather than inherent unreliability. Faced with this sampling issue, we

8 Jennifer Earl et al., 'The Use of Newspaper Data in the Study of Collective Action', Annual Review of Sociology 30 (1 August 2004): 65–80, https://doi.org/10.1146/annurev.soc.30.012703.110603 ; Roberto Franzosi, 'The Press as a Source of Socio-Historical Data: Issues in the Methodology of Data Collection from Newspapers', Historical Methods: A Journal of Quantitative and Interdisciplinary History 20, no. 1 (1 January 1987): 5–16, https://doi.org/10.1080/01615440.1987.10594173 ; George Maney and Pamela Oliver, 'Finding Collective Events: Sources, Searches, Timing', Sociological Methods & Research 30, no. 2 (1 November 2001): 131–69, https://doi.org/10.1177/0049124101030002001 ; Susan Olzak, 'Analysis of Events in the Study of Collective Action', Annual Review of Sociology 15, no. 1 (1989): 119–41, https://doi.org/10.1146/annurev.so.15.080189.001003.
9 M. Herbert Danzger, 'Validating Conflict Data', American Sociological Review 40, no. 5 (October 1975): 570–84, https://doi.org/10.2307/2094196 ; Gabriel Weimann and Conrad Winn, The Theater of Terror: Mass Media and International Terrorism (White Plains: Longman, 1994).

sought to triangulate information contained in the dataset by using multiple sources to create individual incident accounts to offset known or suspected biases.[10]

A further limitation is inherent to the study of drone use: not all drone observations are reported by media sources, and many instances of drone use which do not involve violence will go unobserved or unreported. In particular, the groups under study here may use drones for a variety of purposes in which they intend drone activity to remain hidden, such as smuggling, document transportation, or reconnaissance missions. As such, the absence of significant reports concerning these activities does not mean that the groups do not use drones for these purposes; rather, those limitations are inherent to the collection of data through reported sources. As we choose to conduct empirical research through systematic collection of reports published by governments, media, or other outlets, this limitation must be accepted.[11]

Selection of Groups

This study compares and contrasts five violent non-state actor groups and the use of drones in their operations. These five groups – all based in the broader Middle East region – have all employed drones to launch offensive operations; in addition, all demonstrate sustained engagement and innovation in drone use and significant technical and tactical innovation. The five groups surveyed are the Islamic State (IS), Hezbollah, Hamas, the Houthi Movement in Yemen, and the Kurdistan Workers' Party (Partiya Karkerên Kurdistanê, PKK) and its affiliated/allied organizations.

This selection of groups is based on Don Rassler's excellent survey and typology of drone programs for West Point's Combating Terrorism Center.[12] In this 2016 work, Rassler identified four groups which had drone programs (IS, Hezbollah, Hamas, and Jabhat al-Nusra), of which only IS had employed drones to kill.[13] Since Rassler's study, the Houthi Movement and the PKK have also shown sustained drone use on a scale that justifies inclusion in the current report (since 2018 for the Houthis, 2019–2020 for the PKK). Meanwhile, Jabhat al-Nusra was included in Rassler's list on the basis of prospective development and some initial incidents; since then, however, these prospects appear to have largely failed to materialize. We have therefore chosen not to include Jabhat al-Nusra in our report, as there exists no evidence that the group has established a significant and sustained drone program.

The five groups under study here vary widely in their scope, strategic situation, timelines and activities, providing a well-rounded survey of potential drone capabilities. Some of the groups (Hezbollah, Hamas, the Houthi Movement) enjoy various degrees of state support, while others do not; most employ drones against well-equipped and trained state militaries, while others (Hezbollah, IS) have also employed drones against other non-state actors. Some have seen drone capabilities build slowly over time (Hezbollah, Hamas), while others' capabilities have surged very quickly (IS, the Houthi Movement, PKK). Finally, one (IS) has almost exclusively used small, locally built drones, while others have employed larger equipment of a quasi-military standard.

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10 John T. Woolley, 'Using Media-Based Data in Studies of Politics', American Journal of Political Science 44, no. 1 (2000): 156–73, https://doi.org/10.2307/2669301.

11 In the case of IS, we relied on a significant number of photos published by the group itself and its propaganda outlets. This data also skews towards violent action – either attacks by drones or observation of other attacks – though some photos document observation and reconnaissance missions.

12 Don Rassler, 'Remotely Piloted Innovation: Terrorism, Drones and Supportive Technology' (West Point: Combating Terrorism Center, 20 October 2016), https://ctc.usma.edu/remotely-piloted-innovation-terrorism-drones-and-supportive-technology/.

13 Rassler, V.

Defining Drones and UAVs

Unmanned aerial vehicles (UAVs) – or drones – are employed in a variety of capacities and roles by military or violent actors. Accordingly, they exist in a variety of sizes, types, and systems. In its simplest sense, "drone" designates any vehicle which is piloted remotely (and which generally does not make significant autonomous decisions). The distance from which drones can be piloted ranges from a few dozen metres to several thousand kilometres, either through direct telecommunication link or via satellite connection; in some cases, drones can also be preprogrammed to function without communication link. While most drones are aerial vehicles, there exist some naval drones (and remote-controlled ground vehicles), and limited evidence suggests non-state actors have experimented with these types too.[14]

Most scholarly attention on the subject has been devoted to state-operated drones, and moreover, it is typically focused on large, multirole, armed drones such as the MQ-9 Reaper.[15] These medium-altitude long endurance (MALE) drones provided a natural historical point of departure due to the prevalence of the MQ-1 Predator in the Global War on Terror; however, scholarship on state-operated MALE drones has limited generalizability to other types of drones. Several typologies exist to account for the variety of drone types and capabilities, although all have limitations due to their focus on state drone perspectives. For instance, the Center for a New American Security has proposed a four-part typology, which purports to account for the variation in availability, capabilities, and infrastructure requirements (see Figure 2).[16]

14 'Anatomy of a "Drone Boat": A Water-Borne Improvised Explosive Device (WBIED) Constructed in Yemen', Frontline Perspective (London: Conflict Armament Research, December 2017), https://www.conflictarm.com/perspectives/anatomy-of-a-drone-boat/ ; For an example of a state-operated ground drone, see Oliver Davis, 'Theorizing the Advent of Weaponized Drones as Techniques of Domestic Paramilitary Policing', Security Dialogue 50, no. 4 (August 2019): 344–60, https://doi.org/10.1177/0967010619843483.
15 A notable exception to the focus on large drones is Stefan Borg, 'Below the Radar. Examining a Small State's Usage of Tactical Unmanned Aerial Vehicles', Defence Studies 20, no. 3 (July 2020): 185–201, https://doi.org/10.1080/14702436.2020.1787159.
16 Kelley Sayler, 'A World of Proliferated Drones: A Technology Primer' (Center for a New American Security, June 2015), 9, https://www.cnas.org/publications/reports/a-world-of-proliferated-drones-a-technology-primer ; Ryan Jokl Ball, 'The Proliferation of Unmanned Aerial Vehicles: Terrorist Use, Capability, and Strategic Implications' (Lawrence Livermore National Laboratory, 16 October 2017), 5–6, https://doi.org/10.2172/1410035.
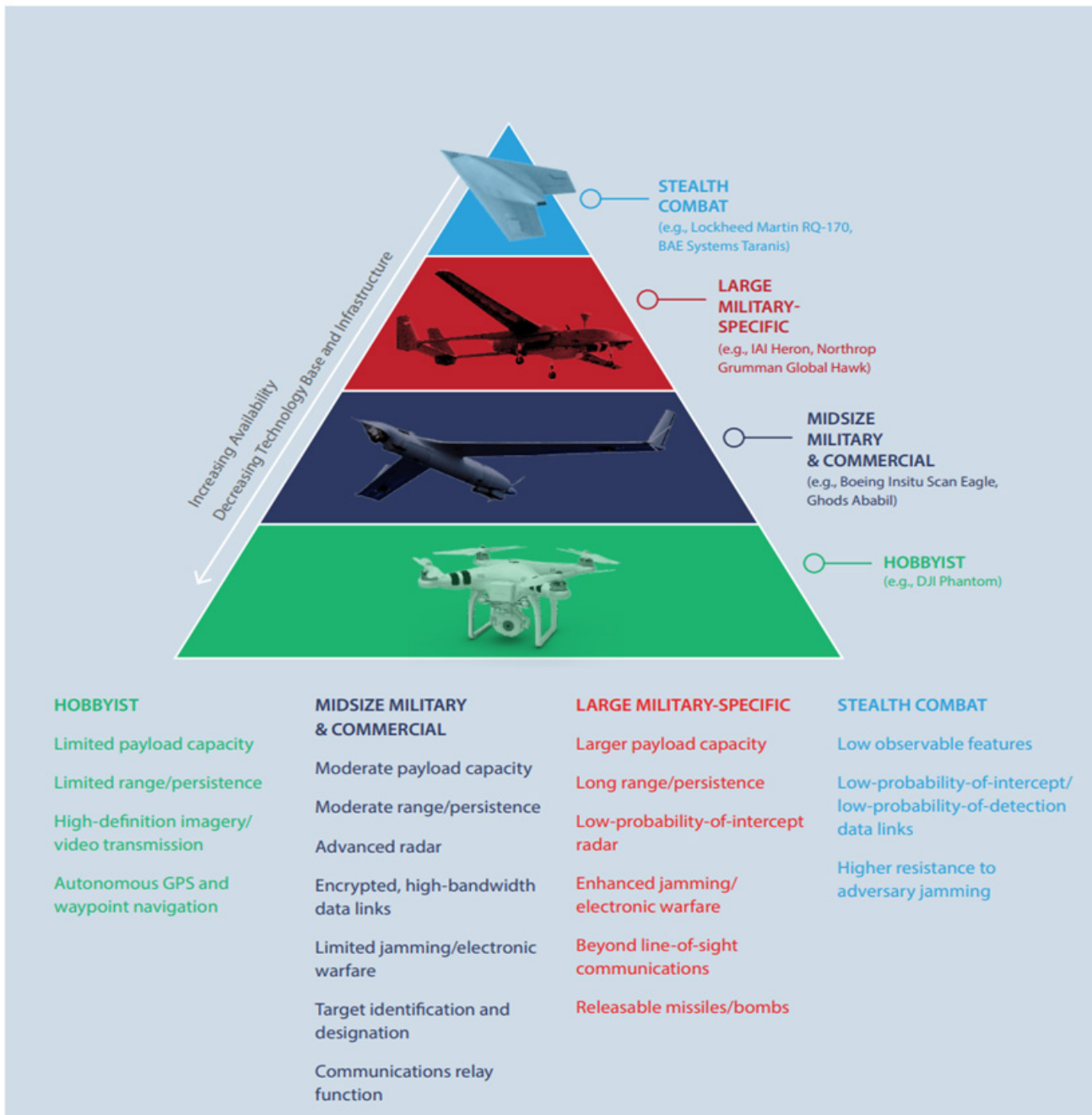
Figure 2: The CNAS typology of drone categories.[17]

While this typology holds some value regarding state-operated drones, it has several drawbacks. First, the top category of "stealth combat" is almost entirely future-oriented, with no such drones in operation.[18] Second, the combined category "midsize military & commercial" conflates a wide variety of systems, capabilities, and roles. Thirdly, while this typology focuses on state military drones and major commercial operators, violent non-state groups have employed such drones, sometimes with great success (and sometimes without success). In sum, while this typology is useful in highlighting the inverse relationship between availability and technical requirements, by concentrating on the size of drones it obscures what these drones do and how they are employed, as well as the means (such as state patronage) through which violent non-state groups can mitigate the higher infrastructure requirements of large drones.

17 Sayler, 'A World of Proliferated Drones', 9.
18 The RQ-170 Sentinel given as an example in the figure is indeed stealthy, but unarmed. Its designation as a "combat" drone is incorrect by most understandings, and it is unclear why stealth alone would warrant it being designated as a distinct category.

The drones discussed in this report belong to the lower two categories. As we argue, within these categories there exists substantial variation in how the groups under study employ drones, what they achieve with them, and how they innovate to achieve enhanced capabilities. Later in this report we introduce a new typology, focusing on how drones are employed rather than classifying them by size and provenance.

Defining the Threat of Drones

A focus on specific weapons systems, such as drones, comes with the risk of falling into technological determinism. As we argue in this report, non-state groups do not employ drones separately from other weapons systems, and they seek to use drones in ways that reinforce their operational and strategic objectives. Nevertheless, drones warrant specific attention due to a number of characteristics which set them apart. First, unlike other forms of military power, air power has traditionally been associated with statehood and sovereignty; non-state drones therefore represent an incursion by non-state groups into the prerogative of sovereign states – not only militarily, but also conceptually and symbolically.[19] Second, drone programs require specific expertise, both technical and tactical; accordingly, countering drone threats likewise requires specific techniques and tactics on the part of state militaries. Finally, a comparison focused on a specific weapons system and its various uses and contexts allows for a nuanced appreciation of how different groups innovate in integrating these weapons into their arsenal, and how drones can shape strategic, political and tactical situations.

This report furthermore engages in an ongoing debate about the capabilities of small and medium-sized drones. While large states – such as the US and its allies – can integrate drones into larger architectures of intelligence gathering, sharing and analysis, smaller groups face different resource constraints. Ongoing debates on the capabilities of drones have neglected this reality, with a disproportionate focus on large state powers. For instance, Amy Zegart presents an argument about the impact of cheap drones on states' ability to engage in and prolong interstate crises by reducing the costs of involvement;[20] however, it is also worth considering how drone systems influence the capabilities and spatiotemporal characteristics of non-state groups. By studying non-state drones, this report contributes to scholarship on how violent non-state groups develop their capabilities as well as to scholarship on drones more generally, enabling a more multifaceted understanding of the influence of weapons development and proliferation on the dynamics of conflict.

Drone Programs of Violent Non-State Actors

Don Rassler's 2016 study identifies a drone program as "a more structured, integrated and resourced capability"[21] compared to occasional users or groups that experiment and then move on. For instance, while Japanese group Aum Shinrikyo is often said to be the first group to have experimented with drone use in 1994 (to disperse the chemical agent sarin), their reported failure to continue employing drones after the first tests refutes the existence of a drone program in this case.[22] Rassler further operationalizes his criteria through two additional variables: (1) significant frequency of drone use, and (2) the development of medium/long-term infrastructure.[23]

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19 Emil Archambault and Yannick Veilleux-Lepage, 'Drone Imagery in Islamic State Propaganda: Flying like a State', International Affairs 96, no. 4 (July 2020): 955–73, https://doi.org/10.1093/ia/iiaa014.
20 Amy Zegart, 'Cheap Fights, Credible Threats: The Future of Armed Drones and Coercion', Journal of Strategic Studies 43, no. 1 (January 2020): 6–46, https://doi.org/10.1080/01402390.2018.1439747.
21 Rassler, 'Remotely Piloted Innovation', 5.
22 On Aum Shinrikyo, see the next section.
23 Rassler, 'Remotely Piloted Innovation', 13.

We accept these criteria as our foundation, though we add a third criterion which demonstrates the significance of investment in drone development: namely, tactical and technical innovation.[24] Drone programs change and evolve over time, and violent non-state actors that develop drone programs seek to maintain the upper hand against well-resourced adversaries through technical novelty, expanded capabilities, and tactical surprise. Raymond Thomas, in the conference presentation quoted in the opening of this report, mentioned this challenge of mutual innovation and adaptation specifically;[25] accordingly, for Canadian security forces seeking to adapt to the "changing nature of peacekeeping operations" and the changing security environment,[26] drone programs present a much greater potential threat than infrequent violent drone users.

A drone program, therefore, is helmed by an organization which displays:

1. A clear structure for drone activities;

2. Integration between drone use and other operations;

3. The availability of sufficient or significant resources devoted to these activities.

These commitments, in turn, are manifested in:

a. Sustained drone use, with a broad geographical and temporal scope;

b. The development of command, control and operation infrastructure enabling complex operations;

c. Innovation and learning in technical and tactical practices.

Terrorist Use of Drones Outside of the Middle East

The proliferation of terrorist UAVs is not geographically limited to the Middle East. Terrorist groups, illicit organizations, and other non-state actors throughout the world have sought to utilize drones. Indeed, the proliferation of drones by non-state actors has given rise to a skewed perception of the threat of violent drone attacks, one which is not borne out by the empirical record. While such threats may arise in the future, the common perception of the threat of drone attacks has tended to focus on three types of threats:[27] (1) WMD attacks, (2) domestic terror plots and unaffiliated terrorist attacks, and (3) criminal actors. In the following, we elaborate on these three types of perceived threat, and argue for a focus on the much more salient threat presented by drone programs.

Weapons of Mass Destruction Attacks

The starting point for most histories of terrorist drone use is the 1995 attack by the Japanese doomsday cult Aum Shinrikyo (hereafter "Aum"). This group, which conducted a deadly sarin gas attack on the Tokyo subway in 1995, is also said have experimented with drones prior to

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24 On terrorist learning, see Veilleux-Lepage, How Terror Evolves; Yannick Veilleux-Lepage, Chelsea Daymon, and Emil Archambault, 'Learning from Foes: How Racially and Ethnically Motivated Violent Extremists Embrace and Mimic Islamic State's Use of Emerging Technologies' (London: Global Network on Extremism and Technology, May 2022), https://gnet-research.org/2022/06/07/learning-from-foes-how-racially-and-ethnically-motivated-violent-extremists-embrace-and-mimic-islamic-states-use-of-emerging-technologies/ ; Audrey Kurth Cronin, Power to the People: How Open Technological Innovation Is Arming Tomorrow's Terrorists (Oxford: Oxford University Press, 2020); Adam Dolnik, Understanding Terrorist Innovation: Technology, Tactics and Global Trends (London: Routledge, 2007).
25 Larter, 'SOCOM Commander'.
26 'Strong, Secure, Engaged - Canada's Defence Policy.', 53–54.
27 See Don Rassler's typology in the next section.

the attack. As part of its chemical weapons program which would later culminate in the 1995 attack, Aum experimented with various means of disseminating nerve agents, which included modifying trucks with homemade vaporizing devices, and, according to some reports, attaching spray nozzles on the Russian imported radio-controlled helicopters in the hopes of using them to deliver chemical agents.[28] According to popular accounts, Aum abandoned this idea after crashing one remote-controlled helicopter into a tree and the other one into the group.[29] This story of Aum's experimentation with remote-controlled helicopters has often been used to illustrate the longevity of the threat posed by violent non-state actors' drone use and to raise the spectre of drones being used to disseminate chemical (or biological/radiological/nuclear) agents – often coupled with the narrative that the subway attack could have been much worse had Aum chosen a more efficient way of disseminating[30] the nerve agent. However, recent scholarship has cast doubt on the extent of Aum's foray into drone use, pointing out that such accounts are largely based on circular citations and that there is a lack of information from primary sources to support them.[31]

Such fears grew further following the 9/11 attacks, sometimes supported by dubious evidence. In 2003, Moazzam Begg, a British Pakistani man who was held in extrajudicial detention by the US government at Guantanamo Bay for nearly three years, confessed to being part of a plot to spray the British Parliament with weapons-grade anthrax spores using a drone, in an attempt to kill British Prime Minister Tony Blair.[32] The existence of such a plot is, however, dubious at best. The plot has been called "laughable", "a cause for hilarity" and "clearly a fantasy" by several security experts, who assessed that such an operation was well beyond the capabilities of al-Qaeda at the time.[33] In addition, the credibility of the confession is further brought into question by allegations that Begg was threatened with death and torture during his over 300 interrogations.[34]

28 'Senate Government Affairs Permanent Subcommittee on Investigations Hearing on Global Proliferation of Weapons of Mass Destruction: A Case Study on the AUM Shinrikyo' (Washington, D.C., 31 October 1995), https://irp.fas.org/congress/1995_rpt/aum/ ; Kyle B Olson, 'Overview: Recent Incident and Responder Implications', in Proceedings of the Seminar of Responding to the Consequences of Chemical and Biological Terrorism, Office of Emergency Preparedness (Washington, DC: U.S. Public Health Service, Department of Health and Human Services, 1995), 2–42; David E Kaplan and Andrew Marshall, The Cult at the End of the World: The Terrifying Story of the Aum Doomsday Cult, from the Subways of Tokyo to the Nuclear Arsenals of Russia (New York: Crown Pub., 1996).
29 Kaplan and Marshall, The Cult at the End of the World.
30 The perpetrators boarded the subway trains with plastic bags containing sarin and released the agent by prodding the bags open with the metal tips of umbrellas before exiting the subway.
31 Zachary Kallenborn, Gary Ackerman, and Philipp C. Bleek, 'A Plague of Locusts? A Preliminary Assessment of the Threat of Multi-Drone Terrorism', Terrorism and Political Violence Online First (20 May 2022): 1–30, https://doi.org/10.1080/09546553.2022.2061960 ; Brian Scheu and Philipp Bleek, 'Death Cult Drones, Maybe', Arms Control Wonk, 26 May 2022, https://www.armscontrolwonk.com/archive/1215915/death-cult-drones-maybe/. Incidentally, in their extensive report on Aum's biological and chemical weapons, which drew extensively on correspondence and interviews with former Aum members, Danzig and his collaborators make no mention of any attempts by Aum to use remote-controlled helicopters to disseminate nerve agents. See Richard Danzig et al., 'Aum Shinrikyo: Insights Into How Terrorists Develop Biological and Chemical Weapons' (Center for a New American Security, 2011), https://www.jstor.org/stable/resrep06323.
32 Severin Carrell, 'British Prisoner "confesses" Plot to Poison-Bomb Parliament', The Independent, 30 November 2003, https://www.independent.co.uk/news/uk/this-britain/british-prisoner-confesses-plot-to-poisonbomb-parliament-80657.html.
33 John Mintz, 'Deals Reported Afoot for Detainees', Washington Post, 6 December 2003, https://www.washingtonpost.com/archive/politics/2003/12/06/deals-reported-afoot-for-detainees/bf58bfac-0c67-46e1-8f18-7ca1154ee077/ ; Sally Bolton, 'The Guantánamo Nine', The Guardian, 12 January 2004, https://www.theguardian.com/world/2004/jan/12/guantanamo.usa ; Linda Heard, 'Guantanamo's Scales of "Justice" Are Loaded', Gulf News, 2 December 2003, https://gulfnews.com/uae/linda-s-heard-guantanamos-scales-of-justice-are-loaded-1.372119.
34 George Kassimeris, 'Torture and Terrorism: An Interview with Moazzam Begg', Critical Studies on Terrorism 1, no. 3 (10 December 2008): 405–18, https://doi.org/10.1080/17539150802515079.

Begg was eventually released from custody in January 2005 due to the largely questionable nature of the original charges.[35] Interestingly, while reports of this plot have been repeated by analysts and scholars on numerous occasions, Rassler decided against including it in his comprehensive survey of terrorist drone use, stating that this case "lack[s] enough evidence to warrant inclusion."[36] Nevertheless, Rassler and Gartenstein-Ross et al. identify WMD attacks using drones as a significant threat, despite the lack of evidence of credible menace.[37]

The rise of IS' drone program brought renewed attention to the threat of WMDs being delivered by drones, with persistent rumours of the group planning such attacks, possibly in conjunction with major events.[38] Evidence of chemical weapon use in the Middle East by IS and other forces raised fears of such attacks taking place; among others, Rassler et al have argued that IS did attempt to modify drones for chemical weapon delivery.[39] However, while an attack with WMDs would be devastating, there is a complete lack of evidence of credible attempts by non-state actors to use drones for the dissemination of chemical, biological, or radiological agents.[40]

Domestic Terror Plots and Unaffiliated Actors

As early as 1971, members of the Jewish Defense League (JDL) plotted to use a drone airplane laden with explosives to attack the Soviet Union's mission to the United Nations in New York, as part of a larger JDL campaign against the Soviet Union's interests in the US. The plot was detailed by the FBI in a 1972 federal court hearing on a motion to dismiss the case of a JDL member accused of fire-bombing the office of Russian-born impresario Sol Hurok in January that year.[41] Members of the JDL spent $370 on sophisticated electronic equipment to modify two remote-controlled model airplanes, to which they planned to attach twelve-and-a-half sticks of dynamite and detonating equipment. While the plot never came to fruition, JDL members went as far as conducting several test flights before deeming the idea impractical due to air currents and aerodynamics issues.[42]

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35 David Ignatius, 'A Prison We Need to Escape', Washington Post, 14 June 2006, http://www.washingtonpost.com/wp-dyn/content/article/2006/06/13/AR2006061301501.html.

36 Rassler, 'Remotely Piloted Innovation', 5.

37 Rassler, 58–59; Daveed Gartenstein-Ross, Matt Shear, and David Jones, 'Virtual Plotters. Drones. Weaponized AI?: Violent Non-State Actors as Deadly Early Adopters' (Valens Global and the Organization for the Prevention of Violence, November 2019), 58–59, https://valensglobal.com/virtual-plotters-drones-weaponized-ai-violent-non-state-actors-as-deadly-early-adopters/ ; see also James Rogers and Dominika Kunertova, 'The Vulnerabilities of the Drone Age Established Threats and Emerging Issues out to 2035' (Center for War Studies, University of Southern Denmark, and Center for Security Studies, ETH Zürich, 2022), 7, https://portal.findresearcher.sdu.dk/en/publications/the-vulnerabilities-of-the-drone-age-established-threats-and-emer.

38 "'روسيا بالطائرات بدون موديلا'' ''روسيا تستهدف مصيرة قذائف اهوانا | السوريا تن طيرية تنظيم الدولة'' يدهي موديلا', Alsouria.net, 2 April 2018, https://www.alsouria.net/archive/content/تنظيم-الدولة-يدهي-موديلا-روسيا-بالطائرات-قذائف-اهوانا .

39 Don Rassler, Muhammad Al-Ubaydi, and Vera Mironova, 'The Islamic State's Drone Documents: Management, Acquisitions, and DIY Tradecraft', Combating Terrorism Center at West Point, 31 January 2017, https://ctc.westpoint.edu/ctc-perspectives-the-islamic-states-drone-documents-management-acquisitions-and-diy-tradecraft/.

40 In 2015, a Japanese man collected radioactive sand from Fukushima and flew it by drone to the roof of the Japanese prime minister's office, in a protest against nuclear energy policy. However, as he did not intend to disseminate the sand as a weapon, it can hardly be described as a WMD attack. More recently, there were accusations that Russia deployed chemical weapons by drone in the battle for Mariupol in Ukraine. However, no corroborating evidence was ever presented, and it appears to have been an incorrect report. 'Japan Radioactive Drone: Tokyo Police Arrest Man', BBC News, 25 April 2015, https://www.bbc.com/news/world-asia-32465624 ; Charlie Parker, Richard Lloyd Parry, and David Rose, 'Russians Accused of Chemical Attack by Drone on City Fighters in Mariupol', The Times, 13 April 2022, https://www.thetimes.co.uk/article/russians-accused-of-chemical-attack-by-drone-on-city-fighters-in-mariupol-z8fswshg7.

41 'Says JDL Planned Air Attack', The Jewish News, 15 February 1973.

42 Shlomo Mordchai Russ, 'The "Zionist Hooligans": The Jewish Defense League' (Ph.D. Thesis, New York, City University of New York, 1981), https://www.proquest.com/docview/303098095/abstract/540868423778406EPQ/1.

Again, following the 9/11 terror attacks, fears of domestic attacks by small cells proliferated. Such fears were borne largely of the perception that anyone with access to a commercial drone could weaponize it relatively easily for violent attack. In the aftermath of 9/11, intelligence reports indicated that, prior to the attack, al-Qaeda had considered using an explosive-laden drone to attack world leaders at the 2001 G8 summit in Genoa, Italy.[43] Rumours of another al-Qaeda plot involving drones surfaced in June 2002: quoting a German intelligence official, the Reuters news agency reported that al-Qaeda might be planning to attack passenger aircraft using model airplanes.[44] A similar and more significant plot emerged in 2011, when Rezwan Ferdaus, a physics graduate from Northeastern University, was arrested by the FBI for a plot to use remote-controlled model aircraft rigged with explosives and set on preprogrammed GPS routes to attack the Pentagon and the US Capitol building. In November 2012, Ferdaus pled guilty in federal district court in Boston and was sentenced to seventeen years in prison.[45] However, as Rassler notes, there is a "major disconnect that existed between [Ferdaus'] grand vision for the operation and the project's feasibility."[46] A number of experts familiar with the case identified several important points of failure, including (1) the need for a very long runway, (2) the airplanes' payload limitations, which would have prohibited the use of a GPS system and the amount of explosive Ferdaus had envisaged (which incidentally would have been insufficient to create the type of carnage he had imagined), and (3) the lack of any careful consideration regarding how the explosives would be detonated. Evaluating the credibility of Ferdaus' plan is made yet more complex by the fact that he had become ensnared in an FBI sting operation, thus raising the possibility of entrapment, and leading to further questions as to whether Ferdaus would have been able to carry out such a plot had he been left to his own devices.[47] Complicating the matter even further, Ferdaus' lawyers argued that the plot was a "fantasy" fuelled by mental illness, which deteriorated to the point that his father quit his job to care for Ferdaus as the plot was unfolding.[48]

Another apparent al-Qaeda affiliated plot in the West emerged in 2012, when Spanish and French authorities arrested two Chechen men and one Turkish man on terrorism charges.[49] Following a tip from a suspicious paragliding instructor who claimed that one of the men had asked him to fly over a shopping centre in Gibraltar, Spanish authorities raided the home of one of the men. Inside, authorities claim to have found traces of explosives, three motorized paragliders, and an undated, grainy video clip showing "a colorful model propeller plane noisily taking off" and, while airborne, dropping "a small object that falls to the ground."[50] While, the identity of the man is not clear from the clip, investigators claimed that this video was evidence that the trio were planning an attack using a remote-controlled aircraft, either on a shopping centre to coincide with the 2012 London Olympics, or on the US-Spanish naval base at Rota.[51] Police subsequently claim to have found enough explosive material to destroy a bus. However, the trio was never brought to trial. In fact, nine months after their arrest, they were freed by Spain's Supreme Court for lack of

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43 Michael A. Gips, 'A Remote Threat', Security Management, October 2002.
44 Gips.
45 Jess Bidgood, 'Massachusetts Man Gets 17 Years in Terrorist Plot', The New York Times, 2 November 2012, https://www.nytimes.com/2012/11/02/us/rezwan-ferdaus-of-massachusetts-gets-17-years-in-terrorist-plot.html.
46 Rassler, 'Remotely Piloted Innovation', 19.
47 Paul Harris, 'FBI Faces Entrapment Questions over Rezwan Ferdaus Bomb Plot Arrest', The Guardian, 29 September 2011, https://www.theguardian.com/world/2011/sep/29/fbi-entrapment-rezwan-ferdaus.
48 Jesse J. Norris and Hanna Grol-Prokopczyk, 'Estimating the Prevalence of Entrapment in Post-9/11 Terrorism Cases', The Journal of Criminal Law and Criminology 105, no. 3 (2015): 609–77; Alex S. Vitale, The End of Policing (Verso Books, 2021), 202; Ros Krasny, 'Massachusetts Man Pleads Guilty in Plot to Attack Pentagon, Capitol', Reuters, 11 July 2012, https://www.reuters.com/article/us-usa-security-ferdaus-idUKBRE8690V420120711.
49 Gordon M. Hahn, The Caucasus Emirate Mujahedin: Global Jihadism in Russia's North Caucasus and Beyond (Jefferson, NC: McFarland, 2014).
50 Harold Heckle, 'Spain Video Purports to Show Terror Plotting', Arkansas Online, 12 August 2012, https://www.nwaonline.com/news/2012/aug/12/spain-video-purports-show-terror-plotting-20120812/.
51 'Judge in Spain Takes Statements from Terror Suspects', CNN, 4 August 2012, https://www.cnn.com/2012/08/03/world/europe/spain-terror-arrests/index.html.

evidence, even though the men were still suspected of belonging to a terrorist organization.[52] The two Chechen men were subsequently deported to Russia while the third man remained in Spain, where he has now launched a lawsuit against the police for unlawful arrest, torture, falsification of evidence and sequestration.[53]

Other fears have related to the threat of organized terrorist groups exporting terror to the West, or drone capabilities circulating between active insurgencies and terror cells, notably Lashkar-e-Taiba and IS. In 2003, the FBI arrested several individuals residing in Virginia on a number of terrorism-related offences related to providing material support to the Pakistani terrorist group Lashkar-e-Taiba (LeT) and attempting to join the Taliban. Among those arrested as part of the so-called "Virginia jihad network", two US residents and an LeT operative based in the United Kingdom had collaborated to purchase sensitive technologies from LeT, including material to assist and enhance the performance of UAVs, notably preprogrammable GPS systems to guide drone flights.[54] The three individuals were eventually convicted for their roles in the conspiracy. Similar fears related to IS' networks of loosely affiliated sympathizers in Western countries.[55] However, while terror attacks relating to foreign insurgencies or terrorist groups have indeed occurred in the past twenty years, no such attacks have involved drones, and there is little evidence that groups such as IS reached advanced stages of planning for any such attacks.

Interest from right-wing extremist groups has also been an area of concern. In 2013, German police disrupted what appeared to be the first plot by right-wing extremists involving drones, recovering "bomb-making materials and a drone from the right-wing extremists, who were allegedly planning to use the device to bomb a German summer camp."[56] Interestingly, there is extremely limited publicly available information about the case; in fact, it is difficult to ascertain if anyone was convicted, let alone charges in connection to these reported plots. Moreover, the plot against the summer camp was omitted from Haugstvedt's survey of right-wing extremist drone plots.[57] Another example of right-wing extremist drone use comes from the 2017 Charlottesville Unite the Right protest, where the notorious night-time tiki torch parade into Lee Park was captured on camera by a drone and uploaded to the internet.[58] In a similar vein, according to US Capitol Police, senior members of the Oath Keepers attempted (but failed) to deploy a camera-equipped drone for reconnaissance during the 2021 attack on the US Capitol. The most high-profile instance of drone use by right-wing extremists is that of Brenton Tarrant, who flew a small commercial drone over the Al Noor Mosque in Christchurch, New Zealand, "recording an aerial view of the masjid grounds and buildings" focusing on "entry and exit doors, as well as the alleyway where he parked" on the day of his attack. These incidents give credence to a growing body of anecdotal evidence that right-wing extremists are increasingly beginning to adopt commercial drone technology.[59] However, again, fears of extensive threats of violent

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52 Karl Smallman, 'Gibraltar "Terror Trio" Released', Olive Press News Spain, 2 April 2013, https://www.theolivepress.es/spain-news/2013/04/02/gibraltar-terror-trio-released/.
53 Braulio García Jaén, Matías Escudero Arce, and Andrés Aguayo, 'Guilty until Proved Innocent: How Spain's Anti-Terrorism Campaign Has Stood Justice on Its Head', Mediapart, 9 April 2014, https://www.mediapart.fr/en/journal/international/090414/guilty-until-proved-innocent-how-spains-anti-terrorism-campaign-has-stood-justice-its-head.
54 Simon Freeman, 'Judge Pleads for Power to Jail Terror Fundraisers for Life', The Times, 17 March 2006, https://www.thetimes.co.uk/article/judge-pleads-for-power-to-jail-terror-fundraisers-for-life-n32kc2fhfbs.
55 See the case study on IS in Chapter 5.
56 Jack Nicas, 'Criminals, Terrorists Find Uses for Drones, Raising Concerns', Wall Street Journal, 29 January 2015, https://www.wsj.com/articles/criminals-terrorists-find-uses-for-drones-raising-concerns-1422494268.
57 Håvard Haugstvedt, 'The Right's Time to Fly?', The RUSI Journal 166, no. 1 (2 January 2021): 22–31, https://doi.org/10.1080/03071847.2021.1906161.
58 'Independent Review of the 2017 Protest Events in Charlottesville, Virginia' (Hunton & Williams LLP, 24 November 2017), https://www.policinginstitute.org/wp-content/uploads/2017/12/Charlottesville-Critical-Incident-Review-2017.pdf.
59 Yannick Veilleux-Lepage, Chelsea Daymon, and Amarnath Amarasingam, 'The Christchurch Attack Report: Key Takeaways on Tarrant's Radicalization and Attack Planning', ICCT Perspective, December 2020,

drone attacks by right-wing actors, and of right-wing actors mimicking techniques employed by other groups such as IS, appear not to have materialized thus far.[60]

Criminal Actors and Hobbyists

A final category of threats relates to criminal or non-politically-motivated actors.[61] In 2002, the Colombia Army discovered nine remote-controlled aircraft at a captured Revolutionary Armed Forces of Colombia (FARC) camp. The intended use of these remote-controlled aircraft remains unknown, but there is some speculation that they may have been intended to carry explosive devices, despite their limited range.[62] In recent years the FARC, along with other narcotrafficking organizations, has embraced drones for a variety of purposes, including reconnaissance, surveillance of drug shipments, protection of said drug shipments with explosive-laden drones, and also as a means of smuggling narcotics.[63] For example, the Frente Oliver Sinisterra (FOS) – a group of former FARC operatives who have refused to lay down their arms since the Colombia Peace Process came into effect in 2016 – began acquiring drones in early 2018 to conduct surveillance around their cocaine-producing factories near Tumaco, Colombia. In Nariño in September 2019, the Colombia military located two drones belonging to FOS laden with 300 grams of explosive. The drones were also equipped with various types of shrapnel, and are believed to have been destined to be deployed against public security forces.[64]

While the FARC and other armed groups in Colombia (and the surrounding area) have employed drone technologies, it is nonetheless possible to overstate their use of drones. In late 2021, a video went viral featuring a drone mounted with a handgun which could fire bullets while in the air, with the associated claim that the drone had been developed by the FARC. However, further investigation showed that the drone was actually made by an eighteen-year-old American student and posted to his YouTube channel in 2015.[65] To date, we could not find any official reports that the FARC or another non-state group in Latin America has employed weapons-mounted drones.

Don Rassler's 2016 report included "weapon mounts" of this sort as a potential threat "that will likely be explored by terror groups", and as evidence that drones present plentiful opportunities for innovation.[66] Once again, such predictions seek to highlight the diffuse threat of weaponized drones: anyone – any criminal element, any hobbyist with a drone and some technical knowledge – could present a deadly threat. To our knowledge, such fears have not materialized, and there is no evidence of criminal or hobbyist individuals using drones for violent attack. On the contrary,

https://icct.nl/publication/the-christchurch-attack-report-key-takeaways-on-tarrants-radicalization-and-attack-planning/.

60 Veilleux-Lepage, Daymon, and Archambault, 'Learning from Foes'.

61 The FARC were of course engaged in a long insurgency against the Colombian government. However, given that their use of drones is more directed towards smuggling, we have chosen to categorize them separately.

62 'Colombia - FARC Drones Discovered', EFE News Service, 28 August 2002; Robert J. Bunker, 'Terrorist and Insurgent Unmanned Aerial Vehicles: Use, Potentials, and Military Implications' (Strategic Studies Institute, US Army War College, 2015), https://www.jstor.org/stable/resrep11741 ; Gormley, Dennis, 'UAVs and Cruise Missiles as Possible Terrorist Weapons', in New Challenges in Missile Proliferation, Missile Defense, and Space Security, by James Clay Moltz (Monterey, CA.: Monterey Institute of International Studies, 2003).

63 Alejandro Sanchez, 'Worst Case Scenario: The Criminal Use of Drones', 2 February 2015, https://www.coha.org/worst-case-scenario-the-criminal-use-of-drones/ ; Robert J. Bunker and John P. Sullivan, Criminal Drone Evolution: Cartel Weaponization of Aerial IEDS (Xlibris Corporation, 2021); 'Narcotraficantes Envían Cocaína a Panamá Con Drones: Policía de Colombia', La Prensa Panamá, 16 November 2016, https://www.prensa.com/mundo/Narcotraficantes-enviando-Panama-Policia-Colombia_0_4622537754.html.

64 Alejandra Navarrete, 'Drones Pose New Threat on Colombia's Pacific Coast', InSight Crime, 25 September 2019, https://insightcrime.org/news/brief/drones-emerge-new-weapon-war-colombia-pacific/. Navarrete.

65 Catherine Bennett, 'Truth or Fake: Is This Armed Drone Being Used by FARC Rebels in Colombia?', France 24, 12 November 2021, https://observers.france24.com/en/tv-shows/truth-or-fake/20211112-truth-or-fake-drone-weapon-farc-colombia. Bennett.

66 Rassler, 'Remotely Piloted Innovation', 55.

as this survey of threats demonstrates, many of the most salient predictions of drone threats — WMD dispersal, small-cell terror attacks, or non-politically-motivated violence — have failed to translate into actual menaces. While they may still do so in the future, the most pressing threat at the moment remains that of sustained drone programs which can innovate, develop, and refine drone tactics and techniques over longer periods of time. Therefore, this report concentrates on the specific threats presented by organized drone programs, and does so through an empirical investigation of actual drone use.

Figure 3: Example of one of many tweets purporting to show that the FARC had developed drone-mounted weapons[67]

Typology of Terrorist Drone Use

In this section, we present a typology of the various ways in which non-state actors might use drones. It draws largely on the framework created by Rassler but is also informed by other frameworks in the published literature. Rassler's typology is based both on observed uses of drones by non-state actors and on expert predictions of likely uses; this report, however, demonstrates that several of these predictions have not materialised. In the table below, the five full-width rows represent the five aims of drone use, and each of these is broken down into multiple methods used to accomplish these aims. The examples which follow are meant as illustrations; in principle, any of these could be adopted by non-state groups that have drone programs, though some are far more common than others.[68]

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67 Blackbreadcrums [@banpercie], '!!Terroristas de las Farc atacan con un dron a centinelas de la base militar Yari, en la Vereda #PlayaRica, Macarena - Meta.!! https://t.co/7aQ7xM5HN6', Tweet, Twitter, 23 October 2021, https://twitter.com/banpercie/status/1452061072404406276.
68 As mentioned in the methodology section, a number of these categories are difficult to observe or report. While weaponization or significant disruption will often be reported publicly, non-state actors often have an interest in keeping their surveillance and logistics operations secret. Furthermore, mere observations of drones not engaged

Categories	Descriptions
Surveillance: Military UAVs were largely developed and produced for both spying and reconnaissance purposes;[69] as such it is unsurprising that commercial drones provide can provide non-state actors with an excellent infrastructure to conduct surveillance operations without being detected. Drones can be also be used to carry conventional spying devices.	
Reconnaissance	Drones can be used by violent non-state actors to capture live footage. There is some compelling evidence that IS used hobbyist drones to gain situation awareness on the battlefield as early as 2014. In August of that year, the group released a 14-minute video showing aerial views of the Tabqa air base prior to its campaign to capture the military installation.[70]
Electronic Collection	Several studies have demonstrated that a drone equipped with a radio transceiver can be used to extract unencrypted information from Wi-Fi and Bluetooth devices.[71] This can include the setup of a fake mobile Wi-Fi network or a rogue access point, enabling the interception of smartphone traffic by luring users to connect to a nearby "free Wi-Fi" point, which in turn captures the users' sensitive information such as passwords or credit card credentials.[72]
Operational Support	Drones can be used for command-and-control purposes, allowing groups to direct attacks, monitor progress, and supervise operations. IS has been known to use drones to direct vehicle-borne improvised explosive device (VBIED) attacks in urban settings by using drones to map out routes and guide attackers.[73]
External Communication: Drones can be used to convey messages to wider audiences by capturing images, dropping leaflets, or by their sheer presence.	
Messaging	Drones can be used to convey messages, by broadcasting audio, by dropping leaflets or other media, or simply through their presence. In 2018, authorities in the US announced that a Sacramento resident had been charged in connection with violating Temporary Flight Restriction areas during two separate National Football League matches where he used a drone to drop leaflets featuring swastikas and anti-media sentiments into the crowd.[74]

in public-facing action are unlikely to lead to published reports.

69 J.M. Sullivan, 'Evolution or Revolution? The Rise of UAVs', IEEE Technology and Society Magazine 25, no. 3 (2006): 43–49, https://doi.org/10.1109/MTAS.2006.1700021 ; Michael J. Boyle, The Drone Age: How Drone Technology Will Change War and Peace (Oxford: Oxford University Press, 2020); Richard Whittle, Predator: The Secret Origins of the Drone Revolution. (New York: Picador, 2015).

70 Peter Bergen and Emily Schneider, 'Now ISIS Has Drones?', CNN, 25 August 2014, http://edition.cnn.com/2014/08/24/opinion/bergen-schneider-drones-isis/.

71 Da-Zhi Sun, Li Sun, and Ying Yang, 'On Secure Simple Pairing in Bluetooth Standard v5.0-Part II: Privacy Analysis and Enhancement for Low Energy', Sensors 19, no. 15 (24 July 2019): 1–26, https://doi.org/10.3390/s19153259.

72 Stephen Gergo Vemi and Christo Panchev, 'Vulnerability Testing of Wireless Access Points Using Unmanned Aerial Vehicles (UAV)[C]', in 14th European Conference on Cyber Warfare and Security, ECCWS 2015, 2015, 425–28, https://pureportal.coventry.ac.uk/files/4028853/panchevcomb.pdf.

73 Susannah George and Lori Hinnant, 'Islamic State Turns to Drones to Direct Suicide Car Bombers', Associated Press, 2 February 2017, https://apnews.com/article/technology-protocols-ap-top-news-islamic-state-group-middle-east-4b36e6f9ed814880ab56a1763060759d. See the case study on IS in Chapter 5.

74 'Sacramento Area Resident Charged with Flying Drone Over NFL Games In Violation Of National Defense Airspace Regulations', The United States Attorney's Office. Northern District of California, 15 May 2019, https://www.justice.gov/usao-ndca/pr/sacramento-area-resident-charged-flying-drone-over-nfl-games-violation-national-defense.

Propaganda Production	In recent years, several terrorist organizations have begun using drones to film their attacks, training and other activities, and disseminating this imagery online. This has been employed extensively by IS, and by right-wing extremist groups in the US.[75]

Smuggling and Internal Communication:

Due to their flight range, size, speed and carrying capabilities, commercial drones pro-vide an optimal infrastructure for smuggling or for gaining access to restricted or protect-ed sites.

Access to Protected Facilities	As airborne devices, drones can access facilities which may be difficult to reach on the ground, and thus present a challenge for defending secure locations. In 2014, France's state-run power firm Électricité de France (EDF) announced that unidentified drones had flown over seven nuclear power plants during the course of a month.[76] A more routine manifestation of this use of drones relates to the smuggling of drugs, phones and even weapons to prisoners within high security prisons.[77]
Logistics and Supply	Drones may allow for the delivery of supplies where other means of transport are difficult. Due to the payload limitations of drones, such supplies are necessarily limited. However, the prospect of drone trans-portation has been raised in other contexts, notably that of humanitarian relief missions with hard-to-reach populations.[78] Similarly, multiple projects exist for the commercialization of drone transportation for smaller packages, a capability which may also be attractive to violent non-state actors.

Disruption:

Without engaging in violent action, drone users can employ remotely piloted aircraft to interfere with events and social processes, or to force restrictions to avoid real or suspect-ed threats, whether real or suspected.

Harassment	Non-violent drone flights can be used to draw attention to political viewpoints or disrupt specific events to convey a message. In 2013, the Pirate Party, a German political party, flew a small drone close to Chancellor Angela Merkel during an outdoor campaign event in Dresden.[79] In 2019, a Europa League football match at Luxembourg's Josy Barthel stadium between F91 Dudelange (Luxembourg) and FK Qarabag (Azerbaijan) was halted for fifteen minutes when a drone car-rying the flag of Nagorno-Karabakh – a disputed territory between Ar-menia and Azerbaijan – flew onto the pitch and began harassing in-censed Qarabag players, who tried in vain to down it using the ball.[80]

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75 See the case study on IS in Chapter 5.
Marc-André Argentino, Maher, Shiraz, and Charlie Winter, 'Violent Extremist Innovation: A Cross-Ideological Analysis' (International Centre for the Study of Radicalisation, 2021), https://icsr.info/wp-content/uploads/2021/12/ICSR-Report-Violent-Extremist-Innovation-A-Cross%E2%80%91Ideological-Analysis.pdf.
76 'Drones Spotted over Seven French Nuclear Sites, Says EDF', The Guardian, 30 October 2014, https://www.theguardian.com/environment/2014/oct/30/drones-spotted-over-seven-french-nuclear-sites-says-edf.
77 Michael Sinclair, 'Death from above: How Criminal Organizations' Use of Drones Threatens Americans', Brookings, 11 March 2021, https://www.brookings.edu/blog/order-from-chaos/2021/03/11/death-from-above-how-criminal-organizations-use-of-drones-threatens-americans/ ; 'Drugs, Weapons "Smuggled to Prisoners by Drone"', BBC News, 4 February 2022, https://www.bbc.com/news/world-us-canada-60262715.
78 John R. Emery, 'The Possibilities and Pitfalls of Humanitarian Drones', Ethics & International Affairs 30, no. 2 (summer 2016): 156–57, https://doi.org/10.1017/S0892679415000556.
79 Jason Bittel, 'German Pirate Party Uses Drone to Crash Angela Merkel Event', Slate, 18 September 2013, https://slate.com/technology/2013/09/german-pirate-party-uses-drone-to-crash-event-with-chancellor-angela-merkel-video.html.
80 Martyn Herman, 'Drone Stops Europa League Game in Luxembourg', Reuters, 3 October 2019,

Fake Threats	Drone presence – real or suspected – can force interruptions in activi-ties due to the potential menace that drones (and their possible weapon-ization) can present. In 2019, climate activists Extinction Rebellion threatened to fly drones over Heathrow Airport to force shutdowns.[81]
Vandalism	Drones can be used to deface property for political messaging, either by damaging buildings or structures or by soiling them with paint or other substances. In 2015, a well-known graffiti artist used a commercial drone to paint a giant red scribble across Kendall Jenner's face on one of New York City's largest and most viewed billboards.[82] In 2018, Greenpeace used a drone to enter the restricted airspace surrounding the EDF nuclear plant in Bugey, and deliberately crashed it into the wall of the plant's spent-fuel pool building to highlight "the extreme vulnera-bility of this type of buildings, which contain the highest amount of ra-dioactivity in nuclear plants."[83]
Interference	The mere presence of unknown drones can disrupt activities, force shutdowns, or otherwise hamper normal functioning. Between 19 and 21 December 2018, authorities at Gatwick Airport suspended over 1,000 inbound and outbound flights from the airport after receiving reports of two drones flying near the airfield.[84] The drone sighting forced Britain's second largest airport to shut three times in as many days, leaving up to 140,000 holiday travellers stranded. The incident represented the largest airport disruption since the 2010 Icelandic volcanic ash cloud.[85]

Weaponization:

This category refers to using drones to cause destruction or injury by equipping them with weapons systems (by dropping explosives such as bombs, by using the drone itself as the impactor, or by equipping the drone with a firearm).

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https://www.reuters.com/article/uk-soccer-europa-f91-qar-report-idUKKBN1WI2J4.

81 Matthew Green, 'Extinction Rebellion Considers Using Drones to Shut London's Heathrow Airport', Reuters, 30 May 2019, https://www.reuters.com/article/us-britain-protests-climate-change-idINKCN1T02RF.

82 Arthur Holland Michel, 'The Age of Drone Vandalism Begins with an Epic NYC Tag', Wired, 30 April 2015, https://www.wired.com/2015/04/age-drone-vandalism-begins-epic-nyc-tag/.

83 'Greenpeace Crashes Superman-Shaped Drone into French Nuclear Plant', Reuters, 3 July 2018, https://www.reuters.com/article/uk-france-nuclear-greenpeace-idUKKBN1JT17G.

84 Samira Shackle, 'The Mystery of the Gatwick Drone', The Guardian, 1 December 2020, sec. UK news, https://www.theguardian.com/uk-news/2020/dec/01/the-mystery-of-the-gatwick-drone ; Sheena McKenzie and Gianluca Mezzofiore, 'London's Gatwick Airport Shut for over 17 Hours in Unprecedented Drone Attack', CNN, 21 December 2018, https://edition.cnn.com/2018/12/20/uk/gatwick-airport-drones-gbr-intl/index.html ; Graeme Paton and Esther Webber, 'Gatwick Airport Reopens after Drone Shuts down Runway', The Times, 21 December 2018, https://www.thetimes.co.uk/article/snipers-deployed-as-industrial-size-drones-shut-down-gatwick-rfbzg3smz.

85 Vikram Dodd, 'Gatwick: Suspects Exonerated as Confusion Deepens over Drone Attack', The Guardian, 23 December 2018, https://www.theguardian.com/uk-news/2018/dec/23/gatwick-drone-chaos-arrested-couple-released-without-charge.

Pilot-to-Target	A drone can be loaded with explosives, piloted onto or near its target, and detonated, destroying the drone. These drones can either be pur-pose-built or modified from commercial or reconnaissance aircraft. For example, on 4 August 2018, as Venezuelan President Nicolás Maduro addressed a military parade in Caracas, at least two drones armed with explosives denoted near the president in an apparent targeted assassination attempt.[86] In 2021, Iraqi Prime Minister Mustafa al-Kadhimi sur-vived a similar assassination attempt after drones laden with explosives targeted his residence.[87] As part of the 2022 Russian invasion of Ukraine, both sides of the conflict have resorted to using loitering mu-nitions – pilotable munitions designed to be piloted to their target (or to attack targets with various degrees of autonomy) – with great success.[88]
Weapons of Mass Destruction (WMD) Delivery	Drones can in principle be used to disperse chemical or biological weapons or spread radioactive material. No successful attack of this kind has been attested; in April 2015, a Japanese man used a slightly modified DJI Phantom to drop a small quantity of radioactive sand col-lected from the area surrounding the Fukushima nuclear plant on the roof of the Japanese Prime Minister's Official Residence, as a means of protesting the pro-nuclear-power stance of the Japanese government.[89]
Explosive Delivery	Drones with release mechanisms can drop explosives onto targets, ei-ther unguided bombs or missiles. Multiple non-state groups have em-ployed drones in this way: IS has employed drones to drop custom-made munitions[90] while Hezbollah has claimed a capacity to launch guided missiles from drones.[91] In addition, in the aftermath of the Russian invasion of Ukraine, the Ukraine Army has resorted to using com-mercial drones to drop ordnance on Russian troops, fitted with 3D-printed fins to improve aerodynamics.[92]
Weapon Mount	There exist many videos made by hobbyists about the possibility of equipping drones with rifles or flamethrowers, though without any evi-dence of use for offensive purposes. In recent years, several videos have surfaced online depicting drone and firearm hobbyists (along with arms manufacturers) mounting firearms on modified commercial drones, ranging from handguns and shotguns to fully automatic assault rifles. One such video was misattributed to the FARC.[93]

86 Boyle, The Drone Age, 137.

87 John Davison and Ahmed Rasheed, 'Iraqi PM Safe After Drone Attack on Residence, Military Says', U.S. News, 6 November 2021, https://www.usnews.com/news/world/articles/2021-11-06/drone-attack-targets-iraq-pm-who-escapes-unhurt-iraq-military ; Louisa Loveluck and Mustafa Salim, 'Iraqi Prime Minister's Residence Targeted by Drone Strike, Military Says', Washington Post, 6 November 2021, https://www.washingtonpost.com/world/drone-hits-iraqi-pm-house/2021/11/06/248a4b4a-3f61-11ec-bd6f-da376f47304e_story.html.

88 Gerrit De Vynck, Pranshu Verma, and Jonathan Baran, 'Exploding "Kamikaze" Drones Are Ushering in a New Era of Warfare in Ukraine', Washington Post, 26 March 2022, https://www.washingtonpost.com/technology/2022/03/24/loitering-drone-ukraine/.

89 'Japan Radioactive Drone'; Shusuke Murai, 'Man Who Landed Drone on Roof of Japanese Prime Minister's Office Gets Suspended Sentence', The Japan Times, 16 February 2016, https://www.japantimes.co.jp/news/2016/02/16/national/crime-legal/man-landed-drone-roof-japanese-prime-ministers-office-gets-suspended-sentence/.

90 'Islamic State's Multi-Role IEDs', Frontline Perspective (London: Conflict Armament Research, April 2017), https://www.conflictarm.com/download-file/?report_id=2490&file_id=2492.

91 Nazir Reda, 'روطي «نورد» ةيرانيس اهمدختسيو يف دورج اقلملون» حزب اللاه', Aawsat, 23 August 2017, https://aawsat.com/home/article/1005981/ .حزب-اللاه»-«نورد»-روطي-ةيرانيس-ويستخدمها-يف-جرود-القلمون.

92 David Hambling, 'Every. Single. Drone. Fighting In Russia's War Against Ukraine', Popular Mechanics, 23 June 2022, https://www.popularmechanics.com/military/a40298287/drone-fighting-ukraine-war-russia/ ; David Axe, 'Ukraine's $10,000 Drones Are Dropping Tiny Bombs On Russian Troops', Forbes, 13 April 2022, https://www.forbes.com/sites/davidaxe/2022/04/13/ukraines-10000-drones-are-dropping-tiny-cheap-bombs-on-russian-troops/.

93 See the previous section.

This typology allows us to categorize the different ways that non-state groups can use drones. As mentioned above, several of these categories remain speculative rather than empirically established; this report aims to establish which types of drone usage commonly feature in violent non-state actors' drone programs.
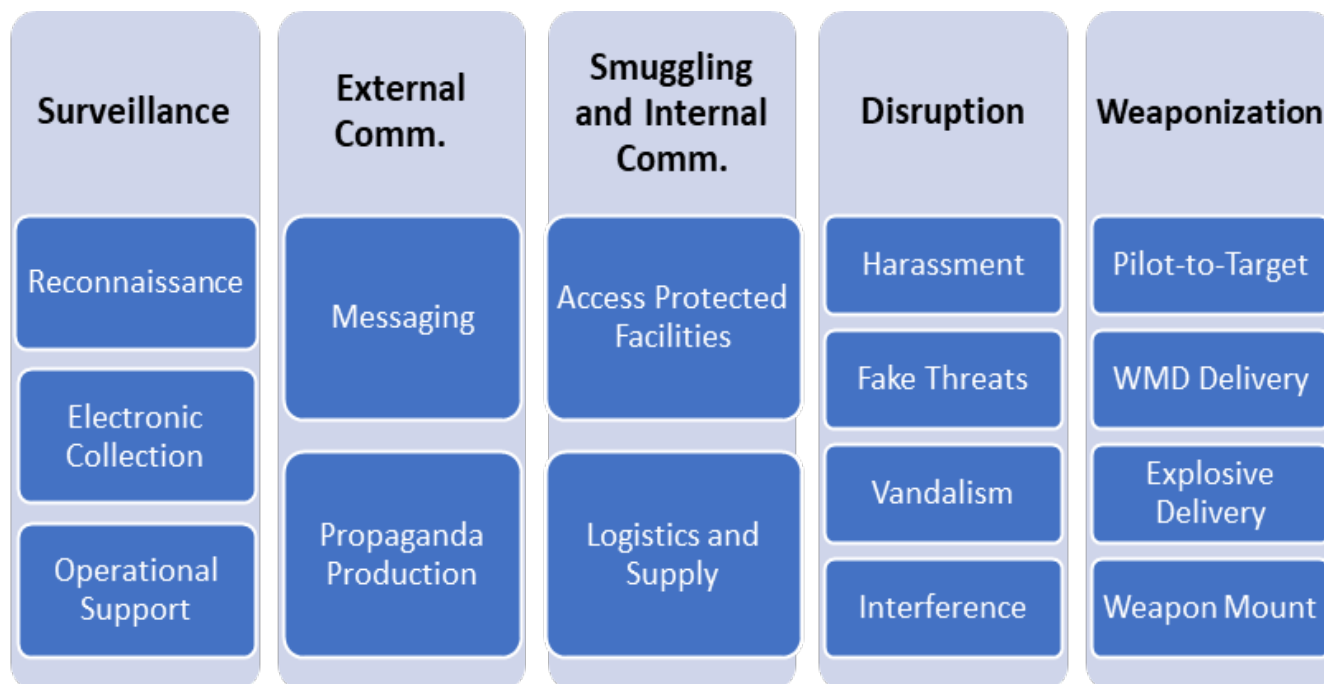

Figure 4: Typology of drone uses by violent non-state actors.[94]

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94 Modified from Rassler, 'Remotely Piloted Innovation', 10–11.

Chapter 2: Hezbollah

Past Developments

Hezbollah first encountered armed drones by being on the receiving end: in 1992, its general secretary was assassinated by Israel in an air strike guided by a drone.[95] Shortly thereafter, Hezbollah reportedly found ways to exploit the Israeli drone flights to their own advantage: in 1997, hacking into unsecured video feeds, Hezbollah detected and ambushed a Shayetet 13 commando, causing twelve deaths.[96] By November 2004, Hezbollah had acquired its own drones – Iranian Mersad-1 – and flown one into Israeli airspace, escaping unscathed.[97] The war with Israel in 2006 saw a flurry of activity, notably with explosive-laden Ababil drones being flown into Israel (and shot down).[98] Reports at the time incorrectly attributed an attack on Israeli corvette INS Hanit to an explosive drone; this was later corrected to a missile attack.[99]

Following a six-year hiatus in drone activity after 2006, Hezbollah resumed reconnaissance flights over Israeli territory, most of which were intercepted.[100] In 2016, a drone alternately attributed to Hezbollah or to Russia overflew Israel Defense Forces (IDF) manoeuvres and successfully evaded repeated interception attempts.[101] Meanwhile, other Hezbollah flights got dangerously close to the Dimona nuclear reactor, on one occasion (in 2012) capturing footage which was reportedly later shared with Iranian officials.[102] In parallel, Hezbollah employed drones to attack enemy militias in Syria, first in 2014 to attack Jabhat al-Nusra positions, and later (from 2016 onwards) to strike IS forces.[103] In these latter strikes against IS, Hezbollah employed small, commercially bought quadcopters to drop Chinese-made submunitions,[104] demonstrating a transition from the mostly Iranian-made military drones it had employed until then.

Current Advances

In its current state, the Hezbollah drone program seems mostly low-activity, though regular interceptions of drones take place in Israel. The group's rumoured drone capabilities, however, continue to be a source of significant concern in Israel. In 2021, for instance, the Israeli research institute ALMA estimated that Hezbollah possessed approximately 2,000 drones, sparking fears that Hezbollah could overwhelm Israel's air defences and cause extensive casualties in the case

95 Ronen Bergman, Rise and Kill First: The Secret History of Israel's Targeted Assassinations (New York: Random House, 2018), 391–97.
96 Roee Nahmias, 'Nasrallah Describes 1997 Ambush', Ynetnews, 9 August 2010,
https://www.ynetnews.com/articles/0,7340,L-3932886,00.html.
97 'Hezbollah Flies Unmanned Plane over Israel', CNN, 7 November 2004,
http://edition.cnn.com/2004/WORLD/meast/11/07/hezbollah/.
98 Milton Hoenig, 'Hezbollah's Drones', Federation of American Scientists - Public Interest Report 67, no. 2 (2014),
https://uploads.fas.org/2014/06/Hezbollah-Drones-Spring-2014.pdf.
99 'Missile, Not Drone, Hit Israeli Warship', The Guardian, 15 July 2006,
https://web.archive.org/web/20060716154601/http://www.guardian.co.uk/worldlatest/story/0%2C%2C-5952824%2C00.html.
100 Hoenig, 'Hezbollah's Drones'.
101 Ilan Ben Zion, 'IDF Fails 3 Times to Bring down Drone over Golan', Times of Israel, 17 July 2016,
http://www.timesofisrael.com/idf-we-tried-and-failed-3-times-to-bring-down-drone-over-golan/.
102 Hoenig, 'Hezbollah's Drones'; 'اسرائيل تهتم بزح هلالا باسراب طائرة بدون نودب رابط لتحقيق فوق مفعال ميدانو الونوي Al Wasat today, 1 ',
April 2016, https://www.alwasattoday.com/site-sections/45464.html.
103 Gili Cohen, 'Hezbollah Strikes Nusra Front Positions Near Syria Border, Iran Says', Haaretz, 22 September 2014,
https://www.haaretz.com/hezbollah-attacks-nusra-front-near-syria-1.5304809 ; Mona Alami, 'Analysis: Hezbollah Enters Drone Age with Bombing Raids in Syria', Middle East Eye, 21 March 2017,
http://www.middleeasteye.net/news/analysis-hezbollah-enters-drone-age-bombing-raids-syria.
104 Asswak Al arab, '22 برنامج "بزح هلالا" للطائرات من نودب رابط اُسجِل بقباس للجهات الافاعلت غير الحكومية'، أسواق العرب November 2017,
https://www.asswak-alarab.com/archives/15153.

of a major conflict.[105] Hezbollah's drone fleet appears to combine foreign – Iranian – models with locally modified vehicles, alongside commercially acquired quadcopters. As such, Hezbollah has demonstrated an advanced capacity to employ medium-altitude large drones such as the Shahed-129/Ayoub[106] Iranian drone – itself likely copied from the Israeli Hermes 450[107] – alongside small, modified quadcopters. This program has benefited from extensive infrastructure: in 2015, Jane's Defence Weekly reported the construction of a runway in the Bekaa valley used to launch larger drones, while other reports have suggested that Lebanese airports have been used to this end.[108] Hezbollah, as such, occupies a unique position among drone-capable non-state groups. It has long engaged with drones, its first flights taking place in 2004. While its efforts to penetrate Israeli airspace have been of mixed success, with some high-profile achievements and many interceptions, it has successfully conducted drone operations against other non-state actors in Syria. Its strong territorial base enables it to receive significant Iranian support, and allows it to operate larger, MALE drones. Finally, while Hezbollah's actual success may be mixed, Israeli actors nevertheless perceive a very major potential risk stemming from hidden or yet-to-be-developed drone capabilities of the group.

The strategic use of these drones for Hezbollah also differs from other groups. As noted above, Hezbollah's actual drone activities remain fairly muted compared to the magnitude of the perceived threat. Hezbollah appears, therefore, keen on demonstrating advanced drone capabilities, but refrains from using drones on a large scale. Massaab al-Aloosy argues that Hezbollah pursues a strategy of defensive deterrence vis-à-vis Israel, one which relies on demonstrating the capability and commitment to inflict unacceptable punishment in a conflict.[109] As al-Aloosy further argues, Hezbollah's forays into offensive warfighting in Syria furthers this deterrence posture by demonstrating capabilities without weakening the main fighting force.[110] In this view, the assertion of hidden drone capabilities reinforces the overall deterrence posture. In al-Aloosy's view, Hezbollah employs rockets (and drones) to wage largely psychological warfare, threatening Israel's northern settlements, spurring population movements, and exploiting Israeli fears of civilian casualties.[111]

In the nearly twenty years that Israel has been experiencing drone incursions from Lebanon and Syria, its methods to combat the threat have evolved as well. While Israel has routinely employed a combination of ground-to-air and air-to-air missiles to down encroaching drones, recent years have seen new capabilities being developed. In February 2022, Iron Dome batteries reportedly shot down a small quadcopter, demonstrating advanced capabilities to counter small, hard-to-detect drones.[112] The previous month, Israel claimed to have obtained photos of Hezbollah operatives from

105 Tal Beeri, 'Iran's "UAV Army" – A Global Threat' (ALMA Research and Education Center, December 2021), https://israel-alma.org/wp-content/uploads/2021/12/Irans-UAV-Army-–-A-Global-Threat.pdf ; Anna Ahronheim, 'Hezbollah Has Some 2,000 Unmanned Aerial Vehicles - ALMA', The Jerusalem Post, 22 December 2021, https://www.jpost.com/middle-east/article-689470 ; Seth J. Frantzman, 'Hezbollah's Drone Threat Is Now on Display', The Jerusalem Post, 19 February 2022, https://www.jpost.com/middle-east/article-697004.
106 'رس بزح هللا الفمضحو... هذه يه الاطائرات وصلاو خير لتقي يتلا اهب السوريين', Zamanalwsl, 19 July 2019, https://www.zamanalwsl.net/news/article/108798/.
107 David Cenciotti, 'Iran's New Spy Drone Is an Israeli Hermes 450/Watchkeeper Clone. Capable of Carrying Missiles.', The Aviationist (blog), 25 September 2012, https://theaviationist.com/2012/09/25/shahed129/.
108 'Hezbollah Builds Airstrip for UAVs in Lebanon's Bekaa Valley', Airforce Technology (blog), 26 April 2015, https://www.airforce-technology.com/uncategorized/newshezbollah-builds-airstrip-for-uavs-in-lebanons-bekaa-valley-4562766/ ; 'Hezbollah Drone Airstrip in Lebanon Revealed', Ynetnews, 25 April 2015, https://www.ynetnews.com/articles/0,7340,L-4650361,00.html ; 'Studies By Arab Researchers Of Distribution Of Foreign Bases Across Syria', Middle East Media Research Institute, 18 January 2018, https://www.memri.org/reports/studies-arab-researchers-distribution-foreign-bases-across-syria ; Assaf Naya, ''تارئاط 24'' بزح "هللا المسيّرة.. تقرير إسرائيلي يكشف أنواع ومساراتها.ae, 6 January 2022, https://24.ae/article/680796/تارئاط-هللا-بز ح-المسيّرة-تقرير-إسرائيلي-يكشف-أنواع-ومساراتها .
109 Massaab Al-Aloosy, 'Deterrence by Insurgents: Hezbollah's Military Doctrine and Capability Vis-à-Vis Israel', Small Wars & Insurgencies 33, no. 6 (August 2022): 999–1016, https://doi.org/10.1080/09592318.2022.2057750.
110 Al-Aloosy, 9.
111 Al-Aloosy, 8–9.
112 Emanuel Fabian, 'IDF Says It Downed Hezbollah Drone That Entered Israeli Airspace amid Major Drill', Times of Israel, 17 May 2022, https://www.timesofisrael.com/idf-says-it-downed-hezbollah-drone-that-entered-israeli-airspace-amid-major-drill/.

a downed drone, suggesting ongoing efforts at counter-intelligence and tracing drone operators.[113] Other reports suggest Israel may intercept drone communications and force drones to return to their base, thus allowing Israeli intelligence to map and track operators.[114] In sum, it appears that Israel seeks to both develop knowledge of Hezbollah's drone operations and intercept its flights. If Hezbollah's deterrence capabilities rely on the perception of a hidden – but credible – threat, such intelligence efforts may weaken the credibility of Hezbollah's deterrence posture and the role of drones in this strategy.
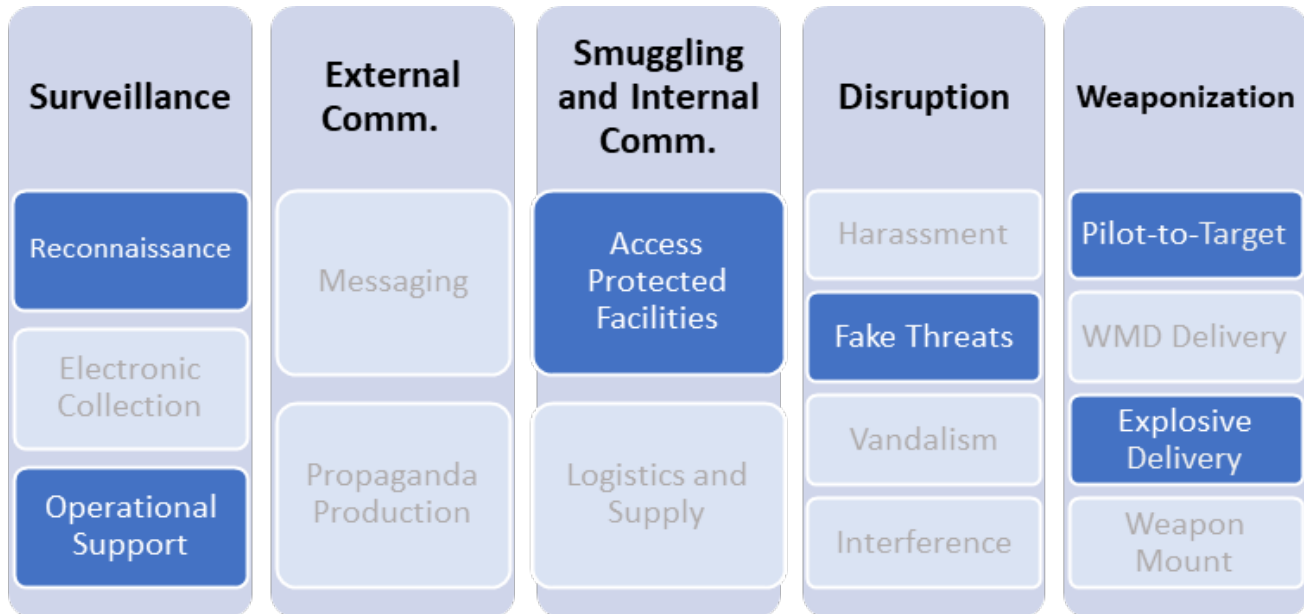

Figure 5: Typology of drone uses by Hezbollah. Blue boxes denote uses observed.

Development of Program

Tactical Innovation

Hezbollah's drone program has evolved through three principal phases, as already detailed above: after an early phase (2004–2007) in which a few isolated observation and pilot-to-target drone flights took place, the group resumed flights with larger, heavier, more sustained drone volumes toward Israel from 2012 onwards. At the same time, in a third phase (or theatre), the group engaged in offensive drone operations in support of Bashar al-Assad's regime in Syria, against other non-state groups. In this campaign, Hezbollah engaged in the first noted cases of non-state actor on non-state actor drone strikes, in addition to employing a plurality of drone types and munitions. Against Jabhat al-Nusra and other militias in Syria, Hezbollah largely employed small commercial quadcopters, equipped with submunitions to be dropped.[115] In some cases, the munitions appear to have been of Chinese origin, attached to the drone by Hezbollah operatives.[116]

In other instances, often against Israel, Hezbollah has employed large drones; often, these are Iranian models such as the Shahed-129/Ayoub, Ababil and Mersad-1/Muhajir models, which are medium-sized, medium-range drones, equipped either for pilot-to-target attacks or for

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113 Anna Ahronheim, 'Hezbollah Drone Downed by IDF Mistakenly Reveals Operatives' Pictures', The Jerusalem Post, 7 January 2022, https://www.jpost.com/breaking-news/article-691853.

114 «درون» حزب الله تتجسس عليه', Al Jarida, 11 January 2021, https://www.aljarida.com/articles/1610301482744419700/.

115 Reda, «حزب الله» درون» يطور إيرانية ويستخدمها في جرود القلمون'.

116 Asswak Al arab, 'برنامج "حزب الله" للطائرات من دون طيار يُسجّل سابقة للجهات الفاعلة غير الحكومية'.

observation.[117] It is in this latter respect – observation and reconnaissance – that Hezbollah appears to have had most success. On several occasions, observation drones have managed to enter deep into Israeli territory, gathering imagery of Israeli military bases or the Dimona nuclear reactor.[118] In the case of the nuclear reactor, these flights followed declarations by Hassan Nasrallah – Hezbollah's general secretary – that Hezbollah possessed the capability to specifically target this power plant, despite its great distance.[119] These flights, therefore, serve a dual purpose of both demonstrating capability and gathering information. As mentioned previously, the importance of Hezbollah's drone program comes from the perception that the group possesses significant drone capabilities which it could unleash in the case of a major conflict with Israel;[120] in launching regular long-range reconnaissance flights, Hezbollah seeks to demonstrate this capability and assert its ability to threaten Israel, despite an otherwise rather muted pattern of attacks.

Development and Sponsors

Hezbollah has succeeded in combining significant support from Iran with other sources of supply, including networks of supporters across the world. Hezbollah's heavy reliance on commercial drones is partly sustained by supporters abroad, who help purchase equipment on behalf of the group. In the last five years, prosecutions were brought in the US against two brothers who pleaded guilty to purchasing drone equipment for Hezbollah.[121] Hezbollah has subsequently demonstrated the capability to modify these drones internally to attach munitions and make them capable of warfare. Among others, Chinese submunitions – of unclear provenance – were identified in Aleppo in 2016 being dropped from a commercial quadcopter.[122]

Hezbollah's largest and most significant patron remains Iran, via Iran's Islamic Revolutionary Guards Corps (IRGC) Quds Force. Hezbollah has operated a number of medium-sized drones of Iranian models, notably the Ababil series of reconnaissance/pilot-to-target drones and the Shahed-129. As reported by Matthew Levitt – largely based on American government sources – Hezbollah relied heavily on Iran to replenish its weapons stocks after the 2006 war, though it always maintained its own networks of supply in parallel.[123] Reports indicate that Iran has welcomed Hezbollah troops in Iran for training on drone operations, in addition to providing tactical advice.[124] In fighting in Syria, Hezbollah engaged in support of Iranian operations, and was reinforced by Iranian officers (and later non-commissioned officers).[125] As Ostovar further notes, the fact that Hezbollah controls swathes of territory in which IRGC advisers and support networks can be deployed makes the group a particularly attractive client for Iran.[126] Despite

117 سر حزب الله المفضوح... هذه هي الطائرات والصواريخ التي يقتل بها السوريين'.

118 'حزب الله" يصوّر قاعدة عسكرية إسرائيلية سرية (شاهد)', Arabi 21, 6 December 2020, https://arabi21.com/story/1319840/حزب-الله-يصور-قاعدة-عسكرية-إسرائيلية-سرية-شاهد; اسرائيل يهتم حزب الله بارسال طائرة بدون طيار للتحليق فوق مفاعل ديمونا النووي'.

119 Al-Aloosy, 'Deterrence by Insurgents', 9.

120 Ahronheim, 'Hezbollah Has Some 2,000 Unmanned Aerial Vehicles - ALMA'; Beeri, 'Iran's "UAV Army" – A Global Threat'.

121 أمريكة يهتم بتصدير أجزاء طائرات بلا طيار لحزب الله', Deutsche Welle Arabic, 17 February 2018, https://p.dw.com/p/2sqRc ; 'Lebanese Man Pleads Guilty in US to Buying Drone Parts for Hezbollah', Times of Israel, 11 March 2020, https://www.timesofisrael.com/lebanese-man-pleads-guilty-in-us-to-buying-drone-parts-for-hezbollah/ ; أمريكة لحزب الله "درون" تكنولوجيا, Skynewsarabia, 19 May 2020, https://www.skynewsarabia.com/middle-east/1345644-لبناني-يعترف-بتصدير-تكنولوجيا-درون-أمريكية-لحزب-الله.

122 Beeri, 'Iran's "UAV Army" – A Global Threat', 29; Asswak Al arab, 'برنامج "حزب الله" للطائرات من دون طيار يُسجّل سابقة للجهات الفاعلة غير الحكومية'.

123 Matthew Levitt, 'Hezbollah's Procurement Channels: Leveraging Criminal Networks and Partnering with Iran', CTC Sentinel 12, no. 3 (March 2019): 1–9.

124 Ibrahim Shamri, 'الـ«درون» إبراهيم رابع باب للحدود', Alriyadh journal, 8 October 2021, http://www.alriyadh.com/1911652.

125 Afshon Ostovar, 'The Grand Strategy of Militant Clients: Iran's Way of War', Security Studies 28, no. 1 (January 2019): 176, https://doi.org/10.1080/09636412.2018.1508862.

126 Ostovar, 167.

Hassan Nasrallah's recent assertion that Hezbollah has the capability to build drones domestically and does not need to depend on Iran,[127] there is little to no evidence that Hezbollah has achieved self-sufficiency in this regard.[128]

Iran, in addition to supplying Hezbollah, has also allegedly been launching its own drone flights over Israel, using similar drones to the ones supplied to Hezbollah, and sometimes blurring lines of responsibility and attribution (a key objective of using clients).[129] In 2018, Israel shot down a Shahed Saeqeh drone, a (loosely) reverse-engineered copy of the American RQ-170 Sentinel captured by Iran in 2011.[130] In this case, Israel also claimed to have identified and destroyed the Iranian command vehicle, based in Syria. More recently, in March 2022, Israel struck a base in Western Iran, destroying what they claimed to be large numbers of Iranian drones in response to Iran's ongoing "UAV Terror".[131]

Finally, Hezbollah has been known to collaborate with other Iran-aligned groups in sharing drone technology, most notably the Houthi Movement (see Chapter 4: Houthi Movement). As Levitt notes, Hezbollah's supply networks have been bidirectional, with Hezbollah also sharing its supplies with Iran and its other clients.[132] There is clear evidence that Hezbollah has helped Houthis train in drone operations, along with other Iranian militia clients in Iraq, among others.[133] In particular, Juneau argues, Hezbollah's expertise developed in the war in Syria has been disseminated to other Iranian clients, notably Houthi forces, including the use of drones.[134] Nevertheless, it should be noted that the two groups use different drone models: while both groups have employed Ababil variants, Hezbollah has also employed different Iranian drone models, notably the Shahed-129 which has not been seen in Yemen. Furthermore, Hezbollah has been accused of collaborating with militias in Iraq, notably Kata'ib Hezbollah (an Iraqi group), in launching drone attacks in Kurdistan in June 2022.[135]

127 'Hizbullah Secretary-General Hassan Nasrallah: We Have Been Manufacturing Our Own Drones And Transforming Missiles Into Precision Missiles For Years; We Do Not Need Missile And Drone Shipments From Iran', Middle East Media Research Institute, 16 February 2022, https://www.memri.org/tv/hizbullah-sec-gen-nasrallah-tech-know-how-missiles-precision-manufacture-drones.

128 In 2021, Hezbollah claimed to have launched a "Hassan" drone over Israel, whose provenance or technical details are not known. 'IAF Flies over Beirut after Drone Enters Israel; Hezbollah Claims Responsibility', The Times of Israel, 18 February 2022, https://www.timesofisrael.com/iaf-flies-over-lebanon-after-drone-enters-israel-hezbollah-takes-responsibility/.

129 Ostovar, 'The Grand Strategy of Militant Clients', 164; Thomas Juneau, 'How War in Yemen Transformed the Iran-Houthi Partnership', Studies in Conflict & Terrorism Online First (30 July 2021): 2, https://doi.org/10.1080/1057610X.2021.1954353.

130 Judah Ari Gross, 'Iranian UAV That Entered Israeli Airspace Seems to Be American Stealth Knock-Off', Times of Israel, 10 February 2018, https://www.timesofisrael.com/iranian-uav-that-entered-israeli-airspace-seems-to-be-american-stealth-knock-off/ ; Wim Zwijnenburg, 'Sentinels, Saeqehs and Simorghs: An Open Source Survey of Iran's New Drone in Syria', Bellingcat, 13 February 2018, https://www.bellingcat.com/news/mena/2018/02/13/sentinels-saeqehs-simorghs-open-source-information-irans-new-drone-syria/.

131 Farnaz Fassihi, Ronen Bergman, and Eric Schmitt, 'Iran's Attack Was Response to Secret Israeli Attack on Drone Site', The New York Times, 16 March 2022, https://www.nytimes.com/2022/03/16/world/middleeast/iran-israel-attack-drone-site.html ; Emanuel Fabian, 'IDF Airs Footage of Drone Interceptions, Accuses Iran of Escalating "UAV Terror"', The Times of Israel, 7 March 2022, https://www.timesofisrael.com/idf-airs-footage-of-drone-interceptions-accuses-iran-of-escalating-uav-terror/.

132 Levitt, 'Hezbollah's Procurement Channels', 5.

133 ''حزب الله'' والطائرات الإيرانية المسيَّرة أمن لزعزعة طهران داوت أبعاد: في اليمن'، Alsahil.net, 17 January 2022, https://alsahil.net/news16585.html ; Naya, 'طائرات ''حزب الله'' المسيَّرة.. تقرير إسرائيلي يكشف أنها ساعدت مسارتها '.

134 Juneau, 'How War in Yemen Transformed the Iran-Houthi Partnership', 9.

135 'Kurdistan Accuses Kataib Hezbollah of Involvement in Erbil Drone Attack', Asharq Al-awsat, 10 June 2022, https://english.aawsat.com/home/article/3694996/kurdistan-accuses-kataib-hezbollah-involvement-erbil-drone-attack.

Hezbollah therefore presents a distinctive drone threat for four reasons. First, the group has the longest-running non-state drone program, with the first flights in Israel taking place in 2004. Furthermore, it has developed extensive supply and support networks, with bases, modification capabilities, and a wide variety of drone models used. Second, the group has acquired extensive expertise in the employment of drones, and has been willing to share it with a wide variety of other clients and Iranian allies across the Middle East. Third, there are long-standing fears in Israel that Hezbollah may have assembled a substantial drone arsenal, which may allow the group to deter Israel and prepare for major conflict. Finally, Hezbollah has demonstrated significant operational flexibility, launching long-range flights in Israel and offensive operations against other non-state groups in Syria, as well as successful reconnaissance flights near the borders of Lebanon and Syria.

Chapter 3: Hamas

Past Developments

Hamas' experimentation with drone technology, though long-standing, has generally been of a significantly lower order of magnitude compared to Hezbollah or other non-state groups. They have displayed lesser tactical and technical innovation, a lower volume of attacks, and accordingly fewer tactical and strategic successes in their employment of drones. Nevertheless, Hamas has continued to invest in building a drone program, and the sheer length of its involvement in drone use warrants consideration. In some ways, Hamas' continued engagement allows for an exploration of the conditions which make a drone program successful, and of why non-state groups continue to employ drones even where success is elusive.

Hamas' first foray into drone development has been traced back to 2003, when Israel reportedly killed members of a Hamas cell working on drone development.[136] After an ensuing lull for the better part of a decade (notwithstanding regular concerns among Israeli security circles), incidents picked up in 2012–2013, when several test flights by Hamas were reported, in conjunction with Israeli strikes on facilities claimed to be supporting drone development.[137] In July 2014, Israeli Patriot anti-air missile batteries intercepted Hamas drones on two occasions, with Hamas claiming to have successfully penetrated Israeli airspace. According to Hamas, several drones succeeded in overflying Tel Aviv and capturing footage, though Israel claimed it chose to let Hamas drones enter its airspace to wait for the optimal opportunity for interception.[138] By May 2018, reports suggested IDF were fortifying Iron Dome missile batteries to reduce the potential damage from regular drone attacks by Hamas, while the following year an IDF vehicle was damaged by drone-dropped explosives.[139]

Throughout these episodic uses of drones to enter Israeli airspace, the IDF regularly engaged in counter-terror operations to hamper Hamas' program. These operations included, first and foremost, the destruction of testing and development facilities. A second aspect of Israeli counter-terror operations against Hamas has relied on targeted killings of key engineers and program managers. Most prominently, in 2016, Mohammad al-Zawahri was killed in Tunis, with Hamas accusing Mossad of conducting the attack.[140] Al-Zawahri was reportedly responsible for developing Hamas' drone program, having previously collaborated with Hezbollah on weapons technology development as well.[141] In April 2018, Fadi al-Batsh, a lecturer in engineering, was

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136 Rassler, 'Remotely Piloted Innovation', 30–31.
137 Rassler, 31; Hamas Test Running a UAV in Khan Yunis, Gaza, 2012,
https://www.youtube.com/watch?v=A3jg4fZLfxQ ; Avi Issacharoff, 'PA Forces Thwart Hamas Attack Drone Plot in West Bank', Times of Israel, 25 October 2013, http://www.timesofisrael.com/pa-forces-uncover-hamas-attack-drone-plot/.
138 Yoav Zitun, 'Hamas Claims Multiple UAVs Launched into Israel', Ynetnews, 14 July 2014,
https://www.ynetnews.com/articles/0,7340,L-4543077,00.html ; 'IDF Intercepts Another Hamas UAV', Ynetnews, 17 July 2014, https://www.ynetnews.com/articles/0,7340,L-4545505,00.html ; Caroline Alexander and Gwen Ackerman, 'Hamas Bragging Rights Grow With Drones Use Against Israel', Bloomberg, 16 July 2014,
https://www.bloomberg.com/news/articles/2014-07-16/hamas-bragging-rights-grow-with-drones-use-against-israel.
139 Alex Fishman, 'The New Explosive Drone Threat from Gaza', Ynetnews, 29 July 2018,
https://www.ynetnews.com/articles/0,7340,L-5318598,00.html ; 'Army: Gaza Drone Drops Explosives in Israel near Border, IDF Vehicle Damaged', Times of Israel, 17 September 2019,
https://www.timesofisrael.com/army-gaza-drone-dropped-explosives-in-israel-near-border-idf-vehicle-damaged/.
140 In his book Rise and Kill First, Ronen Bergman similarly attributes the attack to Mossad. Bergman, Rise and Kill First, 713.
141 Roi Kais and Liad Osmo, 'Tunisian Media Reporting Mossad Assassinates Hamas Official', Ynetnews, 16 December 2016, https://www.ynetnews.com/articles/0,7340,L-4894098,00.html ; 'Hamas Accuses Israel of Killing Its Tunisian Drone Expert', BBC News, 17 December 2016, https://www.bbc.com/news/world-middle-east-38354958 ; Jack Khoury, 'Hamas: Drone Expert Assassinated by Israel in Tunisia Was Part of Our Military Wing', Haaretz, 17

killed in Malaysia, reportedly by Mossad agents.[142] Al-Batsh was known to have expertise in drone development and communications technologies, and was claimed by Hamas as a member. According to reports in the New York Times, he may have worked on sourcing communications equipment from North Korea; other reports suggest he may have been working on encrypted drone communications.[143]

Current Advances

While Hamas' drone attacks remain few, and successful attacks even fewer, the group nevertheless continues to highlight its employment of drones as a marker of military-technological prowess. Israeli security officials have long voiced fears of Hamas conducting drone terrorist attacks, and it appears that Hamas is just as intent on fostering this sense of threat as it is on actually using drones for attacks. Accordingly, recent efforts have focused on the development of propaganda outputs centring on the drone as an artifact of homegrown weapons development. In May 2021, Hamas released a video showing the launch of several Shehab drones, as a way of demonstrating the group's capability to employ drones it claimed to produce itself.[144] In this particular instance, Israel claimed to have shot down all drones involved, while Hamas refrained from claiming any specific success beyond the introduction of new drones.[145] More recently, on 21 September 2022, Hamas unveiled the Shehab Drone Square in Gaza, where a model of the drone is placed on top of a column.[146] In both these cases, the effective use of armed drones by Hamas seems to be of relatively low importance; indeed, Hamas has not demonstrated any ability to regularly use drones successfully. Indeed, since 2012, only a handful of Hamas drone attacks have been tracked – thirteen, in our database – with most of them being shot down by Iron Dome or Patriot batteries, or by air-to-air missiles. Rather, Hamas seems to see in the drone a symbol of military status, and is therefore intent on demonstrating the capacity to launch and control drones, and to occasionally penetrate into Israeli airspace. Therefore, while it may be puzzling why Hamas would continue to invest in drone development despite the lack of success, the association of drone technology with military status may explain the group's continued employment of drones. It should also be noted that there is no evidence of Hamas investing heavily in drone development; while it is impossible to effectively trace the magnitude of effort devoted to this sector, the sporadic nature of these attacks suggests that Hamas' drone program may not be a top priority.

December 2016, https://www.haaretz.com/middle-east-news/2016-12-17/ty-article/hamas-drone-expert-assassinated-by-israel-part-of-our-military-wing/0000017f-e201-d804-ad7f-f3fbcafc0000?v=1664181335653.
142 Elior Levy, 'Palestinian Electrical Engineer Shot Dead in Malaysia', Ynetnews, 21 April 2018, https://www.ynetnews.com/articles/0,7340,L-5236433,00.html.
Israel denied involvement, although Israel has been known to deny operations in which they have well-documented involvement. 'Fadi Al-Batsh Killing: Israel Dismisses Involvement', BBC News, 22 April 2018, https://www.bbc.com/news/world-asia-43854982.
143 Hannah Beech and Ronen Bergman, 'Behind a Roadside Hit in Malaysia, Israeli-Palestinian Intrigue', The New York Times, 25 April 2018, https://www.nytimes.com/2018/04/25/world/asia/hamas-mossad-malaysia.html ; Fishman, 'The New Explosive Drone Threat from Gaza'.
144 Emanuel Fabian, 'Hamas Releases Video of "Shehab" Kamikaze Drone', Times of Israel, 14 May 2021, https://www.timesofisrael.com/liveblog_entry/hamas-releases-video-of-shehab-kamikaze-drone/.
145 كتائب القسام تستهدف إسرائيل بـ"درون" مفخخة.. وأعردي رشني فيديو "مصير طائرة شاب", CNN Arabic, 13 May 2021, https://arabic.cnn.com/middle-east/article/2021/05/13/hama-qassam-brigades-say-they-have-carried-out-drone-attacks-israeli-targets ; תמצ צורי, 'הצ''ל ליפה ילך סיט ילתב יתאומישיו שהדרו משטח הזה | דועית dna, באוי נותיז, א''ילאור לוי', Ynet, 13 May 2021, https://www.ynet.co.il/news/article/SkGGfi9dd.
146 'Hamas' Drone, Shehab, Revealed in Public Ceremony in Gaza', Palestine Chronicle, 22 September 2022, https://www.palestinechronicle.com/hamas-drone-shehab-revealed-in-public-ceremony-in-gaza-photos/.
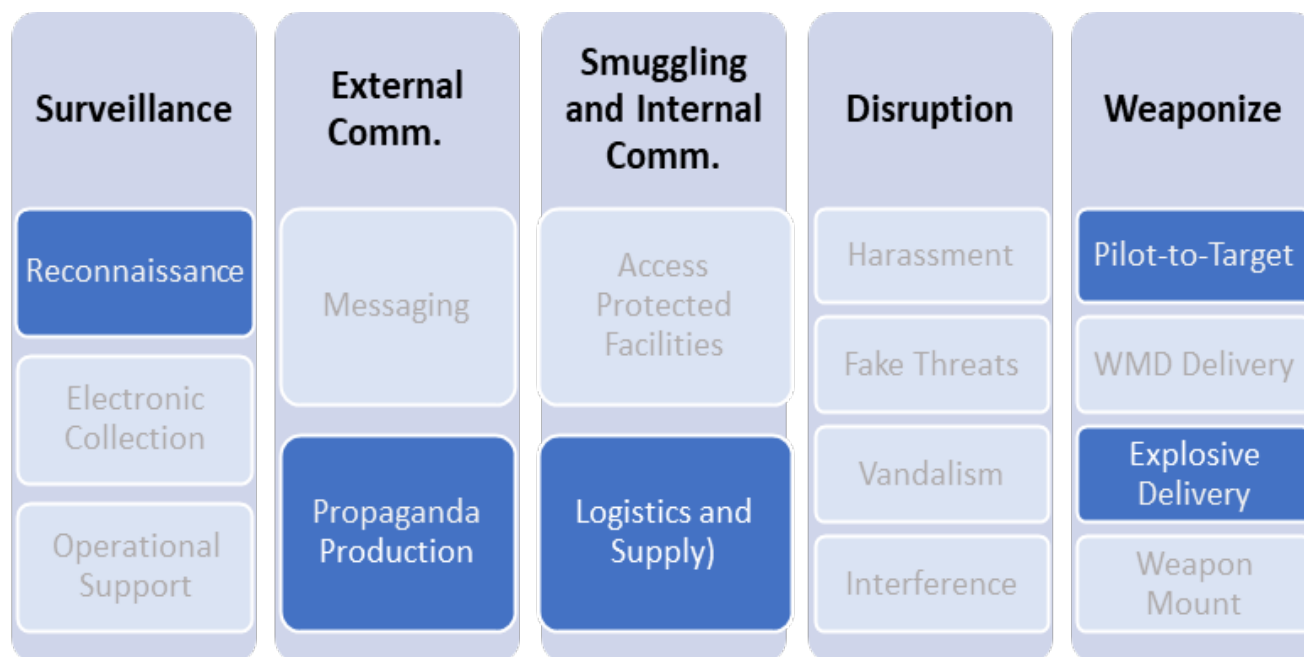
Figure 6: Typology of drone uses by Hamas. Blue boxes denote uses observed.

Development of Program

Tactical Innovation

Hamas has shown little in the way of notable tactical development in drone use, largely tending to use drones individually or in small groups. Unlike other groups such as the Houthi Movement or IS, Hamas appears to have used a combination of small quadcopters for explosive delivery and larger drones for pilot-to-target attacks. Thus, while some commentators tend to associate the use of drones by Hamas with its prior use of kites loaded with explosives and the use of explosive-laden balloons by Palestinian militants,[147] different types of drones serve different purposes and are used in different ways. The path of development is also not necessarily one where more advanced drones replace smaller quadcopters. In 2014, attacks were launched using Iranian-model Ababil-1 drones, and Hamas claimed that at least one drone overflew Tel Aviv, penetrating more than 60 km inland.[148] A few years later, in 2018, reports noted Hamas' use of quadcopters, which were employed to drop explosives, notably targeting Iron Dome batteries.[149] Further evolution took place in 2021, with reportedly self-made Shehab drones (based on the Iranian Ababil drone model) being employed in combat.[150]

Hamas' use of drones, therefore, displays a rather peculiar lack of operational path dependency, engaging in a variety of types of attacks using both small, commercial off-the-shelf quadcopters and larger military drones. Similarly, the group aims at a variety of targets, both tactical (such as IDF vehicles or Iron Dome batteries) and strategic-political ones (such as – it claims – the Ministry

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147 Adam Rasgon, 'Hamas Said to Agree to Gradually Decrease Flaming Kite Attacks on Israel', Times of Israel, 18 July 2018, https://www.timesofisrael.com/hamas-said-to-agree-to-halt-flaming-kite-attacks-on-israel/ ; Steve Hendrix, Hazem Balousha, and Ruth Eglash, 'Gaza Militants Target Israel with Party Balloons Bearing Bombs', Washington Post, 8 March 2020, https://www.washingtonpost.com/world/middle_east/gaza-palestinian-balloon-bombs-israel/2020/03/08/d2069346-54d5-11ea-80ce-37a8d4266c09_story.html.
148 Zitun, 'Hamas Claims Multiple UAVs Launched into Israel'.
149 Fishman, 'The New Explosive Drone Threat from Gaza'. One possible justification might be that as Iron Dome batteries are upgraded and become more effective at shooting down drones, small quadcopters flying at low altitude may be perceived as less vulnerable to anti-aircraft batteries than larger drones.
150 Lenny Ben-David, 'Hamas' Advanced Weaponry: Rockets, Artillery, Drones, Cyber', Jerusalem Center for Public Affairs, 1 August 2021, https://jcpa.org/article/hamas-advanced-weaponry-rockets-artillery-drones-cyber/.

of Defence in Tel Aviv[151]). Nevertheless, the lack of apparent success in drone attacks raises questions concerning the reason for this tactical plurality. One possible explanation lies in a lack of technical and tactical maturity: the group may not have settled on the most effective procedures. Another possible explanation may lie in a lack of effectiveness: as the group sees its efforts countered, it may seek to experiment with other modes of attack. Lastly, another explanation may lie in prioritizing propaganda value: the group is more concerned about being seen using drones than using them effectively, and flexibility may heighten the sense of pervasive menace rather than undermine it.

Structure of Development and Sponsors

Hamas' drone program falls under the umbrella of its military wing, the al-Qassam Brigades. In addition, Hamas appears to rely on a series of more or less closely affiliated weapons experts who possess specific expertise. Mohammad al-Zawahri, assassinated in Tunis in 2016, for instance, possessed extensive expertise in weapons development. More significantly, he also possessed long-standing ties to both Hezbollah and Hamas, and may have acted as a bridge for technology transfer between the two.[152] Another sponsor or supplier of drones to Hamas is Iran, through transfers of both technology and weapons systems themselves. As mentioned above, Hamas has been known to use Ababil-1 drones, an Iranian-made model also employed by the Houthi Movement under the designation Qasef-1. The Shehab drone unveiled by Hamas in 2021 appears to be a version of this Ababil family, which Hamas claims to manufacture locally.[153] In other instances, Israel claims to have intercepted Iranian drones possibly carrying weapons loads to Hamas, suggesting the presence of a supply network between Iran and Hamas.[154] Finally, other Israeli sources have suggested Hamas may have relied on imports of commercial drones, with high numbers of drones and parts being intercepted by the Israeli Overland Crossings Authority. [155]

Hamas, therefore, despite setbacks, appears to be seeking to continue development of its drone program. Notwithstanding the sporadic nature of its activities, it now seeks to emphasize the domestic nature of its production.[156] Propaganda videos of drone activities, as well as public displays in Gaza, demonstrate that the group sees drone use as a symbol of status as a technologically advanced military power. That being said, the group does not appear to have found a reliable use for these drones in combat, and the threat appears to be more rhetorical than actual, aside from limited incidents.

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151 Zitun, 'Hamas Claims Multiple UAVs Launched into Israel'.

152 Bergman, Rise and Kill First, 713.

153 Seth J. Frantzman, 'Iran's Hand Seen in Hamas Drone Threat against Israel', The Jerusalem Post, 15 May 2021, https://www.jpost.com/middle-east/iran-news/irans-hand-seen-in-hamas-drone-threat-against-israel-analysis-668110. We have not been able to verify Hamas' claim to local manufacturing.

154 Dion Nissenbaum, 'Israel Says Iran Tried to Fly Arms to Hamas Using Drones', Wall Street Journal, 7 March 2022, https://www.wsj.com/articles/israel-says-iran-tried-to-fly-arms-to-hamas-using-drones-11646682200 ; Tal Lev-Ram, 'בירעמ תושדח | הזע תעוצרל סכרדב ויהש סינאריא סיט״למ ינש טריי ל״הצ :מוסרפל רתוה', Maariv, 6 March 2022, https://www.maariv.co.il/news/military/Article-902513.

155 Fishman, 'The New Explosive Drone Threat from Gaza'.

156 Ahmad Abu Amer, 'Hamas Bets on Locally Made Drones for next Confrontation with Israel', Al-Monitor, 19 June 2022, https://www.al-monitor.com/originals/2022/06/hamas-bets-locally-made-drones-next-confrontation-israel.

Chapter 4: Houthi Movement

Past Developments

Yemen has been an active ground for American drone strikes since the early days of the War on Terror, subjecting armed groups operating in Yemen to regular long-range attacks.[157] In 2015, Saudi Arabia began waging a long-range and sustained campaign of aerial bombardment against Houthi forces, in support of the central Yemeni government. The Houthi Movement, therefore, finds itself embedded in a regional situation in which it combats enemies both domestically (Yemeni governmental forces) and at long range (American and particularly Saudi forces). It is in this context that the Houthi forces' use of drones has been most prominent, to enable long-range attacks against distant enemies. Houthi forces have employed long-range drones – often Iranian-made or designed – to achieve deep penetration capabilities, often in conjunction with other weapons systems such as cruise missiles. In 2017, the Houthi Movement allegedly experimented with remote-controlled boats, though that was quickly abandoned.[158]

Current Advances

Houthi forces have been using aerial drones extensively since at least 2018, with a rapid increase in the number of attacks the following year. Most of the attacks have taken place in Saudi Arabia, though at least three attacks have targeted the United Arab Emirates, and some further attacks have taken place in Yemen itself.[159] Houthi forces clearly aim at achieving both high-impact strikes (see below) and a high volume of attacks: on 2 January 2022, Houthi spokesperson Yahya Sare'e published a series of four infographics on Twitter describing the number of operations conducted, including one infographic dedicated to drone operations (see Figure 7).[160]

157 Already in 2002, the US' first drone strike outside Afghanistan killed several al-Qaeda militants, along with a number of civilians. In 2011, in a second campaign jointly led with the Yemeni government of Ali Abdallah Saleh, American drone strikes killed the American al-Qaeda preacher Anwar al-Awlaki (as well as his son in a subsequent strike). Houthi forces, meanwhile, have occasionally managed to fight back, with the downing of an American Reaper drone in June 2019 being acknowledged by the American Central Command, among others. Scott Shane, Objective Troy: A Terrorist, a President, and the Rise of the Drone (New York: Tim Duggan Books, 2015); Earl Brown, 'Statement from US Central Command on Attacks against U.S. Observation Aircraft', U.S. Central Command, 16 June 2019, https://www.centcom.mil/MEDIA/STATEMENTS/Statements-View/Article/1877252/statement-from-us-central-command-on-attacks-against-us-observation-aircraft/ ; see also Baraa Shiban and Camilla Molyneux, 'The Human Cost of Remote Warfare in Yemen', in Remote Warfare: Interdisciplinary Perspectives, ed. Alasdair McKay, Abigail Watson, and Megan Karlshøj-Pedersen (Bristol: E-International Relations Publishing, 2021), 110–31.
158 'Anatomy of a "Drone Boat": A Water-Borne Improvised Explosive Device (WBIED) Constructed in Yemen'.
159 Stephen Kalin, Mohammad Ghobari, and Ghaida Ghantous, 'UAE Denies Report of Houthi Drone Attack on Abu Dhabi Airport', Reuters, 26 July 2018, https://www.reuters.com/article/us-yemen-security-emirates-attack-idUSKBN1KG23W ; 'Iran Is Acting Against The UAE By Means Of The Yemeni Houthi Militia – And Threatening More Attacks On It', Middle East Media Research Institute, 8 February 2022, https://www.memri.org/reports/iran-acting-against-uae-means-yemeni-houthi-militia-%E2%80%93-and-threatening-more-attacks-it.
160 The Twitter account in question is not verified by Twitter; however, it has been identified as authentic by Iranian media (and Western media treat it as authentic).

Figure 7: Summary of Houthi Movement drone operations, for 2021, according to the Houthi Movement.[161]

While the totals here are clearly inconsistent,[162] the mention of a "drone force" and of high numbers of operations are in themselves significant. Unlike other groups, which highlight individual missions and seem more invested in the media impact of drone employment, the Houthi Movement seems intent on demonstrating the operational value of drones and its ability to employ them effectively in combat.

The Houthi drone program has yielded a number of high-profile attacks, of which we will mention three here. The first one occurred on 10 January 2019 at al-Anad air base in southern Yemen. A Qasef-2K drone exploded above a dais hosting members of the Yemeni Armed Forces high command at a parade, raining shrapnel over the crowd. At least six soldiers were killed, while the army deputy chief of staff and the head of intelligence were injured.[163] Analysis by Bellingcat and Conflict Armament Research (CAR) demonstrated that the Qasef drones are based on the Ababil-T airframe developed by Iran, and are likely imported from Iran. The Ababil-T is a simple reconnaissance drone, which can be transformed into a loitering munition.[164] Bellingcat speculated that the drone may have been preprogrammed to follow a GPS-guided route, although there is no evidence of that in this specific case.

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161 Yahya Sare'e, 'Tweet: Summary of Houthi Operations, 2021', 2 January 2022, https://twitter.com/Yahya_Saree/status/1477745874499514369.
162 The number of 440 total operations seems to be a copying error from another infographic. The totals are also likely inflated; our partial dataset of Houthi drone activities contains 187 incidents from 2016 to 2022.
163 'Yemen Soldiers Killed in Houthi Drone Attack on Base', BBC News, 10 January 2019, https://www.bbc.com/news/world-middle-east-46822429 ; Patrick Wintour, 'Yemen Peace Talks at Risk after Several Killed in Houthi Drone Attack', The Guardian, 10 January 2019, https://www.theguardian.com/world/2019/jan/10/houthi-drone-attack-on-yemeni-base-kills-several-people-reports.
164 Nick Waters, 'Houthis Use Armed Drone to Target Yemeni Army Top Brass', Bellingcat, 10 January 2019, https://www.bellingcat.com/news/mena/2019/01/10/houthis-use-armed-drone-to-target-yemeni-army-top-brass/ ; 'Iranian Technology Transfers to Yemen', Frontline Perspective (London: Conflict Armament Research, March 2017), https://www.conflictarm.com/wp-content/uploads/2017/03/Iranian-Technology-Transfers-to-Yemen.pdf.

The second and third attacks highlight the difficulty of attribution for long-range drone attacks, further suggesting that the Houthi Movement may be deliberately exploiting such uncertainty and confusion to evade responsibility or protect allied forces. The second attack occurred eight months after the first, on 14 September 2019. A combination of drones and cruise missiles – up to eighteen drones and seven missiles, according to the BBC,[165] though estimates vary – struck the Aramco oil field and refineries at Abqaiq in the eastern part of Saudi Arabia. The attack temporarily disabled the production of over five million barrels of petrol per day – nearly half of Saudi Arabia's output – and led to a 15 percent increase in the price of crude oil.[166] This attack represented an unprecedented innovation, in large part due to the increased distances covered: Abqaiq lies several hundred miles inland in Saudi Arabia, meaning drones and missiles launched from outside the country would have needed to travel several hundred miles before hitting their targets "with pinpoint precision".[167] Houthi spokespersons and media outlets were quick to claim responsibility for the attack,[168] though the actual responsibility for the attack remains unclear. American officials claimed that drones may have been launched from Iran itself, while other sources suggested the drones may have bypassed Saudi defences by being launched by affiliated militias in Iraq.[169] Saudi Arabia displayed wreckage they claimed was that of Ababil drones – Iranian-made – and accused Iran of "sponsoring" the attack, a claim Iranian officials seemed to tacitly endorse.[170] In its analysis of the attack, despite the Houthi claim of responsibility, the UN Security Council-mandated Panel of Experts on Yemen concluded that the Houthi Movement did not conduct this attack, though it did not attribute responsibility to any other party.[171] This attack, therefore, demonstrates capabilities for long-range attacks, for combined attacks of drones and cruise missiles, and for potential cooperation by Houthi forces with other affiliated militias.

The final incident we wish to highlight, which occurred on 23 January 2021, was not conducted by the Houthi Movement itself. A number of "fixed-wing drones"[172] crashed into the Saudi royal palace in Riyadh, causing minor damage. Though the drones were launched from Iraq and

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165 Frank Gardner, 'Saudi Oil Facility Attacks: Race on to Restore Supplies', BBC News, 20 September 2019, https://www.bbc.com/news/world-middle-east-49775849.

166 Gardner; Dion Nissenbaum, Summer Said, and Jared Malsin, 'U.S. Tells Saudi Arabia Oil Attacks Were Launched From Iran', Wall Street Journal, 17 September 2019, https://www.wsj.com/articles/u-s-tells-saudi-arabia-oil-attacks-were-launched-from-iran-11568644126.

167 Gardner, 'Saudi Oil Facility Attacks'.

168 Associated Press, 'Major Saudi Arabia Oil Facilities Hit by Houthi Drone Strikes'; Fahim and Mufson, 'Saudi Arabia Oil Output Takes Major Hit after Apparent Drone Attacks Claimed by Yemen Rebels'. The Houthi spokesperson reportedly claimed ten drones, while Saudi and American sources asserted eighteen drones and seven missiles, or up to twenty drones.

169 Fahim and Mufson, 'Saudi Arabia Oil Output Takes Major Hit after Apparent Drone Attacks Claimed by Yemen Rebels'; Nissenbaum, Said, and Malsin, 'U.S. Tells Saudi Arabia Oil Attacks Were Launched From Iran'. Later that year, Reuters cited American officials who claimed the weapons were launched directly from Iran, with a detour through Iraq to establish plausible deniability. Humeyra Pamuk, 'Exclusive: U.S. Probe of Saudi Oil Attack Shows It Came from North', Reuters, 19 December 2019, https://www.reuters.com/article/us-saudi-aramco-attacks-iran-exclusive-idUSKBN1YN299.

170 'Saudis Say Weapons Prove Iran behind Oil Attacks', BBC News, 18 September 2019, https://www.bbc.com/news/av/world-middle-east-49747800 ; 'Mashhad Friday Sermon by Ayatollah Ahmad Alamolhoda: The PMU, Hizbullah, Ansar Allah, Hamas, Islamic Jihad, Are All Iran; We Can Destroy Israel in Half a Day', Middle East Media Research Institute, 20 September 2019, https://www.memri.org/tv/mashhad-friday-sermon-ayatollah-alamolhoda-iran-resistance-region-yemen-hizbullah-lebanon-others.

171 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen' (United Nations Security Council, 27 January 2020), 82–89, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N20/106/86/PDF/N2010686.pdf. This analysis is based both on technical specifications and on the pattern of behaviour. The Panel of Experts concludes that the Houthi forces "were not known to possess" the "require[d] levels of technical and military know-how" to conduct this attack. Houthi forces have launched other long-range combined attacks since, though none appear to have involved as many weapons (at least eighteen drones and seven cruise missiles).

172 Stephen Kalin, Michael R. Gordon, and Warren P. Strobel, 'Aerial Attacks on Saudi Arabia Expose Vulnerability of U.S. Ally', Wall Street Journal, 19 February 2021, https://www.wsj.com/articles/aerial-attacks-on-saudi-arabia-expose-vulnerability-of-u-s-ally-11613736001.

claimed by a group calling themselves the "Righteous Promise Brigades", Saudi Arabia was quick to blame the Houthi Movement, which denied the claim.[173] Against the backdrop of the abovementioned September 2019 attack – an attack which Houthi forces claimed, but may not have (entirely) launched themselves – a repeating pattern of conflicting responsibility claims suggests that the Houthis and collaborating forces may seek to deliberately exploit the potential confusion arising from difficult-to-trace drone attacks across large distances. The targeting of a potent symbol such as the royal palace, in the middle of Saudi Arabia, emphasizes the desire to demonstrate capabilities for long-range penetrating attacks.

Development of Program

Tactical Innovation

The Houthi Movement's drone program displays two major innovations which distinguish it from the drone programs of other groups, namely a focus on combined operations and long-range strikes.

The first of these innovations entails the regular use of drones combined with other forms of attack, notably cruise missiles. CAR highlighted this mode of operations already in 2017, when – based on confidential interviews with security officials from the United Arab Emirates – they reported regular operations in Saudi Arabia by Houthi forces, who crashed drones into the radar systems directing surface-to-air Patriot missiles, thereby enabling longer-range missions by other drones or by cruise and ballistic missiles.[174] As mentioned previously, the Houthi Movement has also engaged in operations in combination with other groups, either collaborating on launching operations, or on producing contradictory statements concerning the provenance of these attacks to hinder attribution of responsibility.

On several occasions, attacks have been launched using combinations of means of attack, such as ballistic missiles, cruise missiles and drones. Houthi forces themselves seem to maintain a certain fluidity among these categories.[175] CAR has reported that early drone attacks in 2016 and 2017 were preprogrammed with GPS coordinates rather than remote-piloted, which would effectively turn a drone into a form of slow cruise missile.[176]

173 Others have suggested Kata'ib Hezbollah – an Iraqi militia group aligned with Iran – was responsible. Kalin, Gordon, and Strobel; Yahya Sare'e, '1- The Yemeni Armed Forces Warn That They Have Not Carried out Any Offensive Operations against the Countries of Aggression during the Past 24 Hours.', 23 January 2021, https://twitter.com/Yahya_Saree/status/1352976991872495616 ; 'بطائرات مسيرة فصائل عراقية تتبنت هجوم الرياض انا وقتو هذا فذن', Almasdar online, 24 January 2021, https://almasdaronline.com/articles/214106.
174 'Iranian Technology Transfers to Yemen'. A number of incidents reported the employment of ballistic missiles. Recent reports have discussed the use of Zulfiqar (or Zolfaghar) Iranian-made short-range ballistic missiles. Jeremy Binnie, 'Houthis Claim Long-Range Cruise Missile Attack on UAE', Janes.com, 18 January 2022, https://www.janes.com/defence-news/news-detail/houthis-claim-long-range-cruise-missile-attack-on-uae ; واسعة الاعميد عبون تعاله تمكنت القوة الاصاروخية والسلاح الجوي والمسير من تنفيذ عملية هجومية ,[ey12ymra@] عشر طائرات مسيرة نوع صماد 3 يحيى سريع بعون الله تعالت بلاعت واصرخ ,2021 March 7 ,Twitter ,Tweet ,'واصرخ هذا القلا ومشتركة في العلاقمع العسكدوأبعر عشرة طائرة مسيرة وثمانية صواريخ بالستية. منها"، https://twitter.com/army21ye/status/1368630913890983937.
175 Many of the incidents reported in media sources and by Houthi forces use "missile" and "drone" somewhat interchangeably.
176 'Iranian Technology Transfers to Yemen', 2; Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen' (United Nations Security Council, 26 January 2018), 155, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N18/267/20/PDF/N1826720.pdf.

At a July 2019 press conference, the Houthi Movement unveiled a number of systems they claimed to have used to attack Saudi Arabia in the months prior; these included Quds-1 cruise missiles, Sammad-1 and Sammad-3 drones, and Qasef-2K drones.[177] A further presentation in March 2021 included Sammad-2 and Sammad-3 drones (as well as a prototype claimed to be a Sammad-4), Quds-2 cruise missiles, and Zulfiqar short-range ballistic missiles.[178]

Several attacks with combined arms achieved large proportions, with dozens of weapons involved. For instance, on 6–7 March 2021, Saudi defence forces claimed to have intercepted ten Sammad-3 drones, in addition to a number of smaller Qasef-2K drones and Zulfiqar ballistic missiles, the attacks causing negligible damage.[179] More recently, on 17 January 2022, the Houthi Movementclaimed responsibility for a long-range attack which killed three and injured six in the United Arab Emirates, targeting Abu Dhabi's airport and the al-Musaffah oil refinery. The attack reportedly combined four Quds-2 cruise missiles, a Zulfiqar ballistic missile, and an unspecified number of Sammad-3 drones.[180]

While Saudi defences have achieved fairly high success rates in intercepting these weapons, the multiplication of weapons systems makes countering such attacks considerably more difficult. Drones are generally slow and fly at low altitude, whereas ballistic missiles fly at high speed and higher altitude. Furthermore, depending on range (and it is estimated the Sammad-3 may have a range up to 1,500 km),[181] drones and cruise missiles can turn or adopt a circuitous route to the target, multiplying angles of attack. The cooperation between Houthi forces and potential other partners in the region adds further complexity to countering the threat of drones and other long-range weapons.[182]

Supply Chains

Most of the weapons systems mentioned above originated in Iran, either in design or in production, though most weapons systems used by the Houthi Movement appear to have been modified in some way. CAR has accomplished outstanding research in tracing the components of downed Houthi drones, establishing that most of them originated in or transited through Iran. In CAR's analysis, tracing component serial numbers and comparing them to other drones known to be of Iranian origin reveals that a large number of the internal parts of drones used by the Houthi Movement appear to be imported.[183] CAR has, however, identified one Qasef-2K drone where it

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177 'Yemeni Armed Forces Display New Domestically-Built Missiles, Drones', PressTV Iran, 7 July 2019, https://www.presstv.ir/Detail/2019/07/07/600377/Yemeni-armed-forces-display-new-domestically-built-missiles,-drones.

178 Robert J. Bunker and Alma Keshavarz, '"Made in Yemen:" Houthi Exhibition Showcase New Drones, Missiles, and Naval Mines', Small Wars Journal, 8 April 2021, https://smallwarsjournal.com/jrnl/art/made-yemen-houthi-exhibition-showcase-new-drones-missiles-and-naval-mines.

179 Sarah Dadouch, 'Houthis Strike Saudi Oil Giant's Facilities in the Kingdom's East', Washington Post, 7 March 2021, https://www.washingtonpost.com/world/the_americas/saudi-houthi-attack-ras-tanura-aramco/2021/03/07/77f29148-7f72-11eb-9ca6-54e187ee4939_story.html ; Douglas Barrie and Timothy Wright, 'Ansarullah's Missile and Munitions Launches Flex Saudi Responses', IISS, 19 March 2021, https://www.iiss.org/blogs/military-balance/2021/03/ansarullah-missile-and-munitions-saudi-arabia.

180 Binnie, 'Houthis Claim Long-Range Cruise Missile Attack on UAE'; 'Houthi Military Spokesman Brig.-Gen. Yahya Sare'e Claims Houthi Responsibility For Monday Abu Dhabi Drone Strike: The UAE Is Unsafe So Long As Escalation Against Yemen Continues', Middle East Media Research Institute, 17 January 2022, https://www.memri.org/tv/houthi-military-spokesman-general-saree-claim-responsibility-abu-dhabi-airport-drone-attack.

181 'Evolution of UAVs Employed by Houthi Forces in Yemen' (London: Conflict Armament Research, February 2020), https://www.conflictarm.com/dispatches/evolution-of-uavs-employed-by-houthi-forces-in-yemen/.

182 Barrie and Wright speculate that at least for the 7 March 2021 attack, Sammad-3 drones may have been launched from ships in the Persian Gulf to shorten the distance to travel and make a circuitous flight path possible. Barrie and Wright, 'Ansarullah's Missile and Munitions Launches Flex Saudi Responses'.

183 'Evolution of UAVs Employed by Houthi Forces in Yemen'; 'Iranian Technology Transfers to Yemen'.

appears imported internal components were grafted onto a domestically produced fuselage.[184] Houthi forces had previously claimed to have developed domestic production capabilities, though these appear to be a minor complement to imported material.[185]

Some weapons systems map onto or are derived from Iranian weapons systems. The Qasef-1 drone, for instance, is derived from an Iranian Ababil-T airframe.[186] A similar Ababil-T belonging to Hezbollah was shot down in 2006 in Israel, and other Ababil drones have been used by Hamas in Israel.[187] In certain instances, such as after the 14 September 2019 attack on the Abqaiq oil field, Saudi and American sources have reported recovering Iranian-model weapons systems.[188] Attributing possession of such weapons systems to Houthi forces, however, is made more complex by the assertion that some attacks may have been launched by associated forces, or indeed from Iran itself.

It appears, however, that the Houthi Movement has been progressively transitioning to increased domestic assembly and manufacture of drones and other systems. CAR identified one example of a domestically produced drone fuselage in its report on the evolution of Houthi UAVs.[189] The UN Security Council-mandated Panel of Experts on Yemen, meanwhile, suggests that most recently employed Houthi weapons systems are manufactured in Yemen using parts imported from abroad. Already in 2018, the Panel of Experts established that the Borkan-2H missile was likely assembled in Yemen based on Iranian designs and components.[190] The Quds-1 cruise missile, while seemingly not based on any existing design (rather, it is "based on a classic cruise missile design"), is alleged to be smuggled from abroad.[191] The 2021 report, however, states that Houthi supply chains diverge for drones and missiles: while missiles are imported from abroad, drones are largely assembled in Yemen through components made abroad.[192]

While it appears that most components transit through Iran on the way to Yemen, the original sources of supply are much wider. Both the UN Security Council-mandated Panel of Experts and CAR have traced components from far afield, including China, Germany, the Czech Republic, and the United Kingdom.[193] In its 2022 report, the Panel of Experts traced imports from Europe and China through intermediaries in China;[194] in 2019, another chain of supply was identified, through which German-made drone engines (for Sammad drones) were supplied through a company in Athens, Greece.[195] According to the Panel of Experts, while such imports may violate embargoes, as they are not classified as arms components (or dual-use components), Houthi forces may be able to import them without the knowledge of intermediaries.[196]

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184 'Evolution of UAVs Employed by Houthi Forces in Yemen', 8; 12–13.

185 'Yemeni Armed Forces Display New Domestically-Built Missiles, Drones'.

186 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen', 26 January 2018, 32.

187 Zitun, 'Hamas Claims Multiple UAVs Launched into Israel'; 'IDF Intercepts Another Hamas UAV'.

188 'Saudis Say Weapons Prove Iran behind Oil Attacks'; Pamuk, 'U.S. Probe of Saudi Oil Attack Shows It Came from North'.

189 'Evolution of UAVs Employed by Houthi Forces in Yemen', 8; 12–13.

190 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen', 26 January 2018, 125–26.

191 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen', 27 January 2020, 24.

192 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen' (United Nations Security Council, 25 January 2021), 25–26, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N20/372/40/PDF/N2037240.pdf.

193 'Evolution of UAVs Employed by Houthi Forces in Yemen'; Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen', 27 January 2020, 26; Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen' (United Nations Security Council, 26 January 2022), 32, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N21/415/62/PDF/N2141562.pdf.

194 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen', 26 January 2022, 32.

195 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen' (United Nations Security Council, 25 January 2019), 31, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N19/006/48/PDF/N1900648.pdf.

196 Panel of Experts on Yemen, 'Final Report of the Panel of Experts on Yemen', 27 January 2020, 26.

Structure of Development

In summary, the Houthi drone program appears to have developed extremely rapidly from its inception in late 2016 or early 2017 until the group began conducting major attacks from 2019 onwards. Furthermore, the group has developed a local drone industry backed by a comprehensive foreign supply network: unlike missiles, which are supplied from foreign sources, Houthi drones appear to have evolved from being smuggled from abroad to being assembled in Yemen from foreign components and locally produced airframes.

Operationally, three characteristics distinguish the Houthi drone program from that of other groups. First, the Houthi Movement's use of drones puts a premium on long-range penetration, with an emphasis on developing weapons with long ranges. Their use of preprogrammed GPS trajectories – which turns drones into something approaching slow cruise missiles – allows the group to achieve beyond-visual-range flights, as does the development of newer drone models such as the Sammad-3. Their repeated attempts to hit targets including Riyadh in Saudi Arabia and Abu Dhabi in the United Arab Emirates demonstrate an intention to show capabilities which directly mirror the long-range air bombardment campaign waged by Saudi Arabia. Second, Houthi forces favour a large volume of operations, relying on drones as a regular part of their arsenal. Rather than employing drones to demonstrate advanced capabilities or as exemplars for propaganda, their focus on the volume of attacks shows a concern with operational impact. Third, to achieve these objectives, Houthi forces have shown a propensity to collaborate with other groups in the region against common enemies, sometimes claiming attacks likely conducted by others (or possibly letting others claim attacks they themselves conducted). Furthermore, particularly since 2019, the group has shown a propensity to employ multiple means of attack in parallel, using combinations of drones, cruise missiles, and ballistic missiles.

The Houthi Movement, as such, uses drones for three main purposes: reconnaissance, propaganda production (notably through the displays of drone prototypes), and pilot-to-target attacks.

Figure 8: Typology of drone uses by the Houthi Movement. Blue boxes denote uses observed.

Chapter 5: Islamic State

Past Developments

After IS announced the establishment of its caliphate in early 2014, drone usage started appearing almost immediately. In August 2014, the group published footage of a DJI Phantom quadcopter conducting reconnaissance prior to a ground attack in Syria.[197] While a few sporadic observations of IS drones followed in 2015, the first attack on Western forces we identified occurred in March 2016. A few days following a drone overfly of an American base in Iraq – and IS' publication of the video – a precise artillery strike killed one American marine, suggesting that the drone was used to identify targets for the subsequent artillery fire.[198] Following a second lull, IS drone activity took off once again in earnest at the end of September 2016. For the period between 30 September 2016 and 11 February 2018, our research team identified 338 reports of drone use by IS, 262 of which involved offensive action by the drone itself. Since 2018, IS has continued launching sporadic drone attacks, though at an extremely reduced rate; our research team identified nine attacks by drones attributed to IS between July 2018 and October 2021. Since 2021, the IS drone program appears to have ceased; our research team has not identified any drone activity linked to the group since October 2021.

The IS drone program has been the subject of extensive research and, for a time, somewhat monopolized the attention of researchers on non-state drones. Indeed, the conference by General Raymond Thomas which opens this report refers specifically to operations against IS; it was in the course of the campaigns by the Coalition against IS that many found themselves attuned to the problem of non-state drones on a large scale. As we argue in this report, drone programs differ in significant ways, and we reject attempts to take the IS drone program as an exemplar for non-state drone use in general. As such, we identify four significant differences between IS' drone use and the drone programs of other groups, which we detail in the sections below. First, unlike other groups, such as the Houthi Movement, IS innovated by employing its drones largely as flying artillery for purposes of explosive delivery, not as loitering munitions in themselves. Second, IS demonstrated extensive use of drones for observation, combining drone activity with other forms of attack such as artillery fire or VBIEDs. Third, IS innovated by establishing an extensive drone program without any state patron, displaying significant technical prowess in assembling weaponized drones from easy-to-access sources. Fourth, IS extensively exploited the propaganda potential of drones, employing drones as an integral part of its media machine meant to demonstrate its state-building capabilities through visual means.

Development of Program

Tactical Innovation

The first two innovations listed above – the use of drones for explosive delivery and for command and coordination – relate to the employment of drones for tactical purposes. In both cases, IS sought to employ its drones to support tactical operations. The first innovation relates to how drones are employed as offensive weapons. While IS certainly looked for targets with a high psychological and strategic impact – for instance, on 23 October 2017, IS released footage of drone-launched munitions detonating a Syrian army munitions depot in a stadium in Deir Ez-

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197 Yasmin Tadjdeh, 'Islamic State Militants in Syria Now Have Drone Capabilities', National Defense Magazine, 28 August 2014, https://www.nationaldefensemagazine.org/articles/2014/8/28/islamic-state-militants-in-syria-now-have-drone-capabilities.

198 Moutaz Mamdouh, ʻمظن دفاع جوي وطائرات مسيرة: تنظيم الدولة يعزز ترسانة أسلحتهʼ, إضاءات, 13 March 2017, https://www.ida2at.com/air-defence-systems-and-unmanned-planes-isis-enhances-its-weapons-arsenal/.

Zor[199] – most of the attacks were aimed at much more minor military targets. Indeed, among the images released by IS themselves, most attacks target groups of enemy soldiers, individual vehicles or fortified positions.

The large majority of IS attacks in Iraq involved homemade multipurpose munitions attached to a small quadcopter, which are subsequently released using improvised mechanisms. A CAR investigation has identified these munitions as homemade 40 mm multipurpose bomblets; these can be launched by hand, by improvised grenade launchers, or from drones.[200] According to CAR, while most of these grenades contain relatively weak explosives and are therefore more likely to cause shrapnel injuries than severe destruction or death, a further evolution saw some munitions fitted with high explosives, capable of damaging vehicles or fortified targets.[201] Nick Waters from Bellingcat, meanwhile, attempted in May 2017 to categorize IS drone bombs; he identified both regional variation in the types of bomblets used and general consistency in bomb design.[202] In a further analysis, he established a general tendency to prefer unprotected military targets, though harder targets such as armoured vehicles were not always shied away from.[203]

Due to the nature of the fighting in 2017 – when IS drone use was at its highest[204] – much of the group's drone use took place in the major battles for urban areas. IS released extensive imagery of drone use for munition drops in Mosul (January and February 2017),[205] Nineveh (February 2017), Deir Ez-Zor (March 2017), and later in Raqqa (April–September 2017), among others. In some of these cases, drone use took place on a significant scale, with dozens of drones involved. Raymond Thomas cited the figure of up to seventy drone flights over twenty-four hours, with up to twelve simultaneously.[206] Other sources mentioned regular occurrences of ten to fifteen daily drone flights in the battle for Mosul.[207] Yet further reports by the Washington Post highlighted the confusion between small Kurdish and coalition drones and IS drones overflying, with the resulting uncertainty being exploited by IS.[208] In sum, despite its limited means and the rudimentary nature

199 'Islamic State Drone Bombs Syrian Government Munitions Warehouse in Stadium Near Deir Ezzor', Yahoo News UK, 25 October 2017, https://uk.news.yahoo.com/islamic-state-drone-bombs-syrian-234634543.html ; 'Footage Shows Islamic State Drone Blowing up Stadium Ammo Dump', ABC News, 25 October 2017, https://www.abc.net.au/news/2017-10-25/footage-shows-is-drone-attack-on-syrian-government-stadium/9085750. It is unclear when the video was taken.
200 'Islamic State's Multi-Role IEDs'.
201 'Islamic State's Multi-Role IEDs', 2.
202 Nick Waters, 'Types of Islamic State Drone Bombs and Where to Find Them', Bellingcat, 24 May 2017, https://www.bellingcat.com/news/mena/2017/05/24/types-islamic-state-drone-bombs-find/.
203 For instance, in January 2017, IS released images of a drone-dropped munition targeting an American M1 Abrams tank. The munition detonated, though the consequences of the strike are unknown.
204 Asaad Almohammad and Anne Speckhard, 'ISIS Drones: Evolution, Leadership, Bases, Operations and Logistics', ICSVE Research Reports (International Center for the Study of Violent Extremism, 4 May 2017), 2, http://www.icsve.org/research-reports/isis-drones-evolution-leadership-basesoperations-and-logistics/.
205 'IS Attacks on Several Areas of Mosul Leaves at Least 12 Casualties', Iraqi News, 12 February 2017, https://www.iraqinews.com/iraq-war/attacks-several-areas-mosul-leaves-12-casualties/ ; 'IS Drone Attacks on Liberated Areas of Mosul Leave 20 Casualties', Iraqi News, 8 February 2017, https://www.iraqinews.com/iraq-war/shelling-liberated-areas-mosul-20-casualties/ ; 'Islamic State Drone Kills, Wounds 13 Civilians near Mosul', Iraqi News, 18 February 2017, https://www.iraqinews.com/iraq-war/islamic-state-drones-kill-wounds-13-civilians-near-mosul/ ; 'Islamic State Drones, Rockets Kill 11 Civilians, Including School Kids, in Eastern Mosul', Iraqi News, 21 February 2017, https://www.iraqinews.com/iraq-war/islamic-state-drones-rockets-kill-11-civilians-including-school-kids-eastern-mosul/.
206 Larter, 'SOCOM Commander'.
207 Mohamed Izat Rahim, 'أسباب تصاعد استخدام الدرونز في الصراعات الداخلية', المستقبل للأبحاث والدراسات, 22 January 2018, https://futureuae.com/ar/Mainpage/Item/3644/توظيفات-متعددة-أسباب-تصاعد-استخدام-الدرونز-في-الصراعات-الداخلية.
208 Thomas Gibbons-Neff, 'ISIS Drones Are Attacking U.S. Troops and Disrupting Airstrikes in Raqqa, Officials Say', Washington Post, 14 June 2017, https://www.washingtonpost.com/news/checkpoint/wp/2017/06/14/isis-drones-are-attacking-u-s-troops-and-disrupting-airstrikes-in-raqqa-officials-say/.

of its drones and munitions, IS sought to adapt its use of drones to the campaigns it fought, and to maximize tactical utility in urban combat settings, as a form of flying artillery.

In addition to using drones to drop improvised munitions, on several occasions IS sought to turn the drones themselves into improvised explosive devices (IEDs). In one such famous incident, in October 2016, a downed drone exploded when recuperated by Kurdish Peshmerga forces, killing two Peshmerga and injuring two French soldiers.[209] A few other incidents of explosive drones being used as loitering munitions have been reported (our research team identified twelve), although these clearly represent a minority of IS drone employment.[210]

The tactical innovation in the use of drones by IS lay in their use for command, control and reconnaissance. The second tactical innovation in the use of drones by IS lay in their use for command, control and reconnaissance. In itself, the use of drones for coordination was not new – indeed, the large majority of American MQ-1 and MQ-9 flights in Iraq and Afghanistan were undertaken for reconnaissance, not attack missions.[211] IS, however, distinguished itself among non-state groups for both the extensive use of drones in directing other means of attack, and in its publicizing of these uses. One such example has already been mentioned above: IS seems to have used a drone in March 2016 to map out and plan a subsequent artillery attack on American forces, killing one marine. Most prominently, however, IS appears to have used drones to plan and execute VBIED attacks, using the situational awareness provided by overflying to more effectively direct its suicide attacks.[212] Whereas Western drones are often seen as substitute weapons which reduce risk to troops,[213] and whereas speculation existed that IS may replace suicide attacks with drones used as loitering munitions,[214] drone attacks did not replace suicide attacks but rather augmented their capabilities and usefulness. Among the drone images released by IS, a significant number depicted the path and aftermath of VBIED attacks;[215] this development suggests that IS integrated its offensive and propaganda capabilities closely, looking at ways to achieve a synergy between operational use and the media value of drone operations. Furthermore, it suggests that the loss of situational air superiority due to small drone presence, identified by Raymond Thomas, mattered for more than the prospect of aerial attack: IS integrated its drone operations tightly with other parts of its military machine, employing drones to magnify its ability to fight effectively.

As seen in Figure 9, IS' drone activities therefore straddled most categories of Rassler's typology of drone use. However, of these categories, most operations were concentrated in propaganda production, operational support, reconnaissance, and explosive delivery.

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209 Michael S. Schmidt and Eric Schmitt, 'Pentagon Confronts a New Threat From ISIS: Exploding Drones', The New York Times, 12 October 2016, https://www.nytimes.com/2016/10/12/world/middleeast/iraq-drones-isis.html ; '"Booby-Trapped" ISIL Drone in Deadly Iraq Attack', Al Jazeera, 12 October 2016, https://www.aljazeera.com/news/2016/10/12/booby-trapped-isil-drone-in-deadly-iraq-attack.
210 One explanation for this disparity may lie in IS' extensive exploitation of drone attacks for media value: an exploding drone is much more limited in its ability to produce compelling video footage, compared to a drone that launches munitions.
211 Chris Woods, Sudden Justice: America's Secret Drone Wars (New York: Oxford University Press, 2015).
212 Don Rassler, 'The Islamic State and Drones: Supply, Scale, and Future Threats' (West Point: Combating Terrorism Center, 11 July 2018), 3, https://ctc.usma.edu/islamic-state-drones-supply-scale-future-threats/ ; George and Hinnant, 'Islamic State Turns to Drones to Direct Suicide Car Bombers'.
213 Erik Lin-Greenberg, 'Remote Controlled Restraint: The Effect of Remote Warfighting Technology on Crisis Escalation' (Ph.D., New York, Columbia University, 2019), 13, https://doi.org/10.7916/d8-3nse-x110.
214 'تافصاق الخلافة»... خطر تنظيم «الدولة» المقبل يمكن في الطائرات الصغيرة | القدس العربي', Al-Quds Al-Arabi, 19 April 2018, https://www.alquds.co.uk/%EF%BB%BFتافصاق-الخلافة-خطر-تنظيم-الدولة/.
215 Previous research by the authors has collected 160 images of such attacks, representing 47 separate incidents. Archambault and Veilleux-Lepage, 'Drone Imagery in Islamic State Propaganda'.
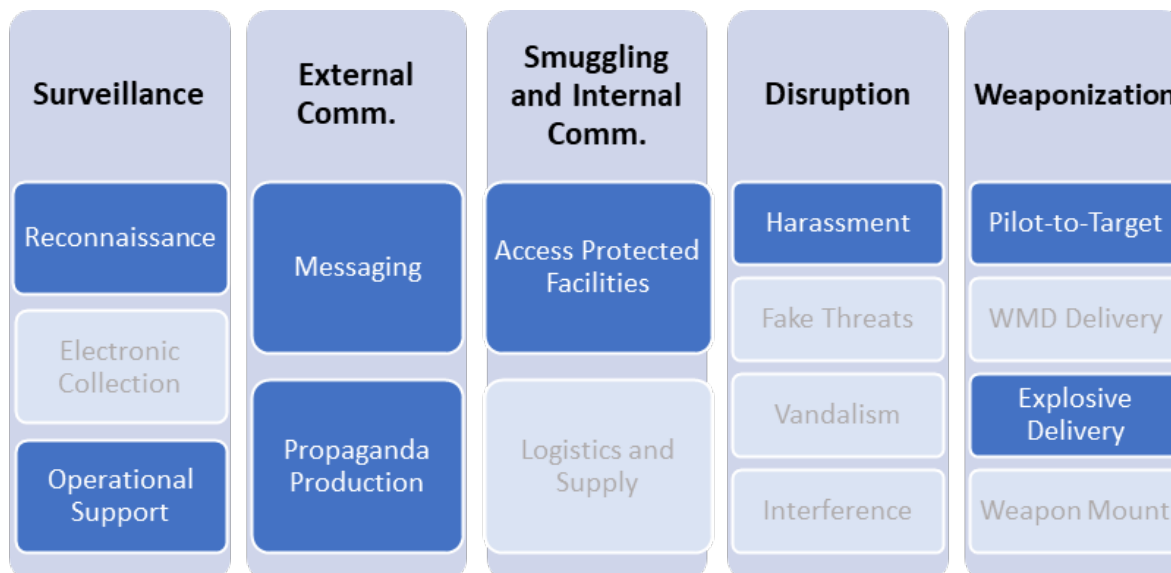
Figure 9: Typology of drone uses by IS. Blue boxes denote uses observed.

A final point concerning IS drone operations relates to what the group did not do. In his report, Rassler identified the delivery of WMDs as a key potential use of drones for non-state groups.[216] In other reports, he suggested IS had experimented with chemical weapons delivery by drone, and that IS' other uses of chemical weapons may make drone-mounted chemical weapons particularly tempting.[217] However, despite repeated concerns about IS using drones to launch chemical attacks in Iraq, Syria and the rest of the world,[218] there is no evidence that IS ever seriously tried to equip drones with chemical weapons or launch airborne chemical attacks. Iraqi officials claimed to have discovered a plot to use remote-controlled planes to disperse sarin and mustard gas in June 2013 – before IS' first documented uses of drones – though no evidence exists outside the assertions of the Iraqi government.[219] Similarly, there has been much concern[220] about the prospect of IS-inspired drone attacks in Western countries by loosely affiliated sympathizers.[221] Indeed, other means of attack – such as vehicle-ramming attacks – have been used in IS-inspired attacks in the West. However, despite IS publishing some propaganda material encouraging drone attacks,[222] there is no evidence at all that IS succeeded in spurring any such attacks outside of Iraq and Syria. One potential explanation might be that while IS proved remarkably effective in modifying drones for offensive operations within its geographical borders, such modifications nevertheless required technical knowledge which is not accessible to all; similarly, IS' supply chain practices may have complicated the access to required materials outside its borders.[223]

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216 Rassler, 'Remotely Piloted Innovation', 58.
217 Rassler, 'The Islamic State and Drones', 21–22; Rassler, Al-Ubaydi, and Mironova, 'The Islamic State's Drone Documents'.
218 تنظيم ''الدولة'' يهدد ''؛ 'القدس العربي'؛ القدس العربية | الطائرات المسيرة في المستقبل يمكن من «الدولة» خطر تنظيم ...«قصافات الخلافة». موندايا روسيا بالطائرات المسيرة وقذائف الهاون | السوري نت تحذيرات دولية من الخطر الداقم.. ''المسيرّات'' / والعراق'؛ الطائرات-المسيرة-بدرون-', Sky News Arabia, 24 December 2021, https://www.skynewsarabia.com/world/1488879 وافريقيا-تحذير-خطر-إرهابي-عابر-للقارات.
219 Gartenstein-Ross, Shear, and Jones, 'Virtual Plotters. Drones. Weaponized AI?', 47.
220 Almohammad and Speckhard, 'ISIS Drones', 7; Alix Culbertson, 'Vatican Terror Alert: Drones Feared to Be Loaded with ISIS Bombs Fly over Pope's City', Express.co.uk, 29 August 2017, https://www.express.co.uk/news/world/847283/Vatican-terror-alert-drones-ISIS-bombs-Pope ; Rassler, 'The Islamic State and Drones', 21.
221 On IS' relations with its loose networks of soft sympathizers, see Yannick Veilleux-Lepage, 'Paradigmatic Shifts in Jihadism in Cyberspace: The Emerging Role of Unaffiliated Sympathizers in Islamic State's Social Media Strategy', Journal of Terrorism Research 7, no. 1 (5 February 2016), https://doi.org/10.15664/jtr.1183.
222 Veilleux-Lepage, Daymon, and Archambault, 'Learning from Foes', 20.
223 See Veilleux-Lepage, Daymon, and Archambault. It is also worth noting that within the borders of IS' caliphate,

Structure of Development and Supply Chains

There exists extensive evidence that IS innovated also in the elaboration of a largely centralized structure for the production and control of drone operations. As in other forms of activity by the group – notably its propaganda production[224] – IS implemented a regimented and well-organized structure which allowed it to retain control over the products of its drone program. In many cases, such structures relied on key individuals who were directly identifiable.[225] Several reports on the IS drone program have identified and visited factories in which drones would be modified and developed according to a "sophisticated production chain."[226] Similarly, former IS fighters reported receiving training specific to drone operations, and that IS specifically recruited foreigners with experience in these domains.[227] In some cases, it appears IS established specific units dedicated to drone operations.[228]

In their report on the IS drone program, Almohammad and Speckhard identified a well-regulated network of drone centres in which IS developed its drone activities. According to them, in March 2017 IS operated at least four centres in Raqqa, dedicated respectively to training, modification of commercial drones, weaponization, and storage prior to deployment. All this structure came under a unified command, which was in charge of allocating drones as needed to frontline units.[229] Reports of other factories, such as in Ramadi,[230] similarly demonstrate the presence of centralized weapons factories responsible for guiding development and ensuring efficient use of resources.

Accordingly, Don Rassler has demonstrated IS' extensive supply chain network, which was both complex and comprehensive.[231] While IS did experiment with building drones from scratch,[232] and while it did attempt to develop more advanced pulse jet engines for such drones,[233] the large majority of IS drones were bought from consumer sources, with DJI models being particularly popular.[234] While IS did develop its own production networks for explosives and munitions in

there was evidence of significant variation in drone weapons design and sophistication, suggesting that technical ability varied even within IS' well-established structures for drone development. Waters, 'Types of Islamic State Drone Bombs and Where to Find Them'.

224 The attempt to achieve consistency in content and production mirrors that of IS' propaganda production. In 2014, for instance, IS cracked down on unauthorized media content and imposed its own central production sources. see Yannick Veilleux-Lepage, 'A Typology of Islamic State's Social Media Distribution Network', in Media and Mass Atrocity: The Rwanda Genocide and Beyond, ed. Allan Thompson (Toronto: Centre for International Governance Innovation Press, 2019): 453-482; Yannick Veilleux-Lepage, 'The ISIS Brand', Open Canada, 20 October 2016, https://opencanada.org/who-winning-syrian-digital-war/.

225 Rassler, 'The Islamic State and Drones', 7–16; Almohammad and Speckhard, 'ISIS Drones:'.

226 'Inside Islamic State's Improvised Weapon Factories in Fallujah', Frontline Perspective (London: Conflict Armament Research, July 2016), https://www.conflictarm.com/wp-content/uploads/2016/07/Frontline_Perspectives_Inside_Islamic_States_improvised_weapons_factories_in_Fallujah.pdf.

227 Mohamed Tahir, 'يصافت وأسرار "حالس وج" شعاد بلع ناسل أحد أضعاهنا!', RT Arabic, 6 April 2018, https://arabic.rt.com/middle_east/936743-حالس-ج-شعاد-بلع-ناسل-أحدأضعاهنا /.

228 Joby Warrick, 'Use of Weaponized Drones by ISIS Spurs Terrorism Fears', Washington Post, 21 February 2017, https://www.washingtonpost.com/world/national-security/use-of-weaponized-drones-by-isis-spurs-terrorism-fears/2017/02/21/9d83d51e-f382-11e6-8d72-263470bf0401_story.html.

229 Almohammad and Speckhard, 'ISIS Drones'.

230 'Islamic State's Weaponised Drones', Frontline Perspective (London: Conflict Armament Research, October 2016), https://www.conflictarm.com/perspectives/islamic-states-weaponised-drones/.

231 Rassler, 'The Islamic State and Drones: Supply, Scale, and Future Threats'.

232 'Islamic State's Weaponised Drones'.

233 'Procurement Networks behind Islamic State Improvised Weapon Programmes' (London: Conflict Armament Research, December 2020), https://www.conflictarm.com/reports/procurement-networks-behind-islamic-state-improvised-weapon-programmes/.

234 Ben Heubl, 'Conflict Groups Arm Consumer Drones for Terror Attacks', Engineering & Technology, 9 April 2021, https://eandt.theiet.org/content/articles/2021/04/conflict-groups-arm-consumer-drones-to-deliver-death-and-terror/.

order to avoid being overly reliant on external supply chains,[235] the ease with which the group obtained commercial drones from abroad – and the relative difficulty of producing drones of its own – encouraged the group to continue supplying itself abroad.[236] Purchasing appears to have been conducted according to well-regulated bureaucratic processes, with invoices, purchase lists, and other purchasing documents found among IS possessions abandoned in lost territory.[237]

Despite Nick Waters' evidence that IS developed a variety of different types of munitions across different regions of its caliphate,[238] it appears the group worked to develop an integrated structure of drone procurement, development, and modification. In turn, these drones were dispatched to frontline units which collaborated closely with other parts of the IS military structure. While drones were ultimately of limited effectiveness in countering the coalition's advance on IS' power centres, they remained an integral part of IS' fighting machine.

Propaganda

IS' activities were always aimed at multiple audiences, to an extent that was not replicated by other groups. From the start, the group cultivated a domestic audience within its caliphate along with a global coalition of more or less committed sympathizers, affiliates, and interested media consumers.[239] Its propaganda efforts, accordingly, spoke to both of these audiences, and relied on an extensive network of media centres producing content for these media campaigns.[240] IS devoted extensive efforts to presenting the image of effective statehood through its propaganda efforts,[241] and drone imagery constituted an integral part of this propaganda campaign, alongside its military importance.[242]

IS demonstrated a repeated interest in highlighting an aerial perspective in imagery of its military campaigns, in both video and photo series. These photos and videos fall largely into three categories. First, a large number of images show attacks in progress (for instance, the video of the attack on the Deir Ez-Zor munitions depot mentioned above), depicting drones targeting enemy positions on the ground and releasing munitions. The purpose of such photos is self-explanatory – IS is demonstrating its technical prowess, and highlighting its ability to attack targets from above. A second prevalent type of images depicts VBIED attacks in progress, in photo series

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235 'Islamic State's Multi-Role IEDs'.

236 As documented in the case of the Houthi Movement, the fact that drones (or drone components, in the Houthi case) are not in themselves restricted for purchase, transport and resale makes international supply easier than for explosives, munitions, or other restricted goods.

237 Rassler, Al-Ubaydi, and Mironova, 'The Islamic State's Drone Documents'.

238 Waters, 'Types of Islamic State Drone Bombs and Where to Find Them'.

239 see Veilleux-Lepage, 'Paradigmatic Shifts in Jihadism in Cyberspace'; Yannick Veilleux-Lepage, 'Retweeting the Caliphate: The Role of Soft-Sympathizers in the Islamic State's Social Media Strategy.', Turkish Journal of Security Studies 18, no. 1 (2016): 53–69.

240 Veilleux-Lepage, 'A Typology of Islamic State's Social Media Distribution Network'.

241 Charlie Winter, The Terrorist Image: Decoding the Islamic State's Photo-Propaganda (London: Hurst, 2022); Charlie Winter, 'Apocalypse, Later: A Longitudinal Study of the Islamic State Brand', Critical Studies in Media Communication 35, no. 1 (January 2018): 103–21, https://doi.org/10.1080/15295036.2017.1393094 ; Charlie Winter, 'Framing War: Visual Propaganda, the Islamic State, and the Battle for East Mosul', Cambridge Review of International Affairs 33, no. 5 (September 2020): 667–89, https://doi.org/10.1080/09557571.2019.1706074 ; Ayse Deniz Lokmanoglu, 'Coin as Imagined Sovereignty: A Rhetorical Analysis of Coins as a Transhistorical Artifact and an Ideograph in Islamic State's Communication', Studies in Conflict & Terrorism 44, no. 1 (2 January 2021): 52–73, https://doi.org/10.1080/1057610X.2020.1793458 ; Simone Molin Friis, '"Beyond Anything We Have Ever Seen": Beheading Videos and the Visibility of Violence in the War against ISIS', International Affairs 91, no. 4 (July 2015): 725–46, https://doi.org/10.1111/1468-2346.12341 ; Simon Mabon, 'Nationalist Jāhiliyyah and the Flag of the Two Crusaders, or: ISIS, Sovereignty, and the "Owl of Minerva"', Studies in Conflict & Terrorism 40, no. 11 (2 November 2017): 966–85, https://doi.org/10.1080/1057610X.2016.1258863.

242 A more comprehensive account of this argument can be found in Archambault and Veilleux-Lepage, 'Drone Imagery in Islamic State Propaganda'.

that often show the perpetrator, the trajectory of the vehicle, the detonation, and sometimes the aftermath. As mentioned above, these photos provide evidence of IS' use of drones for the command of such attacks. Drones were used to direct and map out these attacks, and releasing images of VBIED strikes may follow naturally from the command-and-control function of drones. It further highlights the synergy between IS' propaganda efforts and its military campaigns, both flowing from each other. The third type of image simply shows drones overflying terrain, with no ongoing military activity, or often, no human activity whatsoever. The focus of these images seems to be squarely on the act of overflying terrain – on the very ability to fly and to access the air with impunity.

These three types of drone images, we argue, fed into IS' claim to sovereign statehood through the representation of vertical sovereignty. In other words, to overfly terrain is to lay claim to possessing, controlling, and dominating it.[243] How political realities are visualized impacts how they are grasped and interpreted, and the rendering of a vertical perspective by means of drones is instrumental to IS' presentation of its caliphate.[244] In his work on drone visuality, Roger Stahl ascribes to the drone what Donna Haraway previously termed the "god trick": a specific way of viewing and representing from above, in an omniscient – and potentially omnipotent – manner.[245] By demonstrating an ability to fly over the territory it claims – controlling its airspace, and viewing the ground from above, from the omnipotent viewpoint of the state – drone imagery allowed IS to reinforce its propaganda campaign to legitimize, reify and naturalize the caliphate.

IS' drone program distinguished itself from those of other non-state groups through its tactical, technical, structural, and visual elements. First, IS favoured employing drones as flying artillery platforms to drop explosives rather than as loitering munitions or pilot-to-target weapons. Despite the seemingly higher technical complexity of such platforms, it is likely that explosive drops aligned better with the group's other requirements and constraints, such as the premium placed on the dissemination of images, the use of drones for reconnaissance and command, and the need to reuse the drones. Second, IS integrated its employment of drones tightly with other aspects of its military and propaganda activities, using drones to direct and film VBIED attacks, spot and target artillery, and to augment the effectiveness of other weapons systems. Third, despite its lack of state patron, IS established a comprehensive and integrated technical and organizational structure to centralize drone modification activities and training. Finally, while all non-state groups integrate drones into their propaganda efforts, IS went further in employing the vertical perspective offered by drones to directly further the visual and rhetorical grounding of its claim to a legitimate caliphate.

243 See for instance Alison J. Williams, 'Reconceptualising Spaces of the Air: Performing the Multiple Spatialities of UK Military Airspaces: Reconceptualising Spaces of the Air', Transactions of the Institute of British Geographers 36, no. 2 (April 2011): 253–67, https://doi.org/10.1111/j.1475-5661.2010.00416.x ; Alison J. Williams, 'Hakumat al Tayarrat: The Role of Air Power in the Enforcement of Iraq's Boundaries', Geopolitics 12, no. 3 (31 July 2007): 505–28, https://doi.org/10.1080/14650040701305690 ; Stuart Elden, 'Secure the Volume: Vertical Geopolitics and the Depth of Power', Political Geography 34 (May 2013): 35–51, https://doi.org/10.1016/j.polgeo.2012.12.009.
244 Kyle Grayson and Jocelyn Mawdsley, 'Scopic Regimes and the Visual Turn in International Relations: Seeing World Politics through the Drone', European Journal of International Relations 25, no. 2 (June 2019): 431–57, https://doi.org/10.1177/1354066118781955 ; Antoine Bousquet, The Eye of War: Military Perception from the Telescope to the Drone (Minneapolis: University of Minnesota Press, 2018); Campbell A. O. Munro, 'Mapping the Vertical Battlespace: Towards a Legal Cartography of Aerial Sovereignty', London Review of International Law 2, no. 2 (September 2014): 233–61, https://doi.org/10.1093/lril/lru008 ; Peter Adey, Mark Whitehead, and Alison J. Williams, eds., From above: War, Violence and Verticality (London: Hurst, 2013).
245 Roger Stahl, 'What the Drone Saw: The Cultural Optics of the Unmanned War', Australian Journal of International Affairs 67, no. 5 (November 2013): 664, https://doi.org/10.1080/10357718.2013.817526.

Chapter 6: Kurdistan Workers' Party / Democratic Union Party

Past Developments

For nearly four decades, the Kurdistan Workers Party (Partiya Karkerên Kurdistanê, or the PKK) and its affiliated/allied organizations and offshoots have been leading multiple insurgencies in southwest Syria, northwest Iraq and southern Turkey, with a notable ability to carry out attacks within these three countries and beyond. The PKK's ability to sustain a multi-decade insurrection against the Turkish Armed Forces (TSK) – the second largest NATO military in terms of manpower and (non-nuclear) firepower[246] – owes in part to the PKK's resilience, its ability to adapt to the shifting contingencies in the regions and the changing security environment, and its ability and willingness to adopt new techniques and weaponry.[247]

Concerns that the PKK might seek to weaponize toy-class remote-controlled airplanes emerged as early as 2012, when Barış Kizilcay, – a suspected accomplice of a 2012 bombing in Gaziantep – was put on trial.[248] Kizilcay told investigators that the PKK had acquired seven remote-controlled airplanes capable of being controlled for up to 30 km with the use of a nose camera at speeds up to 20 km/h, and planned to use them in the future against government targets in Turkey.[249] Kizilcay's claims were quickly dismissed by investigators as fanciful and exceeding the technical capabilities of most commercially available remote-control aircraft platforms. Instead, the genesis for the PKK's active drone program can be found in the multifaceted Syrian Civil War.

Throughout the Syrian Civil War, the PKK and its Syrian branch – the Democratic Union Party (PYD) – was routinely targeted with military and commercial drones by both IS and the TSK. IS first used drones to survey soldiers in People's Protection Units (YPG; the armed wing of the PYD) outside of Erbil in May 2015[250] and began to attack Peshmerga forces with explosive-laden drones in mid-December that year.[251] Coincidentally, the Turkish government at the same time drastically increased the frequency of its drone strikes against the PKK in Syria and Iraq, with the aim of using low-cost and persistent airpower to strike PKK leaders and lower-ranking cadres in areas which it could not previously reach. In this context, Turkey has prioritized the development of domestic military drones such as the Baykar Bayraktar TB2 and the TAI Anka.[252] Faced with this two-pronged threat, the PKK and its affiliated organizations not only sought to develop their own drone program but also repurposed captured IS drones. Despite this, the drone program of the PKK and its affiliated organizations has gone largely unnoticed by Western observers.

246 Omar Ashour, 'Punching Above Weights: Combat Effectiveness of Armed Nonstate Actors in the Arab World and Beyond' (Arab Center for Research & Policy Studies, 2020), https://www.jstor.org/stable/resrep25855.5.
247 Mustafa Coşar Ünal and Petra Cafnik Uludağ, 'Eradicating Terrorism in Asymmetric Conflict: The Role and Essence of Military Deterrence', Terrorism and Political Violence 34, no. 4 (19 May 2022): 772–816, https://doi.org/10.1080/09546553.2020.1742113.
248 'PKK'nın Katliam Okulları', Hurriyet, 27 August 2012, https://www.hurriyet.com.tr/gundem/pkknin-katliam-okullari-21313089.
249 'Remote Control Model Airplanes as Terrorist Weapons' (Washington, D.C: Complex Operational Environment and Threat Integration Directorate, November 2012), https://community.apan.org/wg/tradoc-g2/operational-environment-and-threat-analysis-directorate/m/documents/212964.
250 Rassler, 'Remotely Piloted Innovation', 37; 'Peshmerga Shoot Down Islamic State Drone in Gwer', Iraq News Today, 5 May 2015, http://www.islamedianalysis.info/peshmerga-shoot-down-islamic-state-drone-in-gwer-is-insurgents-use-small-drones-for-spying-on-peshmerga-forces/.
251 David Hambling, 'ISIS Is Reportedly Packing Drones with Explosives Now', Popular Mechanics, 16 December 2015, https://www.popularmechanics.com/military/weapons/a18577/isis-packing-drones-with-explosives/.
252 Francesco F. Milan and Aniseh Bassiri Tabrizi, 'Armed, Unmanned, and in High Demand: The Drivers behind Combat Drones Proliferation in the Middle East', Small Wars & Insurgencies 31, no. 4 (18 May 2020): 730–50, https://doi.org/10.1080/09592318.2020.1743488.

Current Advances

Earliest reports of the PKK/YPG drone program date back to 24 March 2015, when several Twitter accounts linked to IS tweeted images of IS militants holding up a small drone, claiming that it had been used by the YPG to conduct reconnaissance before being shot down by IS militants.[253] Similar claims also appeared on IS-linked Twitter and Telegram accounts on 7 June and 29 October 2016.[254] The Turkish military also claimed, as early as January 2016, to have seized a Puma RQ-20 with removable wings used by PKK militants during a search in the southeastern town of Silopi.[255] The exact provenance of this drone has been disputed, but some observers have speculated that this drone was acquired by the PKK from the YPG.[256] The following month, the Turkish military also claimed to have captured a second weapons stash which included several drones rigged with explosives.[257]

The first instances of weaponization of drones by the PKK date back to 12 October 2016, when PKK militants unsuccessfully attempted to use a drone to drop a grenade onto Turkish army troops stations in Hakkari, near the Iraq-Turkey border. The drone was reported to have been destroyed in flight by small arms fire before it could release its payload, and no one was injured. The following year, in June, a PKK armed drone – a modified commercial off-the-shelf quadcopter – was captured on the Iraqi border.[258] The following month, two Turkish soldiers were injured by a modified VOG-17M high-explosive grenade dropped from a multicopter in Semdinli near the Turkey-Iraq-Iran border.[259] This was the first successful PKK drone attack. While modified quadcopters are still used by the PKK, by 2018 a new type of weaponized drone began appearing in its arsenal: small fixed-wing drones.

Tactical Innovation

For the period between 31 August 2018 and September 2021, our research team identified sixty-five reports of drone use by the PKK, nearly all of which involved weaponized drones. The majority of drone action by the PKK and its affiliates or allies appears to have taken place in 2020 and 2021. A survey of these incidents illustrates three important trends in the PKK's development and use of drones: (1) a shift from multicopter and rotary wing drones toward fixed-wing glider type platforms, (2) the use of coordinated groups of multiple drones, and (3) highly symbolic attacks.

253 Steven Stalinsky and R. Sosnow, 'A Decade of Jihadi Organizations' Use of Drones – From Early Experiments By Hizbullah, Hamas, And Al-Qaeda To Emerging National Security Crisis For The West As ISIS Launches First Attack Drones', Middle East Media Research Institute, 21 February 2017, https://www.memri.org/reports/decade-jihadi-organizations-use-drones-—-early-experiments-hizbullah-hamas-and-al-qaeda.
254 Stalinsky and Sosnow; 'Peshmerga Recon Plane Shot Down by ISIS', Middle East Media Research Institute, 8 June 2016, https://www.memri.org/cjlab/peshmerga-recon-plane-shot-down-by-isis.
255 'Drone Used by PKK Found in Southeast Turkey', Hürriyet Daily News, 21 January 2016, https://www.hurriyetdailynews.com/drone-used-by-pkk-found-in-southeast-turkey-94160 ; Son Güncellenme, 'PKK sığınağında İHA bulundu', Milliyet, 21 January 2016, https://www.milliyet.com.tr/gundem/pkk-siginaginda-iha-bulundu-2182198.
256 Güncellenme, 'PKK sığınağında İHA bulundu'.
257 David Hambling, 'Kurdish PKK Militants Step Up Improvised Drone Bomb Attacks In Turkey', Forbes, 27 August 2020, https://www.forbes.com/sites/davidhambling/2020/08/27/pkk-terror-group-steps-up-improvised-drone-bomb-attacks/.
258 Ali Kemal Erdem, 'PKK, Ilk Kez Paramotorla Saldırmıyor: 3 Ay Önce Haftanin'de Saldırmaya Çalışan Kadın Militan 500 Metre Yükseklikte Vuruldu', Independent Turkish, 27 October 2020, https://www.independentturkish.com/node/263526/haber/pkk-ilk-kez-paramotorla-sald%C4%B1rm%C4%B1yor-3-ay-%C3%B6nce-haftaninde-sald%C4%B1rmaya-%C3%A7al%C4%B1%C5%9Fan-kad%C4%B1n; Hambling, 'Kurdish PKK Militants Step Up Improvised Drone Bomb Attacks in Turkey'.
259 Hambling, 'Kurdish PKK Militants Step Up Improvised Drone Bomb Attacks in Turkey'.

In addition to using small fixed-wing drones to conduct reconnaissance and support for ground operations,[260] fixed-wing drones have been weaponized by the PKK both as a means to drop ordnance and as pilot-to-target munitions.

Based on observations, the most popular fixed-wing model employed by the PKK appears to be the commercial X-UAV Talon hobby kit with Styrofoam wings. The Chinese-made multifunctional X-UAV Talon is a simple, compact, and highly manoeuvrable UAV designed to perform a wide variety of tasks, including operations related to reconnaissance, observation missions, terrain monitoring, and aerial photography. According to the manufacturer's specification, the Talon is capable of reaching a maximum flight speed of 100 km/h, and if equipped with a 24 dB(isotropic) parabolic antenna can have a range of up to 40 km.[261] Drone enthusiasts have also reported modifying the Talon to augment its range to up to 240 km.[262] In addition to its speed and range, the Talon and similar fixed-wing UAVs appear to be favoured by the PKK due to their size and low cost; that is, the Talon can be easily acquired, transported and assembled. It can also be preprogrammed to fly to a given destination using GPS, which allows for greater ammunition drop-off speed, angles, and cruising speeds, as well as potentially reducing operators' exposure.

In addition to employing fixed-winged drones, the PKK's drone strategy has evolved to centre around the simultaneous use of multiple aircraft to conduct attacks. On 10 November 2018, in Sirnak, eight fixed-wing drones carrying nail-reinforced C-4 plastic explosive attached using duct tape were used to target Turkish troops during an evening event to honour Atatürk, the founding father of the Republic of Turkey.[263] This included attacks on the Governor's Office, the 23rd Infantry Division Command, and the military bases in Kayatepe, and Aydoğdu, On 1 January 2019, similar attacks took place on the Sehir Ercument Turkmen quarters in Silopi and targeted the Cizre District Gendarmerie Command. In this case, at least three nail-reinforced C-4 plastic explosive-loaded drones were utilized.[264]

The final distinctive characteristic of PKK/PYD drone use relates to the nature of their targets and the timing of their attacks. Early PKK attacks used drones primarily against Turkish combat outposts and other positions in the Northern Kurdistan region; however, the shift from quadcopters dropping munitions onto their targets to the use of fixed-wing pilot-to-target drones represented a shift toward symbolic attacks on hardened or high-value targets. These targets have ranged from military installations to airports. The timings of these attacks have also coincided with national holidays, such as the anniversary of the death of Atatürk or New Year's Eve.

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260 Fixed-wing drones have been used by Kurdish Peshmerga to conduct reconnaissance since as early as 2016. Photos released from the YPG in October 2016 showed Kurdish Peshmerga in the run-up to the Mosul offensive preparing a My Twin Dream fixed-wing hobby drone – a popular and widely available twin-motor remote-control hobby aircraft designed for long-distance flying. @Dr_Partizan, 'Kurdish Pêşmerga Forces Prepare a UAV for Use against ISIS Terrorists Today in the #Mosul Offensive. Https://T.Co/YP5Q3tH6QU', Tweet, Twitter, 17 October 2016, https://twitter.com/Dr_Partizan/status/788057621794287617. Dan Gettinger, 'Drones Operating in Syria and Iraq' (Bard College: Center for the Study of the Drone, December 2016), https://dronecenter.bard.edu/drones-operating-in-syria-and-iraq/.

261 'X-UAV Talon. Specifications', Avia.Pro, 26 September 2017, https://avia-pro.net/blog/x-uav-talon-tehnicheskie-harakteristiki-foto.

262 'X-UAV MINI Talon 240KM LONG RANGE - RC Groups', accessed 26 September 2022, https://www.rcgroups.com/forums/showthread.php?3493103-X-UAV-MINI-Talon-240KM-LONG-RANGE ; 'A Long Range FPV Plane — Plane Documentation', ArduPilot, 2021, https://ardupilot.org/plane/docs/miniTalon-build.html.

263 Cemal Acar [@Acemal71], '#BREAKING Local Sources Say #PKK Attacked with 4 #UAVls in Turkey's Border City Şırnak. The Attack Thwarted by Turkish Security Forces. The UAVs Were Carrying Bombs and Nails. https://T.Co/9eRQY3fPLJ ', Tweet, Twitter, 10 November 2018, https://twitter.com/Acemal71/status/1061194893392011264.

264 Cemal Acar [@Acemal71], 'Last Night, Pkk Attacked with 3 Model Aircrafts with IEDs Attached to Şırnak Police Department and Ercüment Turkmen Barracks. Reportedly 1 of Them Shot down by the Security Forces While Another 2 #UAVls Landed. https://T.Co/MrwamV6aYN ', Tweet, Twitter, 1 January 2019, https://twitter.com/Acemal71/status/1080118417032728577.

A survey of PKK/PYD attacks indicates that they are rarely successful. Of the sixty-five cases of weaponized drone use in our database, eleven appear to have been unsuccessful, while an additional fifteen did not result in any casualties. Of the remaining thirty-nine, twenty-four appear to have successfully hit their targets but no damage reports are available, and for the remaining fifteen instances no information is available. Surveying the failed attacks, it appears that the Turkish military has had considerable success in downing incoming drones either with firearms or by jamming their frequencies.

Traditional insurgent attacks are still being used in addition to drones. As part of its strikes against Turkey, the PKK also employs indirect fire, wire-guided rockets, and IEDs. As drones have cameras that can film attacks, they can assist in a variety of operations. Kurdish Peshmerga and irregular forces have been using commercial off-the-shelf small UAVs in Iraq and Syria with reported significant operational benefits, with Peshmerga officers attributing significant operational success to drone reconnaissance flights.[265] Despite their high propaganda value in attacking symbolic targets, the offensive utility of drones seems to be limited to conducting minor attacks. For the PKK, drones appear to be more of an add-on to existing strategies than a revolutionary transformation in practices; for Turkey, these attacks seem to be more of a nuisance than a major menace.

Development of Program and Supply

Reports from 2017 indicated that the PKK employed of three DJI consumer drones, namely the Mavic, the Phantom, and the Matrice (made for commercial use); these models have also been used by IS.[266] DJI drones are typically equipped with either a homemade or commercially manufactured 'bomb' drop system, such as the Chinese-made 'bombs away' attachment that can be purchased for $16.95.[267] These drones are often armed with either modified mortar shells, VOG-17M high-explosive grenades, or RPG-7 warheads, which are often modified to improve their accuracy. Based on the images surveyed, it appears that the most common modification of these types of ordnance involves adding fins, made from materials ranging from badminton shuttlecocks to plastic bottles. In what is undoubtedly the most high-profile PKK drone attack involving a quadcopter, the PKK audaciously attacked Turkey's Diyarbakir airport with a quadcopter equipped with three RPG-7 warheads in May 2021.[268] The drone was also fitted with the flag of the People's Defence Forces, the military wing of the PKK.

265 Larry Friese, N.R. Jenzen-Jones, and Michael Smallwood, 'Emerging Unmanned Threats: The Use of Commercially-Available UAVs by Armed Non-State Actors' (Perth, Australia: Armament Research Services, 2016), https://armamentresearch.com/wp-content/uploads/2016/02/ARES-Special-Report-No.-2-Emerging-Unmanned-Threats.pdf.
266 Hambling, 'Kurdish PKK Militants Step Up Improvised Drone Bomb Attacks in Turkey'; Heubl, 'Conflict Groups Arm Consumer Drones for Terror Attacks'.
267 Kurt Klinkmueller et al., 'Airborne Delivery of Unmanned Aerial Vehicles via Joint Precision Airdrop Systems', in AIAA Scitech 2019 Forum (San Diego, California: American Institute of Aeronautics and Astronautics, 2019), https://doi.org/10.2514/6.2019-2285.
268 Harwan Faidhi Dri, 'Drones: A New Tactic in PKK's Armed Struggle against Turkey?', Rudaw.Net, 14 June 2021, https://www.rudaw.net/english/analysis/12062021 ; Çetiner Çetin, 'PKK'nın maket uçak siparişleri', Haberturk, 25 May 2021, https://www.haberturk.com/yazarlar/cetiner-cetin/3082644-pkk-nin-maket-ucak-siparisleri.

Figure 10: Example of a munition drop by the PKK

The exact supply chains used by the PKK are difficult to trace, though information suggests a plurality of sources, including equipment found in the field as well as acquired from elsewhere. Commonalities between attacks using nail-reinforced explosives (in 2018, see above) has led some observers to suggest that the drones used in these attacks were prepared in the same workshop, and that this workshop could be somewhere close to Sirnak, on the Syrian side of the border. This, in turn, indicates that the PKK/PYD might be using drone workshops that it captured from IS during the Raqqa offensive.[269] Turkish officials have long claimed that the PKK has established a "drone school" in the Markhmour refugee Camp in Erbil province.[270] In June 2021, the Turkish President claimed in a tweet that security forces had killed Selman Bozkir, the senior PKK official overseeing the school.[271] These claims suggest the presence of a nascent drone development infrastructure, though one perhaps more ad hoc than systematically organized.

Other sources of supply come from the West, either through official channels or commercial ones. Turkish officials have repeatedly claimed that the weapons – including drones – given to the YPG by the US-led global coalition against IS ended up in the hands of the PKK.[272] Furthermore, media reports indicate that the captured PKK drones may contain parts imported from Canada, including systems designed to make drones more difficult to detect by radar.[273] The precise supply chain for these components, however, has not been determined.

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269 Serkan Balkan, 'How Cheap Drones Became Assets for Terrorist Organizations', Politics Today, 17 January 2019, https://politicstoday.org/how-cheap-drones-became-assets-for-terrorist-organizations/.
270 Dri, 'Drones'; Çetin, 'PKK'nın maket uçak siparişleri'.
271 Recep Tayyip Erdoğan [@RTErdogan], 'Buradan Milletimize güzel bir haber vermek istiyorum. Terör örgütü PKK'nın üst düzey yöneticisi ve Mahmur genel sorumlusu "Doktor Hüseyin" kod adlı Selman Bozkır, dün Milli İstihbarat Teşkilatı'mızın kahramanları tarafından etkisiz hale getirildi.', Tweet, Twitter, 6 June 2021, https://twitter.com/RTErdogan/status/1401533629533130756.
272 'US Arms to YPG Will Not End up in PKK Hands, Says PYD Leader', Rudaw, 14 May 2017, https://www.rudaw.net/english/middleeast/syria/14052017.
273 Güncelleme Tarihi, 'Diyarbakır'daki PKK saldırısında Kanada izi', Hürriyet, 20 May 2021, https://www.ensonhaber.com/gundem/diyarbakirdaki-pkk-saldirisinda-kanada-izi ; 'PKK Drones Used Canadian Technology, Report Says', Daily Sabah, 20 May 2021, https://www.dailysabah.com/politics/war-on-terror/pkk-drones-used-canadian-technology-report-says.
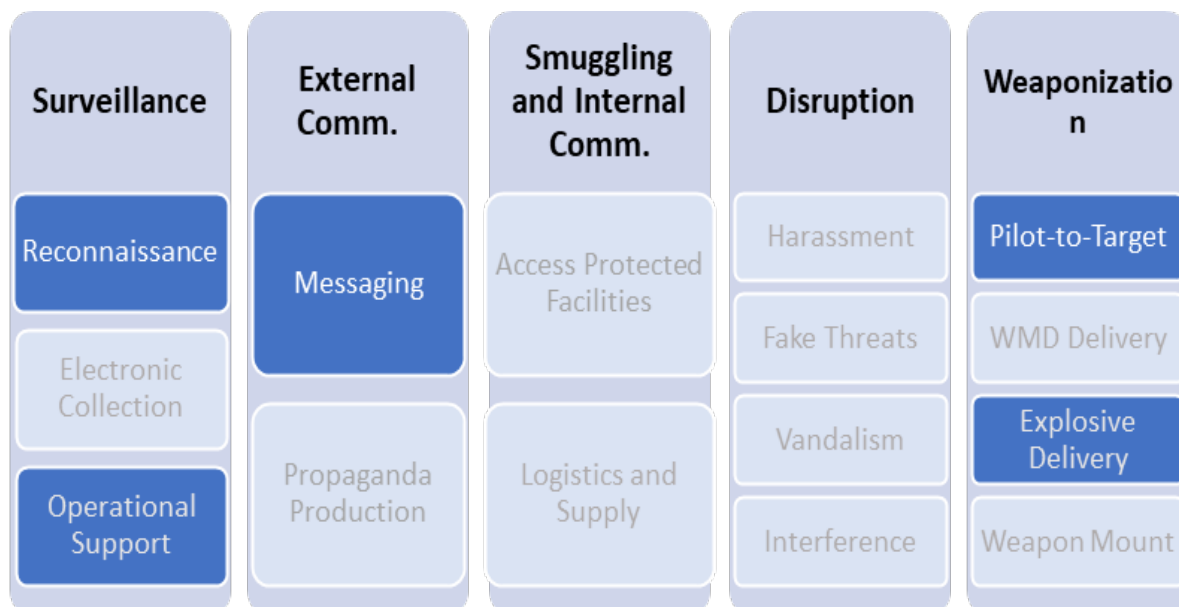
Figure 11: Typology of drone use by the PKK. Blue boxes denote uses observed.

Chapter 7: Comparative Analysis

The groups discussed in this report have all developed drone programs which evolved over time, spanning different methods, means, and objectives. One of the main objectives of this report is to rectify sweeping and incorrect assumptions about the role and development of non-state drone use. To this end, systematic empirical data collection was conducted, focusing on five groups with major long-term drone programs. This data allows us to highlight how such groups actually employ drones – rather than what experts may speculate – and why they use them in this way. Each group employs drones for different objectives and operates under different constraints; this report aims to highlight these objectives and constraints. Contrary to Rassler's suggestion that "the drone methods and approach taken by the Islamic State provide a roadmap for state and non-state actors alike to emulate, to learn from, or—perhaps more importantly—to take in new directions,"[274] we find that each group has largely charted its own path, according to its own circumstances. Counter-drone operations by forces combating non-state groups must therefore adapt to the specific conditions of their adversary. Nevertheless, this final chapter will also establish some points of commonality between several of the non-state drone programs surveyed. In so doing, it draws on the revised typology introduced in Chapter 1. This typology – adapted from Rassler's study – comprises a number of expectations concerning likely uses of drones by non-state actors. In our research we have identified some of these uses, while others have not occurred.
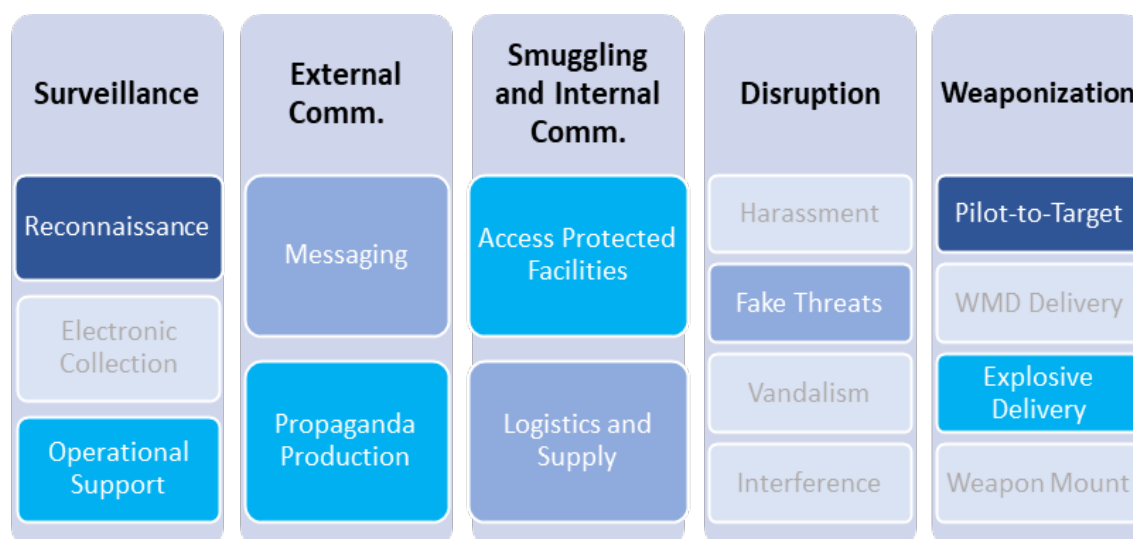
Figure 12: Comparative typology of drone uses. Dark Blue: attested for all groups. Bright blue: attested for two or three groups. Light blue: attested for one group. Grey: not attested for any group.

Comparison of Processes of Development

The groups under study here have operated on significanvtly different timescales. Whereas Hezbollah (and to a lesser extent Hamas) have been engaging with drone development and use for decades, the Houthi Movement, IS, and the PKK developed their programs while in active conflicts, under significantly compressed timescales. The main distinction between the groups under study lies in whether they receive aid from a state patron (i.e. Iran) or whether they developed their programs on their own without state patronage. That being said, even groups receiving aid from Iran rely on their own processes of development and maintain supply chains outside of their patron. In the case of the two major groups – Hezbollah and the Houthi Movement– achieving self-sufficiency in drone production appears to be a significant concern.[275]

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274 Rassler, 'The Islamic State and Drones', 1.
275 'Hizbullah Secretary-General Hassan Nasrallah: We Have Been Manufacturing our own Drones'.

The Houthi Movement, owing in part to the presence of a state patron willing to share technological knowledge and support supply chains, transitioned rapidly from improvised quadcopters to externally supplied technology. In a further evolution of their program, they switched from foreign-supplied technology to assembling their own drones with smuggled parts and homemade airframes. Hezbollah, on the other hand, began with Iranian fixed-wing drones, before adopting modified commercial quadcopters as it engaged in more sustained operations against less advanced enemies in Syria. Against Israel, the group now appears to use both in parallel, in attempts to both achieve long-range attacks and avoid detection. IS, meanwhile, lacking a state patron, established a centralized structure of its own to oversee training, supply, and modification. While IS mostly opted to use drones to drop explosives rather than as pilot-to-target munitions, it nevertheless proved adept at modifying and weaponizing drones with limited means. While IS made some attempts at building drones from scratch and developing more advanced pulse jet engines, the availability of foreign-sourced quadcopters along with time pressures led it to concentrate on the industrial-scale production of simple drones and munitions. The PKK, meanwhile, appears to be making some attempts at modifying commercial drones and achieving more advanced capabilities, though in a more ad hoc manner than IS. Hamas, finally, appears to employ drones mostly in a status-seeking manner, and uses Iranian-designed Ababils.

One further point to note is that three of these groups – at least for a time – controlled sufficient territory which allowed them the space and time to modify, equip, and launch drones. IS established a network of training camps, factories, and storage facilities for centralized management in the territories it controlled; similarly, the ability of Houthi forces to assemble and develop homemade drones is made possible by its ability to operate with relative impunity in swathes of Yemen. This may also explain why the speculation concerning IS drone operations abroad never materialized, or at least never materialized successfully: the modification and preparation of drones for attack requires time and space. As Ostovar noted, Hezbollah has been able to rely much more than Hamas on support from Iran in large part due to the group's control of significant swathes of territory, which has allowed it space to organize and modify drones, to train, and to build heavy infrastructure.[276] Hamas has had far less success in establishing a successful drone program, due among other things to the constant pressure from attempts by Israeli military and intelligence forces to disrupt its activities.[277]

Common Types of Use/Threats

The strategic purposes for which groups employ drones vary significantly, and these variations can be ascribed to the types of conflicts in which these groups are engaged. For IS, engaged in a prolonged conflict which involved significant ground fighting, often in urban settings, the threat of drones accordingly related to this type of warfare. Most strikes involved attacks on fighting positions, vehicles, and infantry units. In urban settings, IS sought to employ drones to improve the ability of its overall fighting forces in combined operations. Drones were used to expand command and control, surveil enemy movements, and attack exposed positions. As Raymond Thomas declared, at times the paralysis caused by such drone presence would hamper Coalition operations for hours at a time.[278] The threat of IS drones, therefore, was multifaceted: in addition to being wary of aerial attacks, Coalition troops would have had to be aware of the increased threat posed by a more capable enemy with expanded intelligence-gathering capabilities. The threat of drones, in other words, reverberated throughout combat operations, for instance through the heightened risk of VBIED attacks guided by drone command and control.

276 Ostovar, 'The Grand Strategy of Militant Clients', 167.
277 Kais and Osmo, 'Tunisian Media Reporting Mossad Assassinates Hamas Official'.
278 Larter, 'SOCOM Commander'.

The Houthi Movement, on the contrary, have been using drones in ways more akin to cruise or ballistic missiles to enable long-range attack. In many cases, in fact, drones are used alongside these missiles to multiply the threats to be countered. Drones can be used both to degrade defensive capabilities – such as by attacking Patriot missile radar positions[279] – and to attack defended targets through unexpected angles of approach, sometimes with the use of allied forces.[280] The threat presented by Houthi drone attacks is therefore much broader in scope, and concerns a large number of economic and symbolic targets across wide areas. In particular, their ability to use drones to disrupt air defence systems suggests a need to upgrade such systems to counter hard-to-detect systems. However, the Houthi forces' employment of multiple means of attack simultaneously (drones, cruise missiles and ballistic missiles) as well as the sheer number of targets to cover suggests fundamental limitations in this respect. So far, he most effective means of controlling the frequency of Houthi drone attacks appears to have been political: ceasefires and restraint.

Hamas and Hezbollah have largely been using drones in manners similar to the Houthi Movement, though with an emphasis on symbolic penetrations of Israeli borders.[281] Overflights of the Dimona nuclear reactor or of Tel Aviv are meant as demonstrations of capabilities, intended to provoke fear and perhaps cause domestic unrest.[282] In the case of Hamas in particular, there is a clear element of status-seeking in the group's drone activity, demonstrated by the christening of "Shehab Square" in Gaza. These demonstrations of capabilities appear to have been quite effective, despite the strengthening of Israeli anti-air defences: as mentioned in Chapter 2, there is significant fear in Israeli media that Hezbollah may have assembled a drone army of several thousand aircraft, which would allow it to overwhelm Israeli defences and cause heavy casualties in Israel in the case of conflict. In other words, the absence of important drone activity by Hezbollah (beyond episodic flights) is not taken as proof of lacking capabilities, but as evidence that Hezbollah is hiding its true capabilities.

The PKK, meanwhile, occupies a position somewhere between IS on the one hand and Hezbollah and Hamas on the other. Like IS, the PKK employs drones largely as part of combat operations, in conjunction with other weapons systems. Indeed, this appears to be where the group's drones are most useful. However, it has also engaged in highly symbolic attacks on salient targets in Turkey; despite the absence of heavy propaganda dissemination (as is the case for IS), the PKK nonetheless appears to seek to demonstrate its ability to employ drones, particularly to achieve strikes on well-defended and difficult targets. In addition, like all other groups, the PKK has been on the receiving end of heavy aerial campaigns, notably by drones, and therefore may see armed drone attacks as a means to reciprocate the violence to which they are subject, thereby claiming state-like status.[283]

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279 'Evolution of UAVs Employed by Houthi Forces in Yemen'.

280 Many sources – American and Saudi officials, as well as the UN Security Council-mandated Panel of Experts on Yemen – have stated that the September 2019 attack on the Abqaiq oil field was likely conducted by forces other than Houthis, though the Houthis claimed the attack. The January 2021 attack on the Saudi Royal Palace, on the other hand, was claimed by another group based in Iraq. Therefore, while the frequency and modalities of joint Houthi-allied operations are unclear, the groups in question certainly collaborate at least sometimes on operations against common enemies.

281 Paul W. Kahn, 'Imagining Warfare', European Journal of International Law 24, no. 1 (February 2013): 199–226, https://doi.org/10.1093/ejil/chs086.

282 Al-Aloosy, 'Deterrence by Insurgents'.

283 See Archambault and Veilleux-Lepage, 'Drone Imagery in Islamic State Propaganda'.

Sources of Supply

The presence or absence of state patronage appears to have a significant impact on the ability of groups to source more advanced drones. Nevertheless, even groups with access to Iranian supplies and support maintain their own sources of commercial supply in order to supplement state deliveries or reduce their dependence.[284] Furthermore, while Houthi forces (and perhaps Hezbollah) appear to have resorted to assembling drones themselves with homemade airframes to bypass embargoes on arms supplies, smuggling remains an effective source of supply for all the groups under study. While a distinction exists between groups with access to state patrons – mostly Iran, though there are allegations that the PKK has obtained weapons indirectly from the US-led coalition against IS[285] – commonalities exist among all groups, in that they all rely on smuggling networks, mostly to obtain Chinese-manufactured parts or drones through circuitous routes.

Most of the commercial drones employed by the groups under study are manufactured in China, largely by DJI. These drones are easy to obtain, cheap to buy, and can be smuggled easily either whole or in parts. Most groups do not import the drones directly from China but have them employ circuitous routes, which sometimes go through Western countries to make them harder to track.[286] While DJI, under pressure from governments, has taken some steps to attempt to counter violent use of their drones,[287] these steps are easily circumvented with minimal technical skills. Overall, non-state groups have found it relatively uncomplicated to obtain commercial drones or drone parts. In large part, the dual-use nature of such technologies makes it difficult for states to impose export restrictions or reporting requirements.[288] Other groups such as the Houthi Movement favour importing parts and assembling them onto airframes themselves, which can make it even more difficult to track provenance and circulation. Some of the materials which support drone operations allegedly originate in Western countries, including potentially in Canada.[289]

The role of Iran as a major supplier of drone technology to client states deserves significant attention. Three of the five groups studied here have some form of client link with Iran, though the scope and nature of these client-patron relations vary. Two of the groups – Hezbollah and the Houthi Movement– control significant terrain, which allows them to obtain significant assistance from Iran, and to operate advanced weapons systems. For example, the Houthi Movement has, in addition to drones, obtained short-range ballistic missiles and cruise missiles.

In some cases, the direction of assistance is reversed, with clients assisting Iranian forces. Hezbollah's drone operations in Syria were undertaken at the behest of Iran on behalf of its client regime, Bashar al-Assad's government. In 2019, as Iran was engaging in sporadic attacks on shipping and on American surveillance drones in the Strait of Hormuz, Houthi forces shot down an MQ-9 Reaper drone.[290]

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284 Heubl, 'Conflict Groups Arm Consumer Drones for Terror Attacks'; Rassler, 'The Islamic State and Drones'; 'Evolution of UAVs Employed by Houthi Forces in Yemen'.
285 'US Arms to YPG Will Not End up in PKK Hands, Says PYD Leader'.
286 Heubl, 'Conflict Groups Arm Consumer Drones for Terror Attacks'.
287 Tim Bradshaw, 'Drone Maker DJI Updates Software to Thwart Terrorist Use', Financial Times, 28 April 2017, https://www.ft.com/content/317ab47c-2baa-11e7-bc4b-5528796fe35c.
288 'Procurement Networks behind Islamic State Improvised Weapon Programmes'; Levitt, 'Hezbollah's Procurement Channels'.
289 'PKK Drones Used Canadian Technology, Report Says'.
290 Brown, 'Statement from US Central Command on Attacks against U.S. Observation Aircraft'.

Inter-client attacks and cooperation also take place: Hezbollah has allegedly also trained and supported drone operations by Houthi forces, and the group declared that it had donated nearly $700,000 to the Houthi Movement for the purchase of drones.[291] The 2019 attacks on the Aramco oil field were claimed by Houthi forces, but were likely undertaken either directly by Iran-launched drones or by Iraqi militias. In 2018, drones that were downed by Israeli air forces after entering from Syria were also attributed to Iranian forces directly, rather than to one of its clients.

Having a state patron who can supply more advanced drone technology presents certain advantages to clients, though it is by no means essential. Groups aligned with Iran employ its technology transfers for ambitious operations, but nevertheless maintain alternative sources of supply and development. In the case of Hezbollah and the Houthi Movement, being able to assert self-sufficiency appears to be a clear marker of status, in addition to allowing their patron to deny responsibility. As such, it appears that state patronage is useful mainly in enabling groups to jump-start their drone programs. The Houthi Movement established a proficient drone program very quickly with Iranian support, with autonomous infrastructures catching up later as they began assembling their own weapons. Hezbollah, similarly, relied at first on Iranian technology transfers before beginning to integrate commercial drones equipped by the group itself. For Iran, meanwhile, in addition to the strategic advantages inherent to client or proxy relations,[292] there is a potential commercial benefit: the extensive use of Iranian drones in conflicts across the Middle East may serve as a proof of capabilities for the Iranian drone industry, boosting foreign exports. Russia's recent purchase of Iranian drones for use in its invasion of Ukraine comes on the back of extensive use of similar models in Yemen and Syria. [293]

Potential Responses

Approaches to mitigating the threat posed by violent non-state drone programs can be classified into four categories: tactical, logistical, technological, and commercial/preventive. None of these has proven entirely effective in itself, and the more successful approaches have drawn on elements from multiple categories. While these approaches apply to countering drone threats in general, countering non-state drone programs presents additional challenges due to the capacity of such groups to adapt.[294] As such, in addition to countering individual attacks, militaries and societies aiming to counter drone threats must consider how to disrupt drone programs as a whole. In some cases, the threat of drone activity may be inseparable from the conflict itself.

Tactical/Operational Responses

As the statement by Raymond Thomas which opens this report suggests, non-state drone programs can require significant tactical adaptation, as militaries must not only deal with a new type of attack but also account for potential contributions of drone surveillance and intelligence gathering to ground-based attacks. Among potential operational responses, two merit particular consideration: targeting drone operators, and targeted killing of major drone commanders.

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291 'Iraqi Hizbullah Brigades Launch Campaign To Finance Houthi Drones With Initial Pledge Of One Billion Dinar ($685,000)', Middle East Media Research Institute, 31 January 2022, https://www.memri.org/tv/iraqi-hizbullah-brigades-campaign-finance-drones-houthis-attack-ksa-uae ; Naya, طائرات "حزب الله".. تقرير إسرائيلي يكشف أعوانها ومساراتها'.
292 Ostovar, 'The Grand Strategy of Militant Clients'; see also Andreas Krieg and Jean-Marc Rickli, Surrogate Warfare: The Transformation of War in the Twenty-First Century (Washington: Georgetown University Press, 2019).
293 Tamir Eshel, 'Yemeni Houthis Display Iranian Drones and Loitering Missiles', Defense Update, 27 September 2022, https://defense-update.com/20220927_yemeni-houthis-display-iranian-drones-and-loitering-missiles.html ; 'Russia's Iranian Suicide Drones Unleashed On Ukraine', Radio Free Europe/Radio Liberty, 6 October 2022, https://www.rferl.org/a/russia-s-iranian-suicide-drones-unleashed-on-ukraine/32067917.html.
294 See Veilleux-Lepage, How Terror Evolves.

The first alternative – targeting drone operators – uses the drone as an indicator or clue to the presence of operators. In dealing with Iraqi insurgencies in the late 2000s, American forces in Iraq adopted a similar approach to eliminating IED threats: using wide-area aerial surveillance systems mounted on aircraft or MQ-1C Gray Eagle drones, the objective was to locate in time and space the cells responsible for planting IEDs following an attack. Through the constant capturing of surveillance imagery, it would be possible to rewind video footage to identify perpetrators and their bases or safe houses, and track their movements to enable arrest or elimination.[295] It should be possible to achieve similar successes with respect to drones, by tracking drone flights and identifying their launch points and controllers. In addition, drones are restricted in the distance they can fly from their operator (depending on the model and on potential modifications), which may make tracking operators easier. Israel reportedly achieved successes of this kind by hacking Hezbollah drones and getting them to return to base, thereby identifying the location of operators.[296]

Such operator-focused targeting has the additional benefit of eliminating potentially skilled enemies. While some drones – particularly commercial ones – may be exceedingly easy to operate, the fact that several groups such as Hezbollah and IS have established drone schools or training centres speaks to the fact that advanced drone operations require specific training. Nevertheless, several limitations exist for this approach. First, several groups have used preprogrammed drones, which do not require an operator to be in communication with the drone. second, depending on the size and type of drone, operators may not need to remain in a specific location or base, making tracking significantly harder.

The second approach – the targeted killing of major drone commanders and operators – represents a more systemic perspective, and is practised by Israel, among others, with a view to "lengthening the campaign between the wars."[297] Israel has reportedly killed several Hamas-affiliated engineers who appeared to be working on acquiring or developing drone technology for the group. The killing in January 2020 of Qassem Soleimani, commander of the IRGC Quds Force, by American forces may also be seen as a means of weakening the links between Iran and its client forces. The effectiveness of this approach, however, depends on the structure of the target group's drone program, and the extent to which it is reliant on one or a few significant individuals. In programs that are more ad hoc, such as those of IS or the PKK, it may be difficult to identify individuals of sufficient prominence that their elimination would materially impact the progress of the drone program. In this respect, efforts to counter a drone program may present similarities with other campaigns of targeted killing and academic debates on their effectiveness.[298]

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295 Arthur Holland Michel, Eyes in the Sky: The Secret Rise of Gorgon Stare and How It Will Watch Us All (New York: Houghton Mifflin Harcourt, 2019), 8.

296 ‘درون» حزب الله تتجسس عليه'.

297 Gadi Eisenkot and Gabi Siboni, ‘Guidelines for Israel's National Security Strategy', Policy Focus, trans. Susann Codish (The Washington Institute for Near East Policy, 2 October 2019), https://www.washingtoninstitute.org/policy-analysis/guidelines-israels-national-security-strategy ; Itamar Lifshitz and Erez Seri-Levy, ‘Israel's Inter-War Campaigns Doctrine: From Opportunism to Principle', Journal of Strategic Studies Online First (10 August 2022): 1–26, https://doi.org/10.1080/01402390.2022.2104254 ; See also Amélie Férey, Assassinats Ciblés: Critique Du Libéralisme Armé (Paris: CNRS éditions, 2020). Ronen Bergman quotes Meir Dagan, former Mossad chief, as comparing this approach to "kill[ing] the driver" in order to stop a car. Bergman, Rise and Kill First, xxi.

298 Jenna Jordan, Leadership Decapitation: Strategic Targeting of Terrorist Organizations (Stanford: Stanford University Press, 2019); Anouk S. Rigterink, ‘The Wane of Command: Evidence on Drone Strikes and Control within Terrorist Organizations', American Political Science Review 115, no. 1 (February 2021): 31–50, https://doi.org/10.1017/S0003055420000908 ; Asfandyar Mir and Dylan Moore, ‘Drones, Surveillance, and Violence: Theory and Evidence from a US Drone Program', International Studies Quarterly, 12 July 2019, https://doi.org/10.1093/isq/sqz040.

Disrupting Supply

As the closest link between consumers and manufacturers, vendors and retailers can have a significant impact in preventing drones and related equipment from getting into the hands of hostile actors. Some countries have already introduced strong regulatory frameworks requiring vendors and retailers to engage in due diligence, including verifying the identities of prospective customers and keeping records of transaction.[299] In his survey of IS' drone supply chain, Rassler detailed how legitimate companies could have potentially avoided supplying drone-related material to the group by simply conducting rudimentary 'know-your-customer' verification.[300] That being said, the multiplicity of conduits across the world can make it difficult to disrupt supplies of drones. While CAR and the UN Panel of Experts on Yemen have repeatedly identified routes of supply to Houthi forces and called for a strengthening of the enforcement of the arms embargo, there remain significant challenges in cutting off supply chains. Nevertheless, given that the loss rate of drones in non-state operations appears rather high, a limited disruption of supplies may already cause a significant reduction in the frequency of attacks.

Counter-UAV Technology

Both militaries and industry have begun to recognize the threat associated with the use and weaponization of commercial drones by violent non-state actors. This recognition has driven the development of systems for detecting and countering nefarious drones. Roughly speaking, the interception of a drone begins with its detection, which can occur through radio frequency (RF) analysis, acoustic sensors, optical sensors and/or radar. RF analysis tracks the RF spectrum in order to find signals used to control drones.[301] Systems that use RF analysis are unable to find drones that are preprogrammed or run entirely autonomously.[302] Acoustic sensors use microphones to detect the sound of a drone's high-speed motor or propeller blades.[303] However, robust detection of acoustically quiet, slow-moving, and small-sized drones can be particularly challenging.[304] In recent years, manufacturers have developed acoustic sensors and RF detection systems that rely on a database of noises or RF signatures made by recognized drones.[305] While promising, these systems have become rapidly outdated due to the speed at which new drones arrive on the market and proliferate. Optical detection involves using video cameras and computer algorithms to detect the presence of a drone. These systems are subject to a high rate of false positives (i.e. mistaking other objects such as birds or aircraft for a drone), and may be affected by environmental factors such as severe weather with limited visibility, shadow, or the sun.[306]

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299 'Protecting Vulnerable Targets from Terrorist Attacks Involving Unmanned Aircraft Systems (UAS)' (United Nations Office of Counter-Terrorism, 2022), https://www.un.org/counterterrorism/sites/www.un.org.counterterrorism/files/2118451e-vt-mod5-unmanned_aircraft_systems_final-web.pdf.

300 Rassler, 'The Islamic State and Drones'.

301 '10 Counter-Drone Technologies to Detect and Stop Drones Today' (The Hague: Robin Radar Systems, 2022), https://www.robinradar.com/press/blog/10-counter-drone-technologies-to-detect-and-stop-drones-today.

302 Houthi forces, among others, have been reported to use preprogrammed drones. See Chapter 4.

303 '10 Counter-Drone Technologies to Detect and Stop Drones Today'.

304 Jian Fang et al., 'Acoustic Detection of Unmanned Aerial Vehicles Using Biologically Inspired Vision Processing', The Journal of the Acoustical Society of America 151, no. 2 (February 2022): 968–81, https://doi.org/10.1121/10.0009350.

305 Mohammad F. Al-Sa'd et al., 'RF-Based Drone Detection and Identification Using Deep Learning Approaches: An Initiative towards a Large Open Source Drone Database', Future Generation Computer Systems 100 (1 November 2019): 86–97, https://doi.org/10.1016/j.future.2019.05.007 ; Muhammad Zohaib Anwar, Zeeshan Kaleem, and Abbas Jamalipour, 'Machine Learning Inspired Sound-Based Amateur Drone Detection for Public Safety Applications', IEEE Transactions on Vehicular Technology 68, no. 3 (March 2019): 2526–34, https://doi.org/10.1109/TVT.2019.2893615.

306 Jiangkun Gong et al., 'Interference of Radar Detection of Drones by Birds', Progress In Electromagnetics Research M 81 (2019): 1–11, https://doi.org/10.2528/PIERM19020505 ; Tijeni Delleji et al., 'An Upgraded-YOLO with Object Augmentation: Mini-UAV Detection Under Low-Visibility Conditions by Improving Deep Neural Networks', Operations Research Forum 3, no. 4 (30 September 2022): 60, https://doi.org/10.1007/s43069-022-00163-7.

Finally, the most common means for long-range detection of drone is radar. Existing commercial technology allows for long-range detection of drones as far as 3 km away.[307] In addition, radar systems are suitable for detecting both low-flying and small drones.[308] While not without flaws, advances in millimetre-wave radar systems should further bolster the range of commercial radar-based drone detection systems.

There are currently several drone countermeasures and active defeat systems on the market. RF jamming systems disrupt the communication link between the pilot and the drone. These systems emit a radio signal that overpowers the operator's transmitter or the GPS signal. Many drones respond to the loss of this signal by acting in one of two ways: either they land, or, if enabled to do so, they return to a preprogrammed location. RF jamming technologies vary in size and portability, and therefore in range and efficacy. Whereas smaller handheld RF jamming systems require a line of sight and must be aimed directly at the drone, larger systems mounted on vehicles or buildings are capable of omnidirectional jamming.[309] RF jamming technology has been used with success by both Turkish and Israeli authorities to disrupt hostile drones.[310] The most common jammer used in Turkey appears to be the locally made IHASAVAR, a backpack-mounted system.[311] The use of this technology, however, involves an important trade off which limits its use in urban settings: while it offers the possibility for drones to be neutralized intact and preserved for forensic analysis, jamming technology can also interfere with a wide variety of electronic signals and communication systems essential to civilian life.

Turning to physical countermeasures, several militaries have had mixed success using kinetic means. American troops in Iraq have been relatively successful in intercepting weaponized drones using counter-rocket, artillery and mortar (C-RAM) systems. C-RAM systems are radar-controlled rapid-fire guns, capable of firing 4,500 rounds of 20 mm high-explosive incendiary tracer self-destruct ammunition per minute. Similarly, US MIM-104 Patriot missiles, designed to intercept missiles and aircraft, have been used with mixed success by Israel[312] and Saudi Arabia[313] to take down drones. However, at nearly $3 million per missile, the use of Patriot missiles to intercept weaponized commercial drones has been described as a poor "economic exchange ratio" and "clearly enormous overkill."[314] Israel, furthermore, has recorded several instances of drones being shot down with air-to-air missiles from helicopters or fighter planes.

Israel's use of the Iron Dome, a system originally designed to intercept and destroy short-range rockets and artillery shells, has been lauded as a more cost-effective way of intercepting UAVs,

307 'Drone Detection Systems', DeTect (blog), 2022, https://detect-inc.com/drone-detection-defense-systems/.
308 '10 Counter-Drone Technologies to Detect and Stop Drones Today'.
309 Claudia Greco et al., 'Jamming Detection at the Edge of Drone Networks Using Multi-Layer Perceptrons and Decision Trees', Applied Soft Computing 111 (1 November 2021): 107806, https://doi.org/10.1016/j.asoc.2021.107806.
310 Balkan, 'How Cheap Drones Became Assets for Terrorist Organizations'.
311 'Turkish Anti-Drone Technology Rolled out against "Aerial Threats"', Hürriyet Daily News, 31 January 2019, https://www.hurriyetdailynews.com/turkish-anti-drone-technology-rolled-out-against-aerial-threats-140908.
312 Leo Giosuè, 'Gaza Drone Enters Israel, Is Shot down over Ashdod by IAF', The Jerusalem Post, 14 July 2014, https://www.jpost.com/operation-protective-edge/gaza-drone-shot-down-over-ashdod-362666 ; 'СМИ: "Патриот" не смог сбить российский беспилотник, случайно залетевший в Израиль', vesti.ru, 7 August 2016, https://www.vesti.ru/article/1689843 ; 'Israel Shoots Down Syrian Drone Over Golan Heights', Haaretz, accessed 6 October 2022, https://www.haaretz.com/israel-news/2017-04-27/ty-article/israel-shoots-down-syrian-drone-over-golan-heights/0000017f-e8f3-dc7e-adff-f8ff92370000 ; Yoav Zitun and Ahiya Raved, 'IDF Fires Patriot to Intercept Hezbollah Drone in Golan Heights', Ynetnews, 19 September 2017, https://www.ynetnews.com/articles/0,7340,L-5018768,00.html.
313 Adam Taylor, 'Billions Spent on U.S. Weapons Didn't Protect Saudi Arabia's Most Critical Oil Sites from a Crippling Attack', Washington Post, 17 September 2019, https://www.washingtonpost.com/world/2019/09/17/billions-spent-us-weapons-didnt-protect-saudi-arabias-most-critical-oil-sites-crippling-attack/.
314 'Small Drone "Shot with Patriot Missile"', BBC News, 15 March 2017, https://www.bbc.com/news/technology-39277940.

costing a "mere" $100,000 per Tamir interceptor.[315] Nonetheless, several countries, including Israel, have made significant recent investments in the development of more cost-effective technology to down rogue drones. For example, in June 2021, Israel reported having destroyed several drones using an Elbit system laser-mounted on a light aircraft.[316] Israeli Prime minister Naftali Bennet announced the feat on Twitter, boasting that the system could "down incoming UAVs, rockets & mortars at a cost of $3.50 per shot" and adding that "it may sound like science fiction, but it's real."[317] In February 2022, the US Navy shot down a drone using an all-electric high-energy laser as part of a test conducted in partnership with Lockheed Martin.[318]

Finally, small arms fire has occasionally proven effective against small drones at low altitude, notably against PKK and (to a lesser extent) IS drones. Nevertheless, these technological solutions – for now at least – appear to be insufficient to successfully counter the drone threat, often mitigating it rather than eliminating it. As the successful attacks by the Houthi Movement in Saudi Arabia demonstrate – and as the significant concern in Israel over Hezbollah's drone potential suggests –technical solutions alone may be insufficient. Non-state groups have also been known to adapt their tactics to degrade air defences, with Houthis targeting radar systems coupled to Patriot missile systems, or Hamas reportedly targeting Iron Dome batteries.[319] Downing the drone itself may not always be sufficient to mitigate the threat, with IS for instance being known to sometimes booby-trap drones to explode upon inspection.[320]

'Design Against Crime'

The notion of 'Design against Crime' uses the processes of product design to reduce harmful misuse of emerging technologies.[321] For example, most modern, commercially sold photocopiers are designed to automatically recognize banknotes, and either refuse to reproduce them or produce a distorted image to prevent counterfeiting.[322] Similarly, several producers of commercial drones have sought to proof their products against criminal or terrorist use. Built-in software restrictions, such as geofencing for drones with GPS, are the first line of design against crime for the majority of commercially available devices.[323] However, although the corporations that manufacture commercial drones manage geofence databases, these are frequently only used at military bases and important facilities. In addition, bypassing geofencing is easy, whether it

315 Barbara Opall-Rome, 'UAV-Killing Iron Dome Eyed as Cheaper Option to Patriot', Defense News, 17 November 2014, https://wayback.archive-it.org/all/20141117144934/http://www.defensenews.com/article/20141117/DEFREG/311170010/UAV-Killing-Iron-Dome-Eyed-Cheaper-Option-Patriot.
316 Robert Tollast, 'Terrorist Drone Attacks: Could New Technology Stop the Threat?', The National, 23 February 2022, https://www.thenationalnews.com/world/2022/02/23/terrorist-drone-attacks-could-new-technology-stop-the-threat/.
317 Naftali Bennett בנט [@naftalibennett], 'Israel Has Successfully Tested the New "Iron Beam" Laser Interception System. This Is the World's First Energy-Based Weapons System That Uses a Laser to Shoot down Incoming UAVs, Rockets & Mortars at a Cost of $3.50 per Shot. It May Sound like Science Fiction, but It's Real. https://T.Co/NRXFoYTjIU ', Tweet, Twitter, 14 April 2022, https://twitter.com/naftalibennett/status/1514661060011245571.
318 Warren Duffie, 'Laser Trailblazer: Navy Conducts Historic Test of New Laser Weapon System', United States Navy, 13 April 2022, https://www.navy.mil/Press-Office/News-Stories/Article/2998829/laser-trailblazer-navy-conducts-historic-test-of-new-laser-weapon-system/.
319 Fishman, 'The New Explosive Drone Threat from Gaza'; 'Iranian Technology Transfers to Yemen'.
320 Schmidt and Schmitt, 'Pentagon Confronts a New Threat From ISIS'.
321 Paul Ekblom, 'Designing Products against Crime', in Handbook of Crime Prevention and Community Safety, ed. Nick Tilley (Collumpton: Willan publishing, 2005), 203–44.
322 Andreas Girgensohn, Lynn Wilcox, and Qiong Liu, 'Automatic Rights Management for Photocopiers', in Proceedings of the ACM Symposium on Document Engineering 2018 (Halifax: ACM Symposium on Document Engineering, 2018), 1–10, https://doi.org/10.1145/3209280.3209531.
323 Mia N. Stevens, Brandon Coloe, and Ella M. Atkins, 'Platform-Independent Geofencing for Low Altitude UAS Operations', in 15th AIAA Aviation Technology, Integration, and Operations Conference (Dallas, TX: American Institute of Aeronautics and Astronautics, 2015), https://doi.org/10.2514/6.2015-3329.

is achieved by tampering with the drone's software or GPS antenna, or by the device owner neglecting to update the firmware.[324] In addition to geofencing, some drone manufacturers have begun experimenting with technology for the continuous radio transmission of UAV identification information.[325] In a manner similar to a licence plate, identification information released by commercial drones might allow authorities to identify drones that are hostile.

While promising, design against crime initiatives require manufacturers to introduce such features in close coordination not only with public authorities but also with other UAV manufacturers, in order to ensure maximum adherence to common standards and protocols.[326] Furthermore, such product design may be insufficient to counter threats arising from non-state groups' drone programs, which may possess the technical knowledge to bypass such security features. For instance, IS created (and distributed on Telegram) several how to guides instructing their sympathizers on which commercial drones to purchase and which to avoid, as well as how to perform several types of modifications including disabling the recording feature and bypassing geofencing restrictions.[327] Furthermore, as several groups assemble or manufacture (parts of) drones themselves, or obtain them from patrons who have an interest in avoiding detection and responsibility, a design against crime approach suffers from significant limitations. Nevertheless, it may prove successful in at least raising the barriers to drone use and increasing the resources required for violent non-state actors to modify commercial drones.

324 Marian Buric and Geert De Cubber, 'Counter Remotely Piloted Aircraft Systems', MTA Review 27, no. 1 (2017), https://www.researchgate.net/profile/Geert-De-Cubber/publication/331258899_Counter_Remotely_Piloted_Aircraft_Systems/links/5c6ed70e299bf1268d1b8372/Counter-Remotely-Piloted-Aircraft-Systems.pdf.
325 'Protecting Vulnerable Targets from Terrorist Attacks Involving Unmanned Aircraft Systems (UAS)'.
326 'Protecting Vulnerable Targets from Terrorist Attacks Involving Unmanned Aircraft Systems (UAS)'.
327 Veilleux-Lepage, Daymon, and Archambault, 'Learning from Foes'.

Conclusion

This report has provided an empirical analysis of the drone programs of five non-state groups in the Middle East: Hezbollah, Hamas, the Houthi Movement, Islamic State (IS), and the Kurdish Workers' Party (PKK). These five groups, unlike other violent non-state actors, have demonstrated a sustained engagement with drone technology over time, the capacity to develop drone infrastructure, and a willingness to engage in tactical and/or technical innovation in the employment of drones. The five groups' experiences differ in timescale, means, strategies, and tactics. Consequently, we reject the suggestion of a common path of development for all non-state groups' drone programs, and argue that each group's drone use must be situated within that group's broader strategic situation. Therefore, we argue, states and militaries confronting these groups must first understand the specific – and enhanced – threat posed by drone programs characterized by innovation (as opposed to episodic drone use) and secondly understand what a given group seeks to accomplish with drones, in order to grasp the specific threat. This report, by detailing five pathways of non-state drone development, offers a framework which is useful not only to understand the drone use of these particular groups, but also to apply to other groups in the future.

Through empirical analysis, this report has made three key contributions to knowledge on this subject. First of all, the findings suggest a need to refocus attention away from the most high-profile threat – that of drone-deployed WMDs – and toward the more common and empirically demonstrated methods used by groups in employing drones. WMD programs are complex, and so are drone programs; while there is evidence of one group (IS) attempting to pursue both in parallel, there is no significant evidence of attempts to integrate the two. Scholars and practitioners should therefore concentrate on empirically grounded analysis of the actual employment of drones. Second, there needs to be a focus on the specific threat presented by drone programs (as distinguished from episodic drone usage) and the capacity for innovation. Drone development is not linear, nor is it static; in confronting drone programs, states and militaries must keep a focus on innovation and adaptation, and understand how groups develop tactically, strategically and technically. Third, there is no single pathway of development for non-state groups' drone use, and there is no blueprint which such groups seek to follow. Each group employs drones differently according to different logistical, political and strategic parameters, and drone programs must be situated within groups' wider military means and operations. As a result, militaries and states confronting drone programs – while they may draw on existing practices which have had varying success in countering drone threats, and engage in preventive action to mitigate the scope of drone programs ¬– must maintain a holistic approach; that is, an approach that considers drone programs not only as a distinct, isolated threat, but also as part of broader military operations, strategies, and conflict processes.

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