THE EXPLORATION OF TERRORIST'S USE OF UNMANNED AERIAL SYSTEM USING
DIFFUSION OF INNOVATION THEORY

by
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Abstract

Islamic State (IS) caught the world's attention because of their brutality and their individuality by using the globalized world in unprecedented ways. One of their introductions was the weaponization of Commercial-Off-the-Shelf (COTS) drones. This research is an exploration of COTS drone proliferation across terrorist organizations through Diffusion of Innovation (DOI) theory's four characteristics of diffusion: innovation, communication, time, and social system. Using a mixed methods approach, this research examines how DOI explains the international community is experiencing the "early adopter" phase of diffusion innovation. Viewing terrorist organizations' use of COTS drone through the lens of DOI theory explains current trends and offers insight into future capabilities.

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Introduction

As the world becomes more technologically advanced, so do terrorist

organizations. With most advanced technologies, there is a natural progression from

invention to commercial use. For example, one of the first computers was called the

Electronic Numerical Integrator and Computer (ENIAC) created in the 1940s by the U.S.

Army for "computing values for artillery range tables."[1] As time went on, inventors and

engineers improved the computer and used innovative thinking to create better

versions. Eighty years later, we walk around with more advanced and powerful

computers on our wrist. The technology was commercialized, innovated, and diffused

on a massive scale.

The same concept is occurring with unmanned systems. In 1943, the first

Unmanned Aerial System (UAS) took flight. The Kaiser-Fleetwings BQ-2 was an

"expendable unmanned assault drone." It was an autonomous UAS meant to carry a

2,000-pound warhead and crash into a target.[2] The Kaiser-Fleetwing is just one example

of the world's attempt to increase the impact of an attack while minimizing soldier risk.

In this case, the UAS was deemed too expensive as a weapon on war and retired under

the experimental (x-plane) classification. Originally used as a weapon of war—like the

ENIAC— the technology was commercialized innovated and diffused on a massive scale.

Today, state and non-state actors (both benevolent and malevolent) use UAS.

[1] Michael R. Swaine, Paul A Freiberger, Encyclopaedia Britannica, "ENIAC Computer," Accessed November 11, 2019, https://www.britannica.com/technology/ENIAC
[2] "Kaiser-Fleetwings BQ-2," Military Factory, accessed November 15, 2018
https://www.militaryfactory.com/aircraft/detail.asp?aircraft_id=1645

Everett M Rodgers developed the Diffusion of Innovation (DOI) theory in 1962. The theory describes how innovation transfers amongst groups or individuals through four characteristics that affect the rate of innovation acceptance: innovation, communication, time, and social systems.3 While many researchers have used Rogers' theory to explain the diffusion of technology, exploring weapon proliferation between terrorist groups through this lens is minimal. This paper will use the four characteristics of DOI as a framework to examine the proliferation of drones. Terrorist organizations like the Islamic State (IS) surprised troops in Iraq and Syria by weaponizing drones uniquely and effectively. DOI theory will demonstrate that drone diffusion is at the "early adopter" level, which implies that many more terrorist groups will adopt drones as a weapon of war.

Definitions

Innovation has many meanings. Rodgers defines innovation as "an idea, practice, or object perceived as new by an individual or other unit of adoption."[4] In contrast to Everett, Nicole Tishler – who examines terrorist weapons adoption—defines innovation differently. Tishler argues that terrorists do not invent new strategies or tactics. Instead, they improve upon already existing inventions.[5] Amongst the literature on innovation, there is a discussion about the stochastic nature of "innovation." Scholars like Tishler

[3] Everett M. Rodgers. "Diffusion of Innovation," New York: The Free Press, 2003

[4] IBID

[5] Nicole A. Tishler, "Trends in Terrorists' Weapons Adoption and the Study Thereof," *International Studies Review* 20, no. 3 (2018): 368–94, https://doi.org/10.1093/ISR/VIX038.

and Rashmi Singh (who explores jihadi learning and innovation) require randomness to classify new behaviors as innovative.

The broad spectrum of definitions requires a more in-depth understanding of terminology. There is a distinct difference between invention and innovation,[6] and diffusion vs. contagion.[7] Inventions are completely new ideas and technology, while innovation is an adaptation of already existing inventions.[8] In addition, innovation "involves any improvement, modifications, or meaningful adaptations of existing technologies."[9] Examining this definition within the scope of this research, recreation UAS were not created by terrorist organizations, but using them as weapons is a form of innovation.

Another vital definition is diffusion, which is "the process in which an innovation is communicated through certain channels over time among members of a social system."[10] Similar to the distinction between invention and innovation, some scholars believe there is a difference between diffusion – a social phenomenon that requires communication between groups— and contagion – imitation of a behavior.[11] The difficulty with the differentiation between contagion and diffusion is that contagion does not leave room for social media and propaganda as tools of communication, which is robust among terrorist organizations.

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[6] IBID
[7] Tishler.
[8] Tishler.
[9] IBID
[10] Everett M. Rodgers. "Diffusion of Innovation," New York: The Free Press, 2003
[11] Tishler, "Trends in Terrorists' Weapons Adoption and the Study Thereof."

Outside of the communication realm, there is a discussion of UAS, which covers a broad spectrum of capabilities. There are many different terms used in conjunction with UAS. Among the other common names are Unmanned Aerial Vehicles (UAV), Commercial-Off-the-Shelf (COTS) drones, and drones. Although the term drone is a colloquialism, scholars have added the term into their research, making it integrated into the discipline. COTS refers to any unmanned system purchasable commercially, which excludes military-grade UAS. Therefore, UAS, UAV, and drones are used interchangeably, however COTS will specifically refer to commercialized technology.

It is difficult to defining UAS because, as a category, there is a significant spectrum of individual capabilities. The U.S. Army uses a tier-system that places UAS into five categories ranging from nano drones to stealth drones.[12] While the tier-system is the official classification system, it is used to define capabilities such as altitude and endurance and is generally applied to military-grade systems. This does little to aid the exploration of smaller commercial systems.

The Center for a New America Security (CNAS) suggests a different classification system. Rather than only focusing on the abilities of the UAS, there should be a focus on "the degree to which they are accessible to any given actor… and the technology base and infrastructure required to produce and/or operate them."[13] Therefore, the four categories are hobbyist drones, midsize military and commercial drones, large military-

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[12] "United States Air Force Unmanned Aircraft Systems Flight Plan 2009-2047," United States Airforce Headquarters, Washington DC, 18 May, 2009, https://fas.org/irp/program/collect/uas_2009.pdf
[13] Kelley Sayler, "A WORLD OF PROLIFERATED DRONES: A Technology Primer World of Proliferated Drones Series | A World of Proliferated Drones Series |," 2015, www.cnas.org/.

specific drones, and stealth combat drones. While an examination of the more complex

UAS is fascinating, this paper will focus on COTS drones that generally share attributes

like programmable with GPS, high-definition video, a real-time video feed, and semi-

autonomous capabilities.[14] Hobbyist UAS are increasingly technologically sophisticated

with user-friendly platforms that can act as a simple yet intelligent tool. In addition to

their technological capabilities, COTS drones are easily accessible and are rapidly

proliferating commercially.

For this research, terrorist organizations are defined in two categories: state-

sponsored terrorist organizations and non-state terrorist organizations. State-sponsored

terrorist groups are terrorist organizations that are backed by a state. Those groups

have an added advantage of protection, funding, and training, which allows significant

advantage regarding learning and innovation.[15] While it is an interesting area of focus,

state-sponsored groups have accessibility to safe havens, the transferring of knowledge,

and (in the case of Iranian-backed groups) access to more advanced technology.

Therefore, this paper will limit its focus to non-state terrorist groups.

Literature Review

Innovation

The first characteristic of DOI theory discusses the innovation itself. Rodgers

defines five characteristics of innovation which explains the likelihood that a new

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[14] Sayler.
[15]Tishler, "Trends in Terrorists' Weapons Adoption and the Study Thereof."

technology will become an attractive option.[16] The characteristics are: relative

advantage – does the innovation significantly improve the status quo; compatibility –

how well does the innovation line up with needs, values and experiences of the group;

complexity – is the innovation intuitive or does it require significant training; trialability

– is the innovation testable before the decision to incorporate it; and observability –

after adopting, are the results tangible.[17] Conceptually, if an innovation will

demonstrate a significant advantage, is compatible with current operations, is not

difficult to learn how to operate, is testable, and the benefits are apparent, the

innovation will be a more attractive option to a group or individual which will result in

more rapid diffusion of the technology. This increases the likelihood that the innovation

will diffuse more rapidly.

Communication

The second characteristic of DOI theory is communication, which examines how

different groups interact and the impact that has on the spread of the innovation. DOI

explores communication between groups and their communication channels.[18] Groups

can spread messages in two ways. First, through mass channels like media or

propaganda which are most effective at creating knowledge. Alternatively, they can

depend on interpersonal channels which have the advantage at being most effective at

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[16]Everett M. Rodgers. "Diffusion of Innovation," New York: The Free Press, 2003
[17] IBID
[18] IBID

changing attitudes.[19] While, according to Rodgers, interpersonal communication is the

most effective communication method in terms of diffusion, his theory does not take

into account modern-day propaganda and the way terrorist organizations employ it. In

1962—when Rodgers created his framework—social media was non-existent and mass

communication operated differently.

While interpersonal communication is important, communication amongst non-

affiliated terrorist organizations is generally done indirectly. Terrorist organizations are

learning from each other, and it is occurring across borders and outside established

relationships and affiliations.[20] According to Rashmi Singh, who explores learning and

innovation, there are four types of terrorist learning: 1) learning between terrorist

groups living within the same "domestic setting"; 2) learning between groups across

state borders; 3) learning between transnational groups; and 4) self-learning where

"learning occurs between the core and its affiliates."[21] Singh's research focuses on

terrorist organizations that are generally homophilic. This fails to acknowledge the

reality that learning between groups that do not share similar attributes also occurs.

Kettle and Mumford's framework for terrorist learning helps understand learning

and diffusion between heterophilic groups. Instead of categorizing groups by type of

terrorist organization, Kettle and Mumford focus on four agents of learning: the

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[19] IBID

[20] Rashmi Singh, "A Preliminary Typology Mapping Pathways of Learning and Innovation by Modern Jihadist Groups," *Studies in Conflict and Terrorism* 40, no. 7 (2017): 624–44, https://doi.org/10.1080/1057610X.2016.1237228.

[21] Singh.

individual, the group, the generation, and the organization.[22] Generational learning is important to this research because the new generation of terrorists are more adaptive and resilient than previous generations and are offered an advantage because of their ease of access to learning materials due to the democratization of information.

There are two types of knowledge: explicit and tacit.[23] Explicit knowledge is information that can be written down or can be learned in a classroom, while tacit knowledge is information gained by experience. Terrorist organizations transfer explicit knowledge through formal and institutionalized lessons, while tacit knowledge—or informal learning—relies on interpersonal connection and social interaction.[24] In addition to the transfer of tacit knowledge, Kettle and Mumford also include media, social media, and pop culture into informal learning.[25] Learning between terrorist groups—whether formal or informal—promotes the diffusion of innovations.

Time/Social System

The third and fourth characteristics of DOI theory are time and social system. The two characteristics are interlaced. The time aspect of DOI theory focuses on how long it will take a group to accept or deny an innovation, which is dependent on the social system. The groups' decision-making process follows a progression: knowledge,

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[22] Louise Kettle and Andrew Mumford, "Terrorist Learning: A New Analytical Framework," *Studies in Conflict and Terrorism* 40, no. 7 (2017): 523–38, https://doi.org/10.1080/1057610X.2016.1237224.
[23] Kettle and Mumford; Brian A. Jackson, "Technology Acquisition by Terrorist Groups: Threat Assessment Informed by Lessons from Private Sector Technology Adoption," *Studies in Conflict and Terrorism* 24, no. 3 (2001): 183–213, https://doi.org/10.1080/10576100151130270.
[24] Kettle and Mumford, "Terrorist Learning: A New Analytical Framework."
[25] Kettle and Mumford; Jackson, "Technology Acquisition by Terrorist Groups: Threat Assessment Informed by Lessons from Private Sector Technology Adoption."

persuasion, decision, implementation, and confirmation. This process leads groups

toward an adopt or deny decision.[26] These steps are similar to the framework put forth

by Kettle and Mumford, who describe the steps of terrorist learning to be identification,

distribution, implementation, and retention.[27] Jackson also refers to technological

awareness, openness to new ideas, attitude toward risk, and nature of the environment

as factors that influence a group's decision to innovate.

Class , also referred to as *level of innovativeness*, is the "degree of an individual's

adoption earlier than others in the social system."[28] The level of innovativeness depends

on the decision-making process.[29] Rodgers places individuals or groups who innovate

into five categories: innovators, early adopters, early majority, late majority, and

laggards.[30] The rate of adoption fits the bell curve (seen in figure 1), where there are

very few innovators, but as groups accept the innovation, there is a gradual then rapid

diffusion of the technology. As seen in figure 1, the groups' categorization is a predictor

of when they will adopt an innovation. Using normal distribution, each of the categories

are determined based on the standard deviation of average time.

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[26] Everett M. Rodgers. "Diffusion of Innovation," New York: The Free Press, 2003
[27] Kettle and Mumford, "Terrorist Learning: A New Analytical Framework."
[28] Everett M. Rodgers. "Diffusion of Innovation," New York: The Free Press, 2003
[29] IBID
[30] Everett M. Rodgers. "Diffusion of Innovation," New York: The Free Press, 2003

Diffusion of Innovation Bell Curve

2.5% Innovators

Early Adopters 13.5%

Early Majority 34%

Late Majority 34%

Laggards 16%

Source: Everett Rogers Diffusion of Innovations model
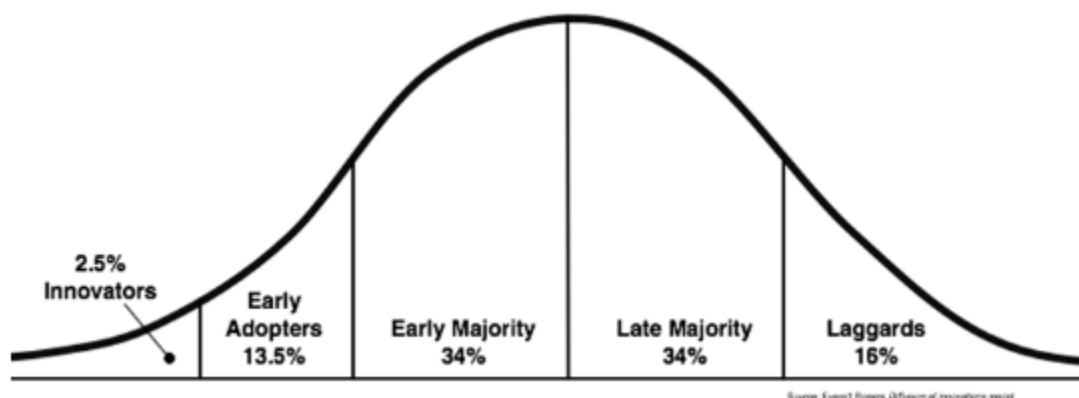
Figure 1[31]

Hypothesis

There is ample information about both state use of UAV and terrorism, but there is not substantial research on how terrorist groups use recreation drones. To focus the research, this paper examines non-state terrorist organizations. The state-backed groups will show up in the data sets used to demonstrate where the capabilities lie, but they will not be the focus of the analysis. As mentioned in the definition section, state-sponsored terrorist organizations have an advantage because money and training are offered to them by their sponsor.[32] Due to the support from state actors, they also use different types of UAS. State-sponsored terrorist groups with UAS capabilities – which is specific to Iranian sponsored groups like Hezbollah, Hamas, and the Houthis – generally

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[31] IBID
[32] Tishler, "Trends in Terrorists' Weapons Adoption and the Study Thereof."

use fixed-wing drones and precision-guided missiles rather than.[33] Hence, they are not innovators.

Using the DOI theory as a framework to examine the proliferation of COTS drones, this paper demonstrates that drone diffusion is at the "early adopter" level and—because of this—the characteristics set forth by Rodgers depicts drones as a perfect contender for proliferation. This means the world can expect a significant increase in terrorist groups using UAS in the near future.

The DOI framework explains IS' use of UAS and how that technology is transferring to other terrorist groups. Traditionally, terrorist learning and tactics are transferred between groups due to affiliation and interpersonal communication. COTS drones ease-of-use and the way UAS are used as both a weapon and a tool for communication, will accelerate the rate of diffusion of the technology. To test this hypothesis, this paper uses a mixed-methods approach.

Methods

The research is organized by the four characteristics of the DOI theory while examining IS and COTS drones. IS is a starting point because its organization is the first to institutionalize the use COTS drones as weapons of war, making it the innovator of the technology. Tracing the movement of capabilities from that point makes connecting relationships easier. The hypothesis will be supported if there is a connection between

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[33] Telephone Interview with Nick Waters, October 7th, 2019

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what Rodgers argues is a strong indication of innovation diffusion and what is currently

occurring with recreational UAS.

This paper also examines the available (yet limited) data to analyze if COTS drone

proliferation is occurring and to which groups. Finding data on weaponized drones used

by terrorists is difficult to collect because this is a relatively new phenomenon. The

IntelCenter Database (ICD) is the most comprehensive open-source database available,

but it does not offer a complete view. The benefits of ICD are its ability to offer a current

collection of data that distinguishes the difference between perpetrator, target, and

location. Unfortunately, there are gaps in the way terrorism-focused databases report

weaponized UAS incidents. One issue with ICD is that it does not explicitly code for

drone attacks meaning their reports include incidents where a drone was shot down,

sighted, or captured, but it does not code the information differently.

It is important to note that ICD uses news articles and open-source reporting to

build its databases. It does not offer a holistic view of incidents. Unfortunately, this is an

examination of the available material, and without access to classified material, it is

difficult to know if more incidents are unaccounted for. Based on open-source material,

the incidents recorded on ICD are also not an exact replication of what is occurring. In

an attempt to mitigate the holes in the research, if there is a report inferring drone

capabilities (i.e., UAV shot down, UAV used for ISR, weaponized UAV, etc.), the terrorist

group is assumed to have the capability. While the weaponization of UAS are important,

there is a natural progression between having UAS capabilities for ISR and transitioning

to arming the drone.[34] For tracking proliferation, the use of the UAS is not as important as distinguishing if the terrorist organization has access to the technology. To supplement the database, terrorist propaganda, interviews, and media sources will be used to analyze available technologies.

There is difficulty in researching terrorism and UAV because there are many unknowns. Terrorist groups are not transparent – although IS does use social media, making it more open in some aspects – and examining terrorist organizations' capabilities is reliant on media outlets and propaganda campaigns. To help corroborate some of the information, three subject-matter experts were interviewed. Nick Waters, an open-source analyst for Bellingcat, is an expert on UAS systems and examines the technology and how IS manipulated it. The second interview was with Don Rassler, a scholar for the Combating Terrorism Center at West Point. His research examines how IS uses UAS and its supply chain. Finally, an interview with Major Aaron Smith, a Senior Security Cooperation Official in N'Djamena, Chad whose expertise lies in the Lake Chad Basin and Islamic State West Africa Province (ISWAP). The interviews with subject-matter experts will offer perspective on the open-source information.

Data

The Data provided by IntelCenter shows there is an increase of both UAS incidents, groups who have capabilities, and the geographical location of where COTS drones are operated. In 2018 there was activity in six countries that did not previously

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[34] Telephone Interview with Nick Waters, October 7th, 2019

experience any drone incidents. This list grew by seven additional states in 2019. Figure

2 (next page) demonstrates a significant increase in where groups are using UAS. This

supports the assertion that drone use is proliferating. Examining the diversity of groups

that use UAS over the four-year period also signifies proliferation between groups. The

question then becomes what is responsible for this proliferation and does diffusion

theory explain the trend?

IntelCenter Data: Terror Use of Unmanned Aerial Systems

Discussion

Based on many characteristics of UAS and the groups that use them, there is a high probability that the diffusion of weaponized drones will continue to proliferate at a rapid rate. To explain this rapid rate of diffusion, weaponized drones will be examined through the lens of the DOI theory.

Innovation

Non-state terrorist organization's access to UAS is not a new revelation. Reports show groups like Hezbollah and Hamas have used UAS since 2004 when their state-sponsor – Iran– supplied them with the Mirasad-1 and the Ababil-1.[35] While these systems only had ISR capabilities, the first recorded armed-UAS attack was in September 2014 by Hezbollah against al-Nusra Front in Syria. [36] Iranian-backed terrorist groups like Hezbollah, Hamas, and the Houthis were the first terrorist organizations to have access to weaponized UAV. In an attempt to mimic their capabilities, IS developed the weapon through innovation and is transferring tactical knowledge to affiliate organizations.

IS may not be the first terrorist group to use armed drones, but their modifications of COTS drones gave the terrorist group unprecedented capabilities. Before the weaponization of drones, states had a near monopoly over the air domain. Don Rassler of the Combating Terrorism Center at West Point describes the features that make UAV attractive to terrorist groups as "low acquisition costs, a variety of

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[35] Asaad Almohammad & Anne Speckhard, "ISIS Drones: Evolution, Leadership, Bases, Operations and Logistics" International Center for the Study of Violent Extremism, May 2017
[36] IBID

purchasing pathways, potential for high accuracy, operational flexibility, a high likelihood of air-defense penetration, high survivability prelaunch and low levels if infrastructure needed to support their deployment."[37] Essentially, UAV fit perfect into Roger's characteristics of an advantageous innovation.

COTS drones offer significant relative advantages. First, when used for ISR, terrorists are given warning of approaching enemies. When used as a weapon, it eliminates the need for suicide bomber—the drone is flown over a target and then releases munitions.[38] In addition to the strategic and tactical advantages, the DJI Phantom (a drone model used by IS) is easily purchased online for $799.00,[39] making it both an affordable and attainable option. As mentioned by Rassler, there is no need to invest in additional infrastructure, and as long as the drone can be recharged, it offers flexibility.[40]

There are multiple ways to turn a UAS into a weapon. As seen in the attempted assassination of Venezuelan President Maduro, one kilogram of C-4 was taped to two DJI Matrice –a quadcopter—and it was used as an "expendable drone."[41] Some researchers have referred to COTS drones with explosives attached as "flying IEDs"[42]— given the crude adaptation makes it comparable to vehicle-borne improvised explosive

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[37] Don Rassler, "Remotely Piloted Innovation Terrorism, Drones and Supportive Technology" (West Point, New York, 2016), www.ctc.usma.edu.

[38] https://www.bellingcat.com/news/mena/2017/02/10/death-drone-bombs-caliphate/

[39] https://www.amazon.com/DJI-Phantom-Advanced-Quadcopter-Camera/dp/B00VSIT5UE/ref=sr_1_11?crid=BQ3AT8QG5BAH&keywords=dji+phantom&qid=1571029235&s=electronics&sprefix=DJI+P%2Celectronics%2C170&sr=1-11

[40] Telephone Interview with Don Rassler, October 16th, 2019

[41] Brian Barrett, "The Explosive-Carrying Drones in Venezuela Won't be the last," *Wired Magazine,* August 4, 2018, https://www.wired.com/story/venezuela-drones-explosives-maduro-threat/

[42] Franke, Ulrike. "Frankie, "Flying IEDs: The Next Big Threat?" War on the Rocks, October 19, 2016

devices (VBIED). Early adaptations were rudimentary because the explosives were set to

detonate remotely. These first examples were used as suicide drones. However, as IS

became more experimental with the technology, it began to use drones weaponized

with grenades that were engineered to drop on targets—enabling the reuse of the COTS

drone.

Figure 3: Custom-made COTS drone with a cup mounted to the bottom[43]

At the beginning of the Syrian conflict—when IS was gaining territory—it was

apparent to the organization that it needed more weapons than they could buy. So

"they looted from the Iraqi or Syrian governments, but when those ran out they did

something that no terrorist group has ever done before… [they] design[ed] their own

munitions and mass-produce[d] them using advanced manufacturing techniques."[44] IS –

when they took over territory— had access to commercial industries with industrial-

[43] Nick Waters, "Bellingcat - Death From Above: The Drone Bombs of the Caliphate - Bellingcat,"
Bellingcat, 2017, https://www.bellingcat.com/news/mena/2017/02/10/death-drone-bombs-caliphate/.
[44] Brian Castner, "Exclusive: Tracing ISIS' weapons supply chain—back to the US," *Wired Magazine,*
December 12, 2017

strength tools, saws, injection-molding machines, and people who knew how to use them.[45] Like other non-state actors, IS crowd-sourced knowledge and skills. Many early recruits were ex-Iraqi officers who were ousted after the fall of Sadaam Hussein and became disenfranchised during the U.S. de-Baathification campaign. Using its knowledge of weapons and access to commercial tools and infrastructure, IS created a weaponized UAS and armed them with a 40mm grenade.

Figure 4: 40mm grenades encased in custom made fins.[46]

Figure 5: Supply of custom-made ammunition.[47]

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[45] IBID
[46] Nick Waters, "Death From Above: The Drone Bombs of the Caliphate," Bellingcat, February 10, 2017
[47] Nick Waters, "Death From Above: The Drone Bombs of the Caliphate," Bellingcat, February 10, 2017

Based on the DOI framework, COTS drones are an advantageous innovation for terrorist groups. There is a significant relative advantage associated with using them as both a weapon and, as described in the next section, a tool for communication. COTS drones are equipped with tools (such as GPS and semi-autonomous piloting) that make it compatible with IS operations and IS' innovative weaponization of the technology increases the compatibility by creating a multifunctional tool. COTS drones are not particularly complex. They are equipped with GPS, are controllable with a smartphone, and have simple semi-autonomous capabilities (take-off and landing is achievable with a simple press of a button). Trialability is specific to groups. Terrorist organizations like IS who have controlled territory can test the innovation and experiment with operations, while terrorist groups who are trying to keep a low profile may not have the same freedoms. COTS drones are an attractive innovation to terrorist organizations based on the characteristics of an attractive innovation.

Communication

Communication amongst terrorist organizations occurs on multiple levels. As globalization created a world where the line between transnational criminal groups and transnational terrorist groups is blurred, it also created a world where communication is simple and not always intentional. IS is an interesting case because they were able to use mass communication channels and interpersonal communication simultaneously to contribute to the diffusion of weaponized UAS. As a recruiting tactic, IS used propaganda and videos of successful strikes to attract people to their group. For

example, IS disseminated posters of a member holding a UAV and aiming toward the

statue of liberty.[48] Figure 6 is the image of a propaganda poster used to attract recruits

using UAVs. Images like figure 6 and 7, and videos of weaponized drone attacks were

posted on social media sites. IS released their first propaganda video demonstrating

their ability to record and publish videos of army bases in Raqqa in August 2014. . These

videos grew more sophisticated as they recorded battles and individual terrorist attacks

which were quickly published on platforms like YouTube.[49]

Figure 6: IS Propaganda[50]

Figure 7: IS Propaganda[51]

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[48] Daniel Lebowitz," TRAC Incident Report: Islamic State Telegram Channel Educates on Weaponized Drones," TRAC Incident Report, *Terrorism Research and Analysis Consortium*
[49] AlMohammad
[50] Daniel Lebowitz," TRAC Incident Report: Islamic State Telegram Channel Educates on Weaponized Drones," TRAC Incident Report, *Terrorism Research and Analysis Consortium*
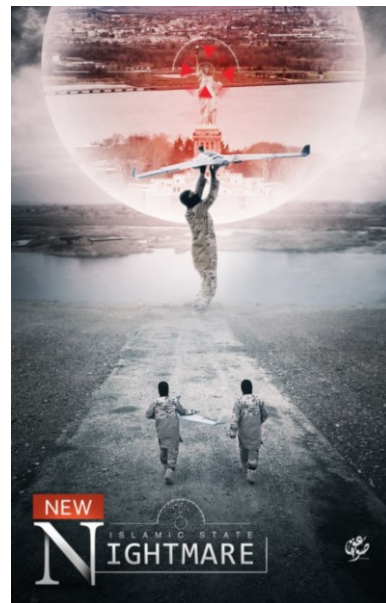[51] Daniel Lebowitz," TRAC Incident Report: Islamic State Telegram Channel Educates on Weaponized Drones," TRAC Incident Report, *Terrorism Research and Analysis Consortium*
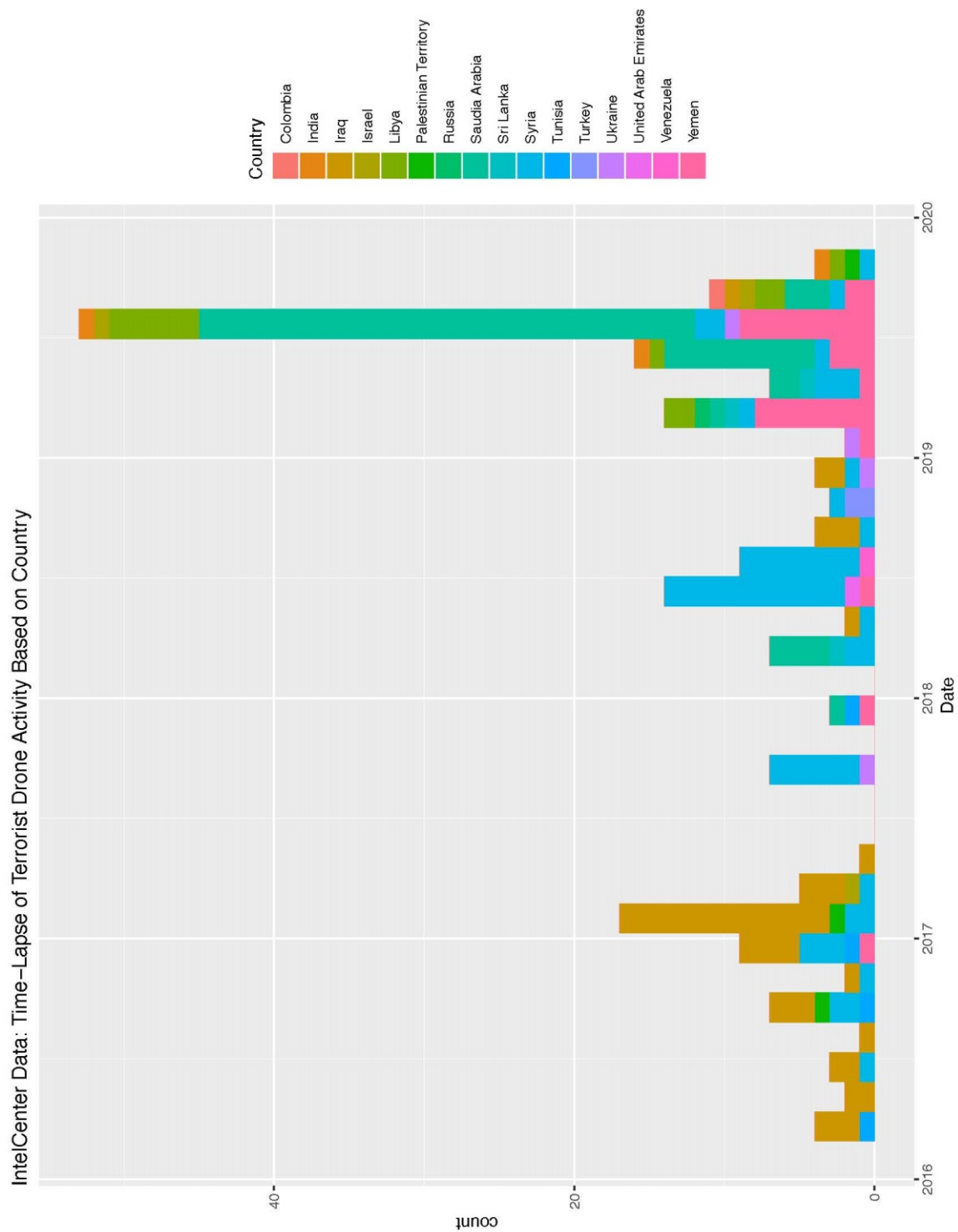
By January 2017 that they uploaded their first propaganda video demonstrating their ability to drop customized munitions with accuracy.[52] UAS quickly became a major part of the IS propaganda campaign, attracting the attention of many. While the influence on other groups may not be intentional, the combination of recreational UAS ease-of-use, instructional propaganda videos on how to operate and weaponize UAS, and accessibility in the commercial market, and the example put forth by IS created an interest.

Interpersonal communication did not occur until after IS started losing territory. It is important to note that the data shows a dramatic drop in drone incidents by IS around the same time there is an increase in the number of groups who have capabilities. Figure 8 illustrates that the number of incidents attributed to IS dropped significantly from 2017 to 2018, with an increase in the number of attacks by unknown actors. Figure 9 demonstrates the same data organized by country. There is a drastic decrease in attacks in Iraq in 2018, with an increase of incidents in Syria at the same time. These numbers coincide with IS' loss of territory and American offensives targeting drone facilities.[53] IS is not the only group using COTS drones, as indicated by reports of Kurdish groups using drones as well.

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[52] Waters, "Bellingcat - Death From Above: The Drone Bombs of the Caliphate - Bellingcat."
[53] Ben Watson, "The Drones of ISIS - Defense One," Defense One, 2017, https://www.defenseone.com/technology/2017/01/drones-isis/134542/.

IntelCenter Data: Time-Lapse of Terrorist Drone Activity Based on Terrorist Organization

Group
- al-Huthi Rebels
- FARC dissidents
- Free Syrian Army
- Hamas [Islamic Resistance Movement]
- Islamic State
- Khalistan Liberation Force
- Kurdistan Worker's Party [PKK]
- Libyan National Army
- National Movement of Soldiers in T-Shirts
- Unknown

IntelCenter Data: Time-Lapse of Terrorist Drone Activity Based on Country

While it is possible to track some interpersonal trends and IS migration trends to make assumption about intergroup and intragroup learning, focusing on the relationships between groups needs more research. Aaron Smith explains there is an increase in IS influence in the Lake Chad Basin. As IS lost control of their caliphate, there was an increase in the strength of ISWAP – a splinter group of Boko Haram.[54] While the ICD did not show any recorded incidents of UAS activity in Africa, there are reports of ISWAP using COTS drones for ISR. As explained by the Soufan Center, "ISWAP has received tactical guidance from IS core, with innovation on utilizing drones merely part of this tacit knowledge transfer,"[55] which demonstrates learning between groups is occurring.

Group learning is occurring on more than an intragroup level – meaning there is a transfer of knowledge larger than just between affiliates. It is challenging to track relationships between terrorist organizations accurately, but COTS drone incidents are occurring in areas where there is an IS presence. For example, Kurdistan Worker's Party (PKK) and the Free Syrian Army – both attributed with UAS capabilities – do not have interpersonal ties to IS, but were the targets of IS drone attacks. It is interesting that IS presence in the region seems to be an indicator of capabilities. The technology is intuitive and accessible, making it possible to see, then imitate tactics. Further research into the connections between these groups and how they influence each other would

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[54] Telephone Interview with Aaron Smith, October 30th, 2019
[55] "IntelBrief: The Islamic State in West Africa Province Is Growing in Strength and Sophistication - The Soufan Center," *INTELBRIEF*, accessed October 3, 2019, https://thesoufancenter.org/intelbrief-the-islamic-state-in-west-africa-province-is-growing-in-strength-and-sophistication/.

be advantageous to the discipline, especially as transnational terrorist groups are increasingly interconnected.

It is possible that the reason for increased attacks in the region are because of state actors use military-grade UAV as a weapon in the Middle East and North Africa – which is where a majority of the groups are located. However, creatively finding a way to imitate state capabilities is part of the innovation process. By creating a way to replicate drone strikes in a way that was feasible for the organization, IS showed other groups that is was possible. This suggests that IS is the innovator, and other groups are early adopters.

The relationship between how terrorist groups interact and how knowledge is transferred is necessary to understand why COTS are such an attractive option. IS uses both tacit and explicit knowledge to reinforce learning. Education of drone operations was institutionalized with explicit knowledge – demonstrated by classroom learning and making publicly available videos published on social media.[56] Drones—specifically quadcopters—are unique in that they are highly intuitive and have semi-autonomous capabilities. The easier a technology is to use, the less tacit knowledge is needed for successful acceptance of the tech into operations.

The one aspect of drone operations that does require tacit knowledge is the weaponization of the drone. This is where the tracking of relationships is possible. Figure 8 shows a significant drop of attacks at the end of 2017. There are many factors that contributed to this. Anti-drone technology became a priority to thwart IS'

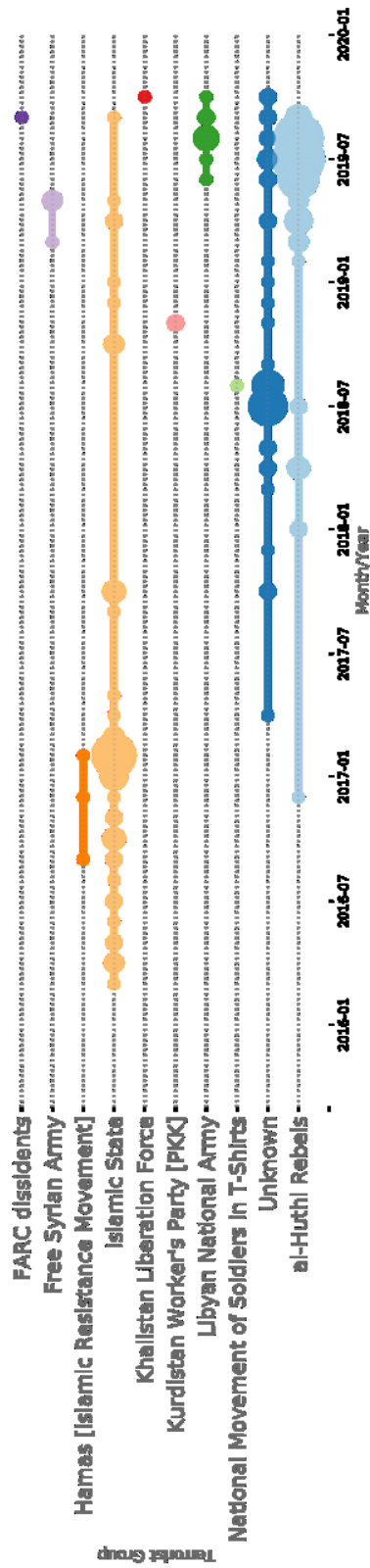[56] Telephone Interview with Nick Waters, October 7th, 2019

functionality in the air domain,[57] but the most important factor was the recapturing of

land in Iraq and Syria. The loss of territory resulted in the migration of members of IS to

their affiliate groups with a significant increase in Africa.[58] This is significant to learning

because as migrants move out of Iraq and Syria to other regions, they take their

knowledge with them. Figure 10 and 11 shows a significant increase in the number of

groups with UAS from 2017 to 2018, with two groups claiming responsibility of 33

incidents in 2017 to four groups claiming responsibility for 15 attacks in 2018. In both

years there are "Unknown" perpetrators but based on location (see figure 8 and 9)

attribution can be placed in either IS or PKK.

   As explained by DOI theory, interpersonal contact is an indicator that a group

will accept an innovation quicker than through mass media. For this reason, tracking

militant migration patterns could be used as a predictive model to explore future
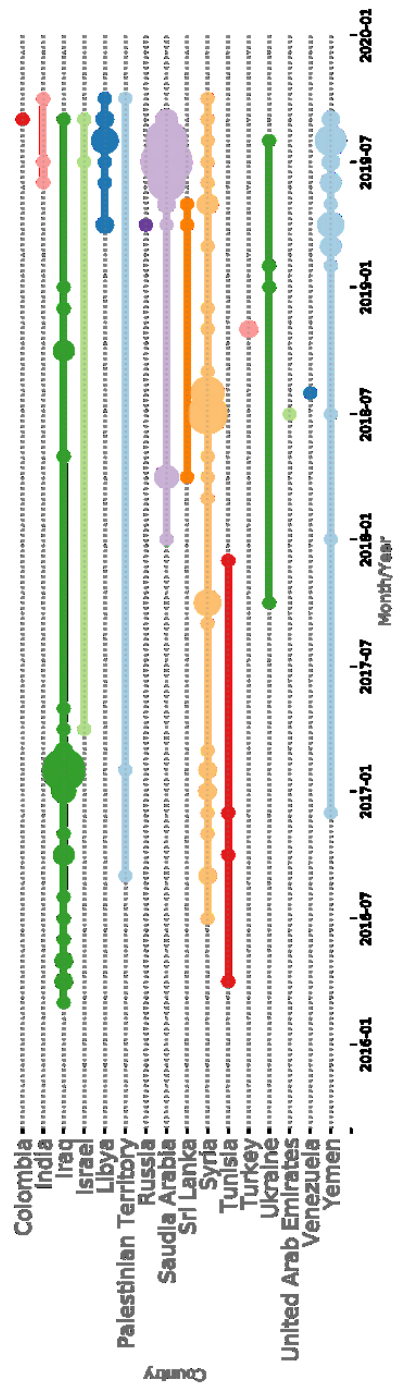
proliferation trends.

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[57] Ben Watson, "The Drones of ISIS," Defense One, January 12, 2017,
https://www.defenseone.com/technology/2017/01/drones-isis/134542/
[58] Telephone interview with Aaron Smith, October 30, 2019

Operational Use of UAV Platforms by Terrorist Group by Month/Year
(Circle Size Indicates Multiple Events)

Terrorist Group (y-axis):
- FARC dissidents
- Free Syrian Army
- Hamas [Islamic Resistance Movement]
- Islamic State
- Khalistan Liberation Force
- Kurdistan Worker's Party [PKK]
- Libyan National Army
- National Movement of Soldiers in T-Shirts
- Unknown
- al-Huthi Rebels

Month/Year (x-axis): 2016-01, 2016-07, 2017-01, 2017-07, 2018-01, 2018-07, 2019-01, 2019-07, 2020-01

Operational Use of UAV Platforms by Terrorist Group by Country and Month/Year
(Circle Size Indicates Multiple Events)

Country (y-axis):
- Colombia
- India
- Iraq
- Israel
- Libya
- Palestinian Territory
- Russia
- Saudia Arabia
- Sri Lanka
- Syria
- Tunisia
- Turkey
- Ukraine
- United Arab Emirates
- Venezuela
- Yemen

Month/Year (x-axis): 2016-01, 2016-07, 2017-01, 2017-07, 2018-01, 2018-07, 2019-01, 2019-07, 2020-01

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Time/Social Structure

The social system and time characteristics will depend on the terrorist group and should be used to evaluate the likelihood of a group to accept the innovation. While innovation and communication are the most important characteristics in tracking how groups attain the technology, social system and time are indicators of the likelihood that a group will adopt.

DOI theory connects leadership style to the decision-making process, which affects the rate of adoption. Generally, more rigid leadership structures are less likely to adapt unless there is a persuasive voice that can inform the leadership's decision-making. In respect to IS, it is clear by the type of munitions used by individuals in different areas of the caliphate that leadership welcomes strategic freedoms as long as it follows the commander's intent.[59] It is possible to trace – based on images and videos – where drones operated tactically based on the type of warhead and tail of the dropped munitions[60] suggesting a more relaxed leadership structure that welcomes innovation. Groups that are daring and experimental are more likely to adopt, and specifically relating to drones, having a safe zone to operate supports trialability.

Time characteristic of innovativeness is a large indicator of rate of adoption placing groups into categories – innovators, early adopters, early majority, late majority, and laggards – based on the innovativeness of the group. Looking at a group's tendencies and tactics is a good indicator of their level of innovativeness. IS is known to

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[59] Telephone interview with Nick Waters, October 7, 2019
[60] Nick Waters, "Types of Islamic State Drone Bombs and Where to Find Them," Bellingcat, May 24th 2017

be inventive in their recruitment efforts, their targeting procedures, and with their use of social media. Groups like the PKK, ISWAP, the Free Syrian Army, and the Khalistan Liberation Force are *Early Adopters* because of the rate of adoption.

Leadership decision-making structure and time can also explain why al-Qaeda (AQ) does not use UAS. Their leadership structure is known to be hierarchal and stringent. Which may indicate that AQ does not allow for interpretation or adaptation – one of the reasons for the splintering of al-Qaeda in Iraq into IS. There is a degree of trial-and-error and risk that comes with adopting new technologies, and groups must be willing to accept the risks. The reason for the more conservative approach could be the need to regain strength after the death of Osama bin Laden, the splintering of IS, and the setbacks they took by expanding too quickly and losing control of groups like al-Shabaab. Regardless of the reasons, AQ does not possess UAS capabilities.

It would be advantageous for future research to explore the relationship between innovativeness and terrorist splintering verses integration with an already established terrorist organization. If a group breaks from its mother organization does it indicate that they are innovators or early adopters? Contrary, if a group decides to join a larger organization does it mean they are more complacent and less imaginative? Historically, innovative attacks are the most devastating. AQ's use of hijacked airplanes were unexpected because it was a new and creative plan. If this research is used as a starting point to create a framework or algorithm that categorizes terrorist organization based on the level of innovativeness, it could act as a tool to assess future threats.

Global security professionals and scholars could use the tool as a potential threat indicator.

<p style="text-align:center">Conclusion</p>

The Diffusion of Innovation Bell Curve (Figure 1) offers interesting insight into the future. Based off of the DOI framework, IS fits into the "innovator" category. They took a technology and created a new tool of hybrid warfare. COTS drones are used for ISR, propaganda, and strategic strikes. As more groups adopt COTS drones – as the Bell Curve demonstrates—there is rapid increase of other groups adopting the technology as well. Currently, terrorist organization using COTS drones are at the "early adopter" level but based on the four characteristics what this research explains about drones, there will be a rapid increase of groups using them in the future.

This research has only scratched the surface of what is, and will be, a significant risk to global security. DOI theory explains that COTS drones are an attractive innovation for terrorist organizations because it is affordable, attainable, multi-functional, and offers unprecedented tactical and strategic advantages. Before UAS proliferated to the non-state level, the war on terror was fought on a two-dimensional battlefield. As the technology continues to diffuse, militaries will need to adapt to fighting terrorists on a three-dimensional plane.

In addition to the tactical significance, UAS act as a communications tool by using the ability to record attack and share videos of the success with supporters over social media. This supports the diffusion of UAVs by reaching large audiences and opens their imaginations. As seen with the PKK, the technology is so intuitive that weaponizing a

drone is possible without an exchange of tacit knowledge. Simultaneously, after the fall

of the caliphate, IS migration is pushing members with tacit knowledge into other

territories and groups, resulting in communication on both a mass and interpersonal

level.

Further research into social structure and time are needed. The innovation and

communication sections help in describing why drone use is proliferating but building a

framework around how social structure and the different levels of innovativeness will

offer predictability. Knowing which characteristics signify how innovative a group is will

allow governments time to react on the ground. Also, based on DOI theory, COTS drones

and how they are armed can act as a tool to connect relationships between terrorist

organizations and supply chains.

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Curriculum Vita

Shannon Genest was born in Culver City, California on April 9th, 1987 and grew up in Redondo Beach, California. She graduated from Redondo Union High School in 2005. After taking a few years to explore life, Shannon graduated from Pennsylvania State University in 2017 where she majored in International Politics with an emphasis in National Security. She became an intermediate Arabic speaker while living in the Middle East while attending Penn State. After earning the B.A. in International Politics, Shannon began her pursuit of a Masters Degree from Johns Hopkins University and has a projected graduation date of December 2019. She hopes to work in the national security field after graduation.