DRONES PROLIFERATION: SHOULD WE WORRY?

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE
General Studies

by

JABER JBELI, MAJOR, ARMY
Engineer in Weapons Technology, Military Academy, Tunisia, 2005

Fort Leavenworth, Kansas
2019

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* 14-06-2019	**2. REPORT TYPE** Master's Thesis	**3. DATES COVERED** *(From - To)* AUG 2018– JUN 2019
4. TITLE AND SUBTITLE Drones' Proliferation: Should We Worry?		**5a. CONTRACT NUMBER**
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Jaber Jbeli		**5d. PROJECT NUMBER**
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Command and General Staff College ATTN: ATZL-SWD-GD Fort Leavenworth, KS 66027-2301		**8. PERFORMING ORG REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)		**10. SPONSOR/MONITOR'S ACRONYM(S)**
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution is Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The advance in RPA technology made during the 21st century changed a lot in the nature of warfare. Acquiring new and sophisticated technology appears as an advantage for modern warfare, but the vast proliferation associated with the complexity of the new operational environment may transform this advantage to disadvantage. It is now easy for non-state actors such as VEOs to possess small RPAs that could be armed with small munitions and even Chemical-Biological-Radioactive-Nuclear substances. Small UAVs have been used by ISIS against a Russian Air Base in Syria, the 250 gram UAVs carried IEDs to deliver to designated locations. Being widely available, cheap, and expandable small UAVs are used by many countries as well as non-state actors primarily for intelligence, surveillance, and reconnaissance (ISR) purposes but they are also used armed with small munitions to target certain objectives surprisingly. No doubt, the threat already exists, but the real issue for planners is how to plan with that threat in mind? This research aims to provide the Chief Decision Maker with some recommendations that could help mitigating the risk of vast proliferation of RPAs and the possible misuse of this technology especially by non-state actors.

15. SUBJECT TERMS
RPA's proliferation, impact in future warfare

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. PHONE NUMBER** *(include area code)*
(U)	(U)	(U)	(U)	82	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

MASTER OF MILITARY ART AND SCIENCE

THESIS APPROVAL PAGE

Name of Candidate: Maj Jaber Jbeli

Thesis Title: Drone's Proliferation: Should We Worry?

Approved by:

____, Thesis Committee Chair
Kenneth. E. Long, Ph.D.

____, Member
Steven. D. Rosson, MA

____, Member
Gerald. J. Leonard, M.S

Accepted this 14th day of June 2019 by:

____, Director, Graduate Degree Programs
Robert F. Baumann, Ph.D.

ABSTRACT

DRONES PROLIFERATION: SHOULD WE WORRY? by Major Jaber Jbeli, 82 pages.

The advance in RPA technology made during the 21 century changed a lot the nature of warfare. Acquiring new and sophisticated technology appears as an advantage for modern warfare, but the vast proliferation associated with the complexity of the new operational environment may transform this advantage into a disadvantage. It is now easy for non-state actors such as VEOs to possess small RPAs that could carry small munitions and even Chemical-Biological-Radioactive-Nuclear substances. ISIS has used small UAVs against a Russian Air Base in Syria; the 250 gram UAVs was carrying IEDs to deliver in designated locations. Being widely available, cheap, and expandable, many countries, as well as non-state actors, are using small UAVs primarily for intelligence, surveillance, and reconnaissance purposes but they are also utilized armed with small munitions to target specific objectives surprisingly. No doubt, the threat already exists, but the real issue for planners is how to plan with that threat in mind?

This research aims to provide the Chief Decision Maker with some recommendations that could help to mitigate the risk of the vast proliferation of RPAs and the possible misuse of this technology, especially by non-state actors.

ACKNOWLEDGMENTS

Firstly, I would like to thank GOD who gave me the strength and power to work through this research paper along with many other assignments during my CGSC year. It has been a challenge for me to manage my limited time to research a hard topic like drones' topic.

Second, my wife, Wafa. Without her continuous encouragement, I would not have been able to complete my thesis. Not only did she support me, but she also sacrificed her own time to give me more opportunity to perform this research and finish my master's degree.

Third, my MMAS committee that provided much support and encouragement throughout the process. To Dr. Kenneth D. Long, the Chair of the committee, with all what he offered of guidance and support in every step of the research, to Mr. Steve Rosson, my committee first reader who supported me by valuable feedback about the coherence and the sense-making of my paper, to Mr. Gerald. J. Leonard, my committee second reader, for offering his significant experience to help me go through this research paper.

Last, to all who helped me directly or indirectly in my staff group SG07 D. To my section leader Dr. Olsen who encouraged me on my research with his valuable advice and guidance. To my SGA Mr. Geregory Bedrosian, who always showed me his concerns about the advance of my study. To the helpful staff at the Combined Arms Research Library at Fort Leavenworth, Kansas; and to Mrs. Ann Chapman and all the MMAS staff and teachers who gave me continuous support with all the needed forms and models to produce a well-written research paper.

TABLE OF CONTENTS

ACRONYMS

MALE	Medium Altitude, Long Endurance
UCAV	Unmanned Combat Aerial Vehicle
RPA	Remotely Piloted Aircraft
UAV	Unmanned Aerial Vehicle
WOT	War On Terror
UAS	Unmanned Aerial System
CNAS	Center for New American Security
VEO	Violent Extremist Organization
CDM	Chief Decision Maker
ISTAR	Intelligence, Surveillance, Target Acquisition, Reconnaissance
MGTOW	Maximum Gross Takeoff Weight
GCS	Ground Control Station
LOE	Lines of Engagement
WMD	Weapons of Mass Destruction

ILLUSTRATIONS

TABLES

CHAPTER 1

INTRODUCTION

> It is already clear that, because of advances in technology, drones are going to play an increased role in warfare in the years ahead. It is therefore vital that the legal frameworks governing their use are robust and internationally recognized.
>
> —Douglas Alexander[1]

Background

UAVs, UASs, RPAs, RPVs, and "Drones" are all names to design crewless aircrafts that are increasingly in evolution especially during the War on Terror (WOT). To unify the nominations of this "flying Robot," we will use the acronym RPA which stands for Remotely Piloted Aircraft. This is also to emphasize the role of human in the employment of this new technology, and to say that we are still in a warfare that does not exclude human even with a smart generation of war machine. UAVs and Drones acronyms will also be used frequently in this research paper.

Many authors wrote about RPAs, and most of them dealt with their construction, possibilities of use, and the legal and ethical side of their use. Like any other military technologies, RPAs attracted many developed and even developing countries into a race and competition to produce or purchase their more sophisticated and smart versions. Currently, at least 90 countries as well as non-state actors possess RPAs, and more than

[1] A British politician from the Labor Party. Born on 26 October 1967, Douglas has served in the Cabinet from 2006 to 2010 during the mandates of the Prime Ministers Tony Blair and Gordon Brown as the Secretary of State for Scotland, Secretary of State for Transport and Secretary of State for International Development.

30 of these possess or are developing armed versions of this system (Ewers, Fish, and Horowitz 2017).

Compared to crewed aircraft, RPAs are relatively cheap and can perform different kinds of missions with a low-risk. These characteristics will lead to Unmanned Aerial Vehicles be one of the significant elements that could shape future warfare, but they are also believed to be utilized by some non-state actors. The progress in communications and information technology during the twentieth century, allowed modern armed forces to fight in a network and share real-time information. The combination of sensors and precision ammunition can provide an accurate targeting capability that allows continuous surveillance and close engagement of the enemy. In the era of rapid technology evolution, many countries are racing to build reliable ISR/ISTAR systems using sophisticated and undetectable drones (Scharre 2014).

Statement of the Problem

In October 2014, a Birmingham Policy Commission took place to discuss some issues that the UK faces in developing RPAs and to explore the government's future reaction to the increasing proliferation of this new technology (Commission 2014).

In Jun 2017, the Center for New American Security CNAS presented "policy choices for the Trump administration concerning Drone Proliferation. The document stated that the drone proliferation is now unstoppable. CNAS also mentioned that while the proliferation of hardware is difficult to control, the proliferation of software is nearly impossible to stop (Ewers, Fish, and Horowitz 2017).

The question of the impact of RPAs' proliferation in modern and future warfare looks similar to the question asked to a military theorist in 1915 on the effect of the

Aircraft in future warfare (Kreuzer 2016). But with the increasing evolution of this new technology, the answer to this question might be an emergency for governments to plan future challenges adequately. The study of the different categories, manufacturers, and sellers of RPAs combined with the study of the impact of their proliferation in modern and future warfare will provide planners with an idea about how to plan in a complex battlespace with a vast spread of drones.

Purpose of the Study

The concern of this research paper is to highlight the impact of the increasingly widespread of RPAs in modern and future warfare and to answer the primary question of how should planners plan for operating in a complex battlespace with a vast proliferation of this technology. This research can be useful especially when we know that a lot of debates that took place in different kind of media didn't clarify things about this subject (Hallen 2016).

It is necessary, before digging into these questions, to give the reader a clear vision about RPAs: their history, their different categories, and their actual range of capabilities.

Primary Qualitative Research Question

The primary research question this research will attempt to answer is:
How should planners plan for operating in a complex battlespace with a vast proliferation of RPA technology?

Answering such question is important because it will allow decision makers to plan for short and long term protection of vulnerable facilities and operating units. Also, it will provide and understanding of the real threats far from the propaganda relative to the subject of UAVs and their advantages and disadvantages.

Secondary Research Questions

To answer the primary research question, it is necessary to build a base of understanding of the subject of UAVs through providing answers to the following subordinate research questions:

1. How can we best define RPAs and what are their different categories?
2. What countries are known to be the most manufacturers, sellers, and buyers of RPAs?
3. What is the impact of using RPAs on modern warfare and what might be their impact on future warfare?

Hypotheses

Regarding all capabilities that RPAs can have, a vast proliferation associated with possible misuse of this technology might be an issue that planners should worry about.

Limitations

The limitations of this research are lack of relevant information about the proliferation of RPAs. We may find difficulties in knowing some of the secret deals that might take place aiming to equip VEOs. Also, information related to the military industry of some countries is classified. Time may also be limited to conduct profound research about the subject of RPAs.

Delimitations

This research will not go into technical details about UAVs. We will focus on Networked RPAs, the tactical drones, and small drones. We will also limit the research to recent data (last ten years) related to the subject of RPAs.

No surveys will be conducted during the research, and we will only use open source data.

Assumptions

We will conduct this research based on two assumptions: The first assumption is that human will not be excluded from RPAs operations from planning to executing. The second assumption is that VEOs are not equipped yet with armed drones; however, this will not mean that they can't find a way to own them.

Key Terms and Definitions

Remotely Piloted Aircraft: RPAs are all robotic fixed or rotary-winged remotely piloted aircrafts, capable of flying using on-board propulsion and aerodynamic lift and meant to be reused (Kreuzer 2016).

Networked RPAs: large, expensive, and capable of operating at great distances. Can contribute to the air superiority by performing strategic bombing against non-fixed targets (Kreuzer 2016).

Unmanned aerial system (UAS): refers to the whole system included in the operation of flying a UAV. Generally, a UAS is composed of an Arial Vehicle, a Ground Control Station GCS, a Launcher, and a Retriever if needed.

Drones' swarm: a large number of small drones massed together in a synchronized way in order to provide the element of surprise and limit the adversary reaction.

ISTAR : Intelligence, Surveillance, Target acquisition, and Reconnaissance. It is a practice that relates warfighting functions together to assist a combat force in employing intelligence sensors and managing the information they collect.

LSS UAVs: Low, Slow, Small Unmanned Arial Vehicles.

CHAPTER 2

LITERATURE REVIEW

Introduction

The purpose of this chapter is to provide readers with a coherent and focused summary of what has been written about the subject of RPAs in general, and about the primary and secondary questions of this research paper in particular. The review of literature will also permit to:

1. Provide a background for this research paper form previous published papers;
2. Classify the research into themes and categories based on research questions;
3. Identify gaps and limitations in current focus on the subject of RPAs while evaluating previous research;
4. Justify the utility of this research from by clarifying its difference from other research conducted in the same field.

The research began with collecting and reviewing data related to Drones and organizing them in a logic way based on their linkage to the research questions. As a reminder, the research questions was:

1. How should we plan for operating in a complex battle space with a vast proliferation of RPA technology? (Primary research question)
2. How can we best define RPAs and what are their different categories?
3. What countries are known to be the most manufacturer, seller, and buyer of RPAs?
4. What is the impact of using RPAs in current warfare and what might be their impact in future warfare?

Based on the presented research questions, a possible way to look at the existing researches will be through the following three types of literature:

1. Literature that generally spoke about RPAs: definition, categories, main manufacturers and users;
2. Literature focused on studying the impact of RPAs on the current and future warfare;
3. Literature focused on the subject of Drones proliferation.

Summary of the Existing Literature

Before going on detail about the primary question of this research paper, it is necessary to give the reader a background on how existing literature spoke about definition, categories and main manufacturers and users of RPAs.

Literature that Generally Spoke about RPAS in Terms of Definition, Categories, and Main Manufacturers and Users

Definition

In their article "Drones and Possibilities of Their Using," Piotr Kardasz,[2] Jacek Doskocz,[3] Mateusz Hejduk,[4] Paweł Wiejkut[5] and Hubert Zarzycki,[6] defined UAVs as

---

[2] Vice Coordinator in the Foundation Research & Development & Innovations.

[3] Klaster B+R&I, Poland; Research and Development and Innovation Cluster.

[4] International University of Logistics and Transport in Wroclaw, ul. Sołtysowicka, Wroclaw, Poland.

[5] Lower Silesia Accelerator Technology and Innovation, SAP ABAP BW Consultant Nowodworska, Wroclaw, Poland.

[6] Dean, Rector, Vice-Rector, Assistant Professor; Department of Computer Science Wroclaw, Lower Silesian Voivode ship, Poland.

"the aircrafts, which are able to fly without a pilot and passengers on board. Drone controlling is performed remotely by radio waves or autonomously (with a predetermined route)" (Kardasz and Doskocz 2016).

Maria De Fatima simplified the definition of UAVs in her article "unmanned aerial vehicles: an overview" to limit it to "an aerial vehicle capable of sustained flight without the need for a human operator onboard."

Kreuzer[7] defined RPAs as "robotic, fixed-or rotary-winged aircraft capable of sustained controlled flight using on-board propulsion and aerodynamic lift and designed for return and reuse" (Kreuzer 2016).

Defining RPAs is a way to differentiate between crewed and crewless aerial vehicles and give an idea about categories and purpose of use. But it is also necessary to distinguish between Unmanned Aerial Vehicles and other unmanned systems.

<u>Categories/Classification</u>

Maria De Fatima[8] asserts that RPAs can be classed in many ways based on different parameters such as endurance, flight altitude, maximum take-off weight, size, and speed. The author identified four possible significant categories based on the criteria mentioned before: micro/mini UAVs (MAV/Mini), tactical UAVs (TUAVs), strategic UAVs, and the special tasks UAVs (Bento 2008).

---

[7] Michael P.Kreuzer is the director of Operations, 497th Operations Support squadron, Joint Base Langley-Eustis, Virginia.

[8] Maria De Fatima has a degree in Avionics Engineering, from the PAFA Portuguese Air Force Academy, a Master of Science in Satellite Positioning and Navigation from the Faculty of Sciences Porto, and is a Ph.D. student at the Institute of Geodesy and Navigation of the University FAF Munich.

This classification contains most of the parameters mentioned above and is more related to the purpose and area of use of RPAs.

Many organizations such as NATO, NASA, and US DoD have defined different groups or classes of RPAs (Fladeland, Schoenung, and Lord 2017). Most of these classifications are based on speed, weight or altitude. (See Table 1)

Table 1. NASA UAS Classification

Category	I	II	III
Weight	≤ 55 lb (25 kg)	55-330 lb (25-150 kg)	> 330 lb (150 kg)
Airspeed (kt)	≤ 70	≤ 200	> 200
Type	Model or sUAS	sUAS	UAS

Source: Fladeland, Schoenung, and Lord 2017, 2.

In his book "Drones and the future of Air Warfare," Michael Kreuzer introduced another categorization of RPAs. This categorization is based on the communication systems that RPAs use. The first category is the Networked RPAs which are strategically used and are expensive compared to other types. The second category is the Tactical RPAs: relatively cheap and widely available for both sides of conflicts (Kreuzer, Drones and the Future of Air Warfare: the Evolution of Remotely Piloted Aircraft 2016).

ATP 3-01.81 published in April 2017, presented a categorization of RPAs based on weight, operating altitude, and speed (O'KEEFE 2017). The publication grouped the RPAs' categories into five groups (see Figure 1).

UAS Groups 1 thru 5 (Emphasis on Low- Slow- Small Systems)		
Group 1 Micro / Mini UAS	Weighs 20 pounds or less and normally operates below 1,200 feet above ground level (AGL) at speeds less than 100 knots	These systems are generally hand launched including hobby type UAS. They offer real time video and control, and have small payload capabilities. Operated within line of sight of user.
Group 2 Small Tactical	Weighs 21–55 pounds and normally operates below 3,500 feet AGL at speeds less than 250 knots	Small airframes, low radar cross-sections, and provide medium range and endurance. Requires line of sight to the ground control station.
Group 3 Tactical	Weighs more than 55 pounds, but less than 1,320 pounds, and normally operates below 18,000 feet mean sea level (MSL) at speeds less than 250 knots	Range and endurance varies significantly among platforms. Requires a larger logistics footprint than Groups 1 and 2.
Group 4 Persistent	Weighs more than 1,320 pounds and normally operates below 18,000 feet MSL at any speed	Relatively large systems operated at medium to high altitudes. This group has extended range and endurance capabilities (may require runway for launch and recovery).
Group 5 Penetrating	Weighs more than 1,320 pounds and normally operates higher than 18,000 feet MSL at any speed	Operated at medium to high altitudes having the greatest range, endurance, and airspeed. Requires large logistical footprint similar to that of manned aircraft.

AGL above ground level MSL mean sea level UAS unmanned aircraft system

Figure 1. UAS Categories

Source: HQDA 2017, 1-2.

ATP 3-01.81 emphasized the first three groups of RPAs to say that they present more threat than the other two groups (O'KEEFE 2017).

The possible payloads that UAVs may utilize are in an increasing number and can go from electro-optical or infrared optics, radar, signals intelligence, laser designation supporting the delivery of electronic warfare to air-to-surface weapons or one-way lethal payloads (O'KEEFE 2017).

Main Manufacturers and Users

In their report "Unmanned Ambitions: Security implications of growing proliferation in emerging military drone markets," Wim Zwijnenburg[9] and Foeke Postma[10] state that currently, over 90 States own military drones, 24 have armed versions which have been used at least in 13 countries (Zwijnenburg and Postma 2018). The number of drones' possessors is very significant and reflates the increased proliferation of RPAs around the world (nearly half of the world's countries possess RPAs).

The same report numbered around 450 manufacturers of RPAs globally, and one-third of them oriented to military drones. The drone market for sophisticated high-tech military drones is currently dominated by the United States, Israel, and China but other countries are taking their chance in the development of military drones (Zwijnenburg and Postma 2018).

The report also affirmed that there is an increased interest among armed forces, particularly in the medium and short range of drones, which are characterized by simple communication systems but capable of a useful role in military operations at both ISTAR and strike capabilities. Iran, Turkey, Ukraine, Pakistan, and South Africa are countries that have made steps to buy positions in the military drone market, while countries from Latin America, Eastern Europe, and Asia are also taking part of this new market. This

[9] Project Leader of Humanitarian Disarmament for the Dutch peace organization PAX. His researches focus on the impact of emerging military technologies on warfare and the consequences of their proliferation.

[10] Research and advocacy on humanitarian disarmament, focuses on emerging military technology, social media, environmental and LGBT-issues.

report also stated that 21 States are producing over 60 different types of military RPAs in the medium and short range of drone technology (Zwijnenburg and Postma 2018).

Literature Focused on Studying the Impact of RPAS on the Current and Future Warfare

Impact in Current Warfare

In her article "The efficacy and legality of drones in modern warfare", Lise Kanner[11] described the use of drones as a characteristic of modern warfare that cannot be replaced by any other technology. He also related the importance of using RPAs to the current change of nature of conflicts from symmetric to asymmetric. Kanner stated that the impact of RPAs strikes in military operations such as intelligence operations is obvious and clear (Kanner 2016).

Colonel Jeffrey Kappenman also spoke about the impact of RPAs in modern warfare in his article titled "Army unmanned aircraft: decisive in battle" published in Joint Force Quarterly in 2008. He compared the US war on terror with and without the use of RPAs to conclude that drones provided commanders with ground maneuver and critical battlefield information that led to outstanding results.

Kappenman stated that army drones give tactical commanders quick responsiveness and provide them with eyes on target much faster than other ISR assets (KappenMan 2008). The author described the effectiveness of RPAs by listing their deferent roles that started from theater intelligence to tactical missions such as surveillance, reconnaissance, attack,

[11] Research assistant at Freshfields Bruckhaus Derringer, Cologne Area, Germany Higher Education.

communications, and convoy security. He also spoke about the integration of RPAs into the commander's mission planning that helped a correct development of the tactical situation to limit force exposure and reduce collateral damage (KappenMan 2008).

Impact in Future Warfare

In the article "Unmanned Aerial Vehicles and The Future of Airpower," Gerald Goh Qi Wen[12] linked the impact of the use of RPAs in the future warfare to the next performances that will be integrated into drones. The author stated the example of the integration of COMINT and ELINT sensors within tactical RPA platforms which will provide forces with detection, geo-localization, and radio-frequency transmissions to allow them enhanced capabilities in terms of survivability and enemy capabilities disruption (Wen 2015).

Literature Focused on the Subject of Drones Proliferation

In her papers of November 2014, Ulrike Esther Franke[13] argued that RPAs proliferation should not be a problem as long as it is limited in the proliferation of unarmed drones (Franke 2014). She also stated that the fact that terrorist organizations own RPAs is unlikely to cause a threat for states. Her arguments on that were that terrorists can only manipulate simple drone systems and not sophisticated ones, supposing that the latter are not easy to control (Franke 2014).

---

[12] Gerald is an Air Force Engineer by vocation who graduated from Imperial College London with a Masters of Aeronautical Engineering.

[13] Ulrike Esther Franke is a DPhil student in International Relations at Oxford University and focuses on the strategic implications of the increasing use of Unmanned Aerial Vehicles (UAVs or "Drones") by Western armed forces.

The Director of the Center for 21st Century Security and Intelligence at the Brookings Institution Peter Warren Singer addressed the same issue in his article "The Proliferation of Drones Changes in size, intelligence reframes questions of use" of 2013. He concluded that it is not impossible to address the challenges caused by drone proliferation, but this is only possible if we start recognizing RPAs' status today, and in short term plans (Singer 2013).

Singer also emphasized the importance of creating global standards for operating, trading, and utilizing this technology (Singer 2013). He also brought up the fact that armed drones are becoming smaller and can carry smaller munitions, which is a very important factor to consider in discussions of this category of RPAs (Singer 2013).

The common point between the two mentioned authors is the necessity of differentiating categories of RPAs when discussing their proliferation.

In his book "Drones and the Future of Air Warfare," Michael Kreuzer asked the question about the possibility of limiting "drones" proliferation through international agreements. He also described RPAs as tools with minor importance if isolated, but when paired with specific capabilities like global communications, precision targeting, advanced information collection, and qualified operators and working staff to put together all these capabilities, RPAs proliferation could be an essential subject to discuss and take adequate measures for future warfare.

Kreuzer considered that organizational and financial costs barriers could oppose Networked RPAs' proliferation since this category of drones can only be owned by rich countries, and most of the non-state actors are most likely unable to purchase relatively expensive RPAs (Kreuzer 2016).

As drones' proliferation seems to be a vague subject for some authors, Atul Pant chose to write about the spread of drone swarms as an emerging new technology. The "issue brief" had the title "Aerial Drone Swarms: The Next Generation Military Weapon" to mention that we will be reading about a separate issue inside the subject of RPAs. The author stated that Drone swarms are based on software and can be affordable because of their reduced mission costs. He also concluded that the advantages of this new technology would probably lead to a vast proliferation even among non-state actors. According to Atul Pant, the subject of drone swarms as a new technology that could quickly emerge must be taken more seriously and dealt with without delay (Pant 2018).

In a paper for the president titled "Drone Proliferation Policy Choices for the Trump Administration" written by "Elisa Catalano Ewers, Lauren Fish, Michael C. Horowitz, Alexandra Sander, and Paul Scharre", the authors stated that in the subject of drone software is what matters because it can be easily copied and reproduced. They also considered that stopping the proliferation of software is almost impossible to do because of the vulnerability that some software presents (Ewers, Fish, and Horowitz 2017).

Evaluation of Existing Literature

In the evaluation of the existing literature will follow the same organization made in the first part of this chapter.

In defining RPAs, most of the sources we found didn't go deep in detail and limited the definition to the fact that drones are aircraft that can perform a sustained flight without a pilot onboard, but with control from a ground control station. Some of the authors tried to be more precise in defining RPAs by adding some details about the type of aircraft (fixed/rotary-winged) and the type of communication used in the control station.

For a simplification reason, we will use the definition that describes an RPA as "an aerial vehicle capable of sustained flight without the need for a human operator onboard." By using this definition, we have to mention that human will still be an essential element for this unmanned aerial system to work either in the control stations or in the flight preparation and maintenance tasks.

In the literature focused on the subject of drones, the authors used many criteria for the categorization of this new technology. Some of them used technical data as a criterion, some used purpose of employment, while others used both of these two criteria to come up with two main categories of RPAs: Networked RPAs and Tactical RPAs. Using these two main categories will give us a clear vision about how we will address the first question of this research paper.

In the existing literature, many authors spoke about the dominating countries of the drones' market and limited them currently to the United States of America, Israel, and China. However, some sources start discussing the ambition of some countries and even non-state actors to build their arsenal of Unmanned Aerial Vehicles. The literature covers most of the actors in the drones' market, but some of them are still unknown or at least not mentioned in enough detail in the existing sources.

The literature presents many potential advantages of the military use of crewless aircraft but also some disadvantages related to the possible use of small drones to carry small munitions and IEDs. The examination of the impact of RPAs in modern and future warfare from the existing literature is well covered especially when talking about the advantages and disadvantages that can lead to the conclusion concerning their impact.

In conclusion, this chapter focused on finding a good definition and categorization of RPAs, examining the trends of drones' market and its major players, and finally setting the stage for an understanding of the threat related to RPAs' proliferation. The purpose of chapter 2 was to narrow down the problem of drones' proliferation to use the methodology explained in chapter 3 to answer the primary question of the research.

CHAPTER 3

RESEARCH METHODOLOGY

Although many authors wrote about the subject of RPAs, the debate about the impact of this new technology in future warfare as well as the possible measures that planners should take to plan well in a complex battlespace characterized by vast drones' proliferation, is still confusing and needs more profound research. In this research, we will try to find logical answers to the three subordinate questions to answer the main research question finally. We will use the Operational Approach as a method to mitigate the threat and the DOTML PF to fix the Lines of Engagement that will lead to achieving the desired end state.

This research will use the Applied Professional Case Study (APCS) method (Long 2016) because it will combine both quantitative and qualitative data from a variety of sources to make useful, professional policy recommendations to a senior military Chief Decision Maker (CDM). It will apply best-practice models, concepts, and processes from the Professional Body of Knowledge (PBOK) to be persuasive to the CDM (Long 2016).

Generally speaking, case studies methods are used when answering 'how' and 'why' questions, (which is the case of this research paper), when there is little control over events, and when the investigator is trying to examine a particular phenomenon in a real-life situation or context (Stjelja 2013).

Applied Case Studies are useful methods for conducting qualitative research for problem areas that are human-centric, dynamic, volatile, and contain a mix of stakeholders, interests, variables and information concepts that demand a deep understanding of the context to produce informed policy choices (Creswell 2014).

We will use a standard of sound and professional judgment to manage what will be an iterative valid inquiry into a complex problem and operating environment. The following models, processes, and concepts will be applied during the research and analysis, and are described and referenced in Chapter 2:

1. Army Design methodology: we will use the Operational Approach in the mitigation part to answer the primary research question.
2. DOTMLPF: from DOTMLPF only Doctrine, Training, and Material will be used to present recommendations to the CDM.

Final recommendations to the Chief Decision Maker CMD will be evaluated, at a minimum by the criteria of Suitable, Feasible, Acceptable. As we progress in the research, we will make three recommendations R1, R2, and R3:

Recommendation 1: the first recommendation is a description of the researcher's position, which is that planners should take into consideration the vast proliferation of armed crewless aerial vehicles. (Armed UAVs are generally the strategic UAVs possessed mainly by state actors). This recommendation is subject to changes based on the review of the literature conducted in Chapter 2.

Recommendation 2: After the review of the existing literature about the subject of RPAs, the second recommendation is an improvement of the first one and will be followed by a third recommendation once an analysis of the findings is conducted (Chapter 4).

Recommendation 3: this recommendation will be the second recommendation looked at through Stakeholder Lens Analysis. R3 will be the proposed policy changes after the analysis of the findings. The purpose of this recommendation is to present to the CDM a finalized proposal using DOTML-PF (D-T-M precisely).

Visual models:

The following graphics will be used to simplify the research and will help synthesize the findings of the reviewed literature:

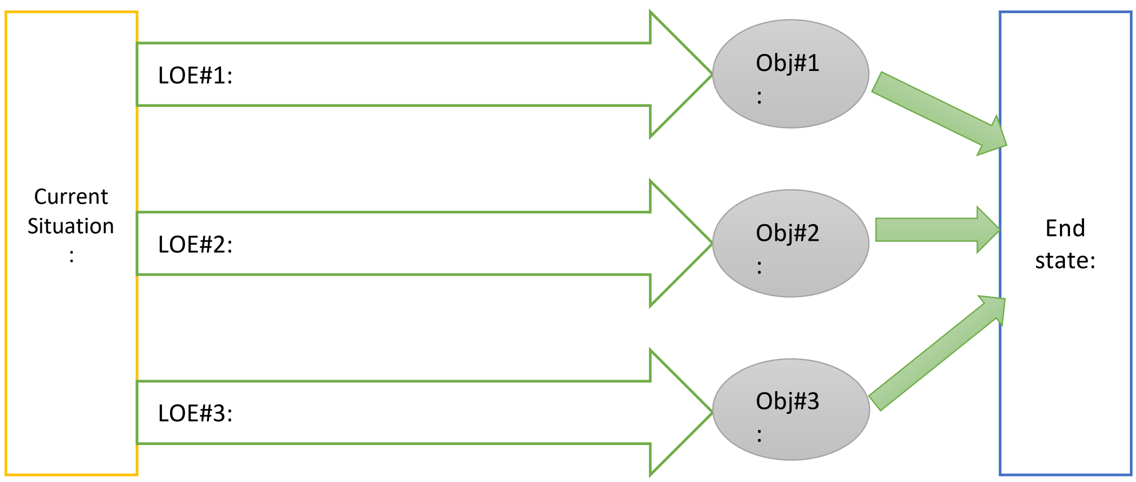


Figure 2. Operational Approach

Source: Created by author.

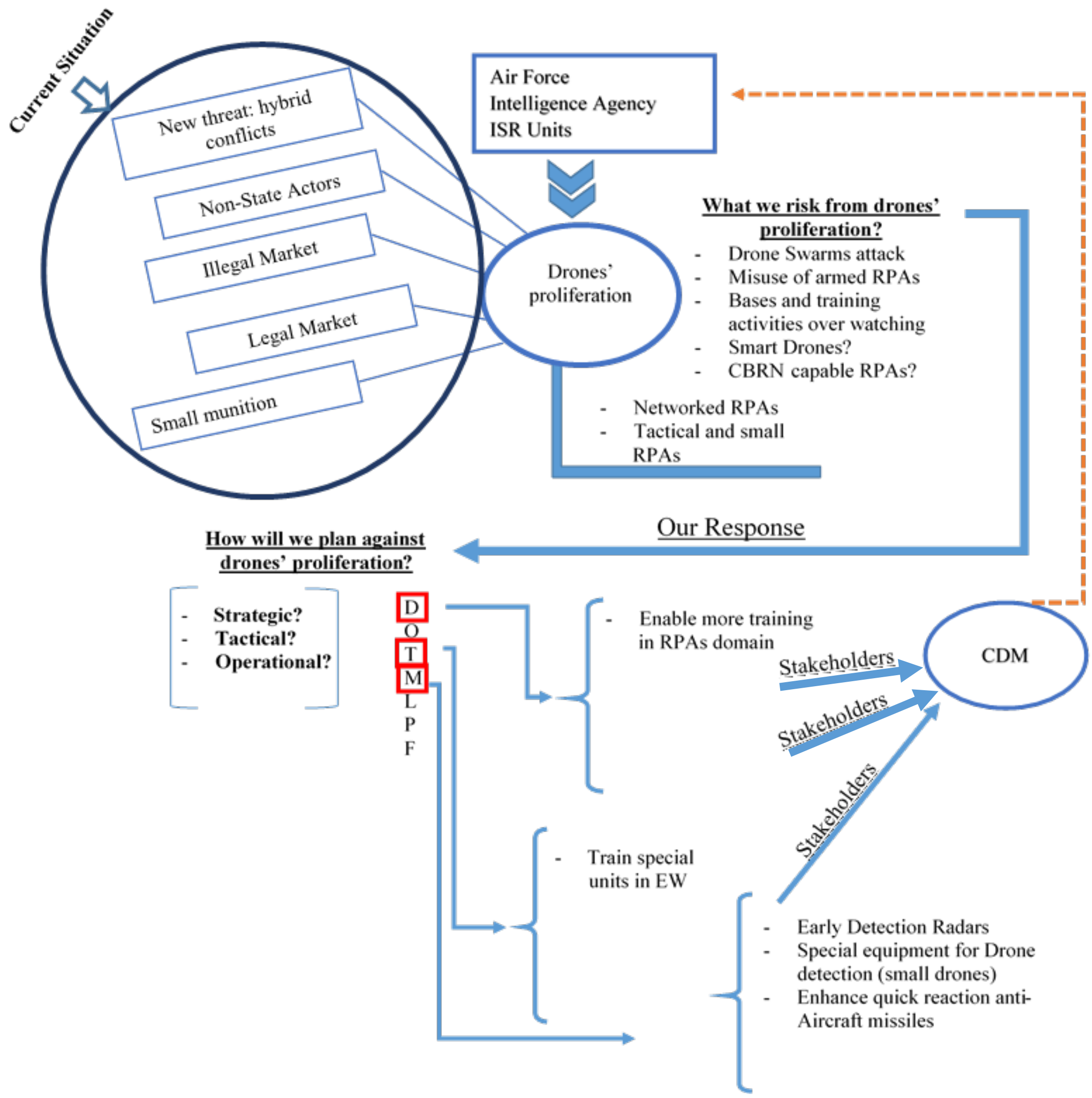


Figure 3. Visual Model of Drones' Proliferation Issue

Source: Created by author.

CHAPTER 4

ANALYSIS

Organization

Chapter 4 is organized based on the research questions into four research parts. We will start this chapter from broad to narrow, to end up focusing on the primary research question. The first part will be a continuity of the data mentioned in chapter 2 about finding a good definition of an Unmanned Arial Vehicle and building an explicit knowledge about UAVs' categories. In this area, we will answer the first secondary question: how can we best define RPAs, and what are their different groups? Answering this question will be a necessary step to provide a context to answer the primary research question. In the second part, we will look at the drone's market to give a clear idea about leading manufacturers, sellers, and buyers of RPAs. Based on the findings on this part, we might add some factors to the big picture of RPAs threat such as who is really influencing the proliferation and who is probably involved in the illegal market of drones. In the third part, we will continue narrowing down the subject by analyzing some of the impacts of RPAs' proliferation in current and future warfare. This part will directly support the primary research question. The last research part will address the main research question: How should we plan for operating in a complex battlespace with a vast proliferation of RPA technology? The answer to this question will be deducted from the analysis of the findings in Chapter 4 and will be presented in Chapter 5.

Research Part 1: Unmanned Aerial Vehicles: Definition and Categories

The purpose of this research part is to provide the reader with a clear definition of UAVs and with a classification that takes into consideration many factors such as size, range, altitude, and payload capability.

Definition of UAVs

Unmanned Aerial Vehicles (UAVs), also named Remotely Piloted Aircraft (RPAs), can be defined as uninhabited fixed or rotary wing aircraft, but this definition sounds like excluding or neglecting the human role in this technology. The U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035: Eyes of the Army states that "the human element is vital to successful UAV employment" which means that even though the name does not specify his role, the human element is still playing a crucial role in the Unmanned Aerial System. To emphasize the significant human role in operating UAVs, some experts choose the name Remotely Piloted Aircraft RPA. Usually, an RPA does not work alone, but it is part of a system called the Unmanned Aerial System (UAS). A UAS is composed of an aircraft (with a weapon system platform if armed), a payload, an operator or a crew, a control station with a network of communication and display, a launch and recovery platforms (if applicable), and a support logistics. As stated before, all these components require a qualified operator, maintainer, or imagery analyzer to operate them.

The central part of an Unmanned Aerial System is the Unmanned Aircraft UA. A UA is capable of carrying different types of payload:

1. Sensors such as EO/IR cameras, synthetic aperture radar (SAR), SIGINT, moving target indicator, and electronic attack;

2. Communications payloads such as relays, amplifiers and range extension, and translation capabilities;
3. Weapon payloads: lethal (missiles and bombs) and non-lethal (CoE 2010).

Oxford dictionary defined UAV as an aircraft without a pilot, controlled from the ground or by a computer on board. This definition brings up two ways of control of UAV: from the ground or by a computer on board, but most of the known UAVs are controlled from the ground by a crew composed of a pilot also called operator, a ground operator, and a maintainer. The principal role in the team is played by the operator who is usually trained to fly and control the drone from a ground control station GCS. The GCS is composed of computers, antenna, and pilot console. Most of the UAVs are pre-programmed to follow routes and receive control from the operator to orbit, track targets, and return to base.

UAVs can have different shapes, sizes, range, and endurance. Also, their payloads can vary from camera to missiles. ATP 3-01-81, published in 2017, provides a categorization of UAVs based on size, range, and payload capability.

Categories of UAVs

Mainly, we distinguish two categories of UAVs: Armed and Non-Armed UAVs. Under these two categories, we can find five groups based on size, range, and payload capability. Years ago, the Armed Forces mainly used strategic long-range networked drones. However, during the last few years, things have changed, and the advancement in drone technology led to the use of small UAVs that can carry small munitions. The report "Unmanned Ambitions" of "Wim Zwijnenburg" and "Foeke Postma" introduced a categorization of UAVs. Based on the way of launch and recovery, fields of use, altitude, and endurance, the report mentioned five UAVs' categories:

Vertical take-off and landing: covers military and civilian versions of quadcopters and rotary wing UAVs. These drones can be launched and recovered on any terrain without requiring a ground control station.

Loitering Munitions: Kamikaze Drones designed to crash and explode at the target. The Russian "high-precision attack unmanned complex" named the "KUB-BLA" recently displayed by the Kalashnikov Company in the international exhibition of Arms and Military Equipment in Abu Dhabi, is an example of this type of UAVs(see Figure 4).

Figure 4. The "KUB-BLA" Kamikaze Drone of Kalashnicov

Source: Connex Drones 2018.

Military-grade: type of UAVs that are for military use only. This type of drones can perform Intelligence, Surveillance, Target Acquisition, and Reconnaissance (ISTAR) missions.

Medium Altitude, Long Endurance (MALE UAVs): are capable of long endurance missions (over 24 hours) and can fly at altitudes between 10000 and 30000 feet. High Altitude, Long Endurance (HALE): are UAVs capable of reaching high altitude (above 30000 feet) and long endurance that can reach 32 hours of continuous flight commonly used for ISR missions.

ATP 3-01.81 grouped UAVs into five groups based on range, size, and capability: Group1: Mini/Micro UAVs. Hand launched Small drones that are difficult to detect using detection assets. These UAVs have 20 pounds or less of Maximum Gross Takeoff Weight (MGTOW) and operate below 1.200 feet AGL at speed less than 100 knots. Although they are of small payload capabilities, Group 1 UAVs can offer real-time video and can be used in ISR missions but for a small perimeter and under the vision of the operator. Due to their small size, easiness of operation, and low flying altitude, drones of group 1 category can be used for spying missions and can carry and deliver biological substances. Some examples of group 1 UAVs are the US Skate (60X33 cm), the Israeli Mosquito (35 cm of wingspan), and the Australian Cyber-Quad Mini (42X42 cm square) followed by the Maxi version

Figure 5).

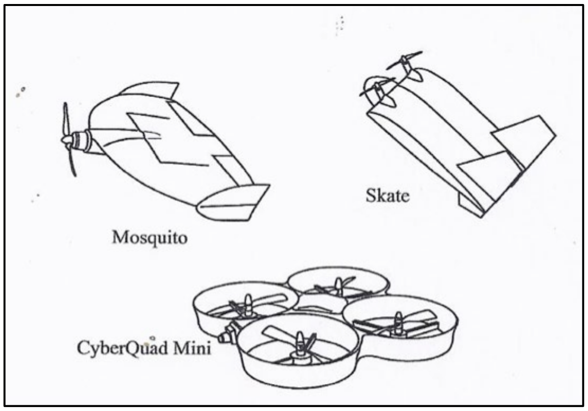


Figure 5. Examples of Group 1 UAVs

Source: Fahlstrom and Gleason 2012.

Group 2: Small tactical UAVs. 21 to 55 pounds of MGTOW and flying level below 3500 feet AGL at speeds less than 250 knots. These UAVs can be hand or catapult launched and can perform for RSTA and ISR missions due to their payload capabilities such as EO/IR cameras and laser range finder and designator. These UAVs can provide medium endurance and require a direct line of sight from the Ground Control Station(GCS). Like group 1 UAVs, group 2 UAVs are challenging to detect by radars and can deliver CBRN substances and small munitions. Examples of the use of small tactical UAVs with lethal payloads are direct attacks conducted by ISIS using small munitions(grenades) carried by commercial drones in Mosul, and the drone swarm against a Russian Air Base in Syria in 2016.

Group 3: tactical UAVs, larger than group 1 and 2. Their MTOGW can reach 55 pounds, with a flight altitude below 18000 feet MSL at speeds less than 250 knots. This group of UAVs requires more logistics to operate but can provide more endurance and flight time. Also, the range of payload capability is more extensive and can include different kinds of sensors such as EO/IR cameras SAR radars, moving target indicator, relays of communications, SIGINT, sensors for hazardous substances detection, laser designator and range finder. This group of UAVs can carry weapons, but this will limit their endurance.

Group 4: larger than previous groups, this group of UAVs need more massive logistic support and require a runway for launch and recovery almost like crewed aircraft. Also, this type of UAVs has an extended range and higher altitudes of flight compared to group 3. Group 4 can be considered a strategic group of UAVs due to the large variety of payloads that can perform missions like ISR, target acquisition, SIGINT, moving target indication, target designation. The maximum altitude of this group of UAVs can reach 18000 feet MSL at any speed.

Group 5: this group of UAVs has an MTOGW that exceeds 1320 pounds and can operate higher than 18000 feet MSL at any speed. This group is the largest group of UAVs, which are purely strategic drones. Due to their large size, group 5 requires runways for launch and recovery. Large UAVs can carry a multitude of payloads that can provide excellent targeting capabilities and precise targets engagement. Until now, only a few countries possess strategic drones, and non-state actors do not own them yet. Contrarily to small UAVs, group 5 UAVs can be detectable with anti-aircraft assets.

Figure 6. Different Types of UAVs

Source: Drone Lab 2016.

Among the five groups of UAVs, groups one and two are the most abundant and difficult to detect due to their low price and easiness of use and carry. Moreover, small drones are proved to be possessed and used by non-state actors as small munitions delivery tool. To focus more on the subject of UAVs proliferation, we will take a look at the leading manufacturers, sellers, and buyers, and also the drones' hot market.

Research Part 2: Main Manufacturers and the RPAs' Market

Main Manufacturers

According to UAV Global, among 450 drone manufacturers in the world, two-thirds are focused on military UAVs. The first countries in the military UAVs' manufacturing are the USA, Israel, and China. However, many other countries like Iran, Pakistan, Turkey, and South Africa are seeking the way to join the game of drone technology.

The US

The US has currently around 20 manufacturers of military UAVs from small to strategic. Due to the increased use of UAVs during the last decade, the US military research organization increased the range of research to introduce new capabilities such as drone swarming, jet-powered unmanned systems, and improved long-endurance UAVs. During the last two decades, the United States has used technological growth to improve its UAVs' capabilities in terms of range extension, strike capacity enhancement, and fleet enlargement. The US drones' companies have the necessary technical knowledge and the developed infrastructure that allow them to conduct in-depth research and development of sophisticated UAVs and to lead the world market in drone technology (Boyle 2015).

According to the article "The Proliferation of Drones Changes in size, intelligence reframes questions of use" of Peter W. Singer, the US military currently possesses more than 8000 UAS in its inventory. Totally, US drone companies develop around 20 types of UAV. The following is a listing of the famous UAVs' companies in the United States: 3DRobotics: American company (HQ in Berkeley, California) that produces consumer UAVs, quadcopters, and fixed-wing UAVs. The 3DR Solo is an autopilot quadcopter made by 3DRobotics. Its dimensions are 33cm long and 23cm wide and 18.8 cm high. Its weight is 1.5kg without the basket and 1.8kg with his basket. This small drone can fly 20 to 25 minutes with a lithium-polymer battery of 5200 mAh.

AAI Corporation: Produces crewless aircraft and ground control technologies, simulators and training systems, and armament systems. AAI is one of the producers for the DoD and the allied foreign government.

Shadow 200 Tactical UAS or RQ-7B, is one of AAI Corporation products in addition to the UAS Shadow 400 and Shadow 600. The AAI RQ-7 Shadow and other Shadow drones performed more than 920,000 flight hours (as of 2014) from it 90% were in support of the US Armed Forces and its allies' in the operations conducted in Iraq and Afghanistan. Shadow can perform flights from 6 to 9 hours of endurance, with a maximum speed of 110 knots and a maximum altitude of 15,000 feet.

Figure 7. RQ-7 Shadow in Flight

Source: Wikipedia 2018.

General Atomics: although specialized in nuclear research, General Atomics design and develop Remotely Piloted Aircraft for the US military and other clients worldwide. The most known product of GA-ASI (General-Atomics Aeronautical

Systems, Inc) is the Predator characterized by its high endurance of 24 hours, its service ceiling of 25,000 feet, and its maximum speed of 117 knots. The US had used Predator RPA series in Kosovo, Afghanistan, Iraq, Yemen, Libya, and Syria.

Figure 8. Predator RPA Launching a Hellfire Missile

Source: Wikipedia 2018.

China

China has moved from a country that depends on other powers, such as the Soviet Union in military equipment, to an industrial nation. In the domain of Unmanned Aerial Vehicles, the Chinese industry started in the 1950s (Hsu 2013). The priority of the developed UAVs is equipping the PLA to perform missions of ISR, communications relay, targeting, and even electronic warfare EW. With the development of more sophisticated UAVs, their range of use extended to cover border security and maritime missions. In the last decade, China encouraged more research groups within and out of the department of defense to respond to the high demand of both civil and military customers. The latest UAVs developed by Chinese drone companies can flight to a high endurance, more extended range, and increased payload capacities (Hsu 2013).

Moreover, the Chinese UAVs' industry focused more on developing armed UAVs and unmanned combat aerial vehicle (UCAV). Both the civil and defense industry performs the research and development of UAVs. The most known research centers are: Civilian Research Centers: Beijing University of Aeronautics and Astronautics (BUAA): it considered one of the leading university in the field of aeronautical research. The development of UAVs in this University is mainly conducted in the Department of Aircraft Design. The research and development include rotary-wing aircraft, fixed-wing aircrafts, and UAV models. One of the famous UAVs designed by the BUAA is the BZK-005 which is a high-altitude and long-range reconnaissance UAV. The BZK-005 can reach a cruising speed of around 170 km/h and a service ceiling of 8000 m with a maximum payload of 150 kg and an MTOGW around 1,200 kg. Its endurance can reach 40 hours and it normally works at an attitude between 5 and 7 km (see Figure 9).

Figure 9. BZK-005

Source: Wikipedia 2018.

Nanjing University for Aeronautics and Astronautics (NUAA): is a key research and development center of UAVs in China (Hsu 2013). Specialized in tactical UAVs, the NUAA is considered the first research center to develop a rotary-wing and a high-altitude UAV in China. The unmanned helicopter LE 110 is one of the drones designed by the NUAA.

Northwest Polytechnical University – Xi’an ASN Technology Group: specialized in the development of small, tactical, and short range UAVs. Xi’an ASN Technology Group is one of the main providers of UAVs to the PLA and has delivered over 1,500 small and short range UAVs. Also, statistic showed that Xi’an ASN group has developed over 40 different type of UAVs during the last 50 years for both civilian and military use. The ASN group developed the ASN-207 which is a long-range UAV later succeeded by the satellite-based data link and long-endurance (8 to 16 h) and longer-range (600 km) ASN-229A with the capability of targeting (able to carry and fire air-to-ground missiles). ASN-207 is known by its mushroom-shaped antenna (see Figure 10).

Figure 10. The ASN-207 Parade

Source: Kania 2017.

Defense Industry Research Centers: Chengdu Aircraft Industry Group/Chengdu Aircraft Design Institute: has developed the Yilong/Pterodactyl 1 MALE UAV in the mid-2000s to perform ISR missions as well as meteorological operations (see Figure 11).

Figure 11. Picture of the Yilong/Pterodacty, also Known as the Wing Loong Graduation Photo

Source: Hsu 2013.

Guizhou Aircraft Industry Corporation (GAC): developed a copy of the US RQ-4 Global Hawk UAV named the Xianglong/Soar Dragon. Xianglong UAV can perform ISR missions and also battle damage assessment, in a high altitude and long endurance. Shenyang Aircraft Company/Shenyang Aircraft Design Institute (SAC): has designed and developed The Anjian (Dark Sword) UCAV model to escape radar detection. This model is a supersonic-capable UAV that can carry air-to-air missiles. SAC also designed the Zhanying (Warrior Eagle) to perform SEAD (suppression of enemy air defense) missions.

China Aerospace Science and Technology Corporation (CASC): the CASC Academy of Aerospace Aerodynamics is the designer and developer of the CH-3

Unmanned Combat Aerial Vehicle. This model of UAV can perform missions such as intelligence collection, reconnaissance missions, indirect fire adjustment, communication and data relay, strike missions, and EW missions.

The drones' companies mentioned above are not all the existing companies in China; many other companies are active in the field of UAVs development from small low endurance to extensive high range and endurance ones.

Israel

The Israeli UAV industry dates to the 1970s. Since that date, the Israeli drone companies have worked on improving the qualities and capabilities of the UAVs they manufacture. The development on the field of UAVs led Israel to be the most significant world exporter of drones with total revenue of more than 4 billion dollars. What differentiates the Israeli UAV industry form other countries are the high quality and the low cost of products. The future drone projects for the Israeli companies are the development of air fighters UAVs, mini-satellites UAVs, solar energy UAVs, and fully programmable UAVs.

The leading drone companies in Israel are:

Israel Aerospace Industry IAI: famous UAVs: Pioneer (with the USA), RQ-5 Hunter (with the USA), Heron family of the long-endurance unmanned aerial vehicle (UAV), Harpy, Eitan, I-View, Harop, Ranger, Scout, Searcher, Bird-Eye family of mini-UAV, Panther, and Ghost.

Elbit systems: famous developed UAVs: Elbit Hermes 90, Elbit Hermes 450, Elbit Hermes 900, Elbit Skylark, Silver Arrow Micro-V, and Silver Arrow Sniper.

Aeronautics: is a lead company in the field of unmanned solutions. Aeronautics Produces unmanned platforms, payload, and communications capabilities for both military and civil use. Aeronautics produces drones that can fulfill ISR missions and offer an operational solution for information collection. Dominator XP is one of the UAVs of Aeronautics designed as MALE UAV (Medium Altitude Long Endurance) to provide a strategic solution for ISR missions at long ranges. The Dominator can carry a multitude of payloads together (multipurpose payload) such as EO/IR camera, SAR radar, Communication Intelligence (COMINT), Electronic Intelligence (ELINT), Magnetic Anomaly Detector (MAD) and other sensors. Its maximum payload weight is around 373 kg (Aeronautics Group 2019). The essential features of the Dominator are its automatic take-off and landing and its autonomous mission programmable flight capability.

Figure 12. Dominator XP MALE UAV of Aeronautics

Source: Aeronautics Group 2019.

Other Countries

Although lead countries like the US, China, and Israel dominate the UAVs market, many other countries are seeking for a chance to join the market of drones in terms of manufacturing and selling. The new emergent countries in the field of unmanned aerial systems present an alternative for many states unable to purchase drones from the lead countries of the market. Although the primary reason for these countries to enter the drone manufacturing market is to serve to equip their military, exporting their products to many other countries is a fact that will contribute to enlarge the drone proliferation in the world. In the following, we will review the most known states to be new emergent in the UAVs' market.

India: currently, the Indian UAVs development aims to satisfy the increased demand of Indian's armed forces. Under the lead of the Defense Research and Development Organization (DRDO), the Aeronautical Development Establishment (ADE), the National Aerospace Laboratories (NAL), Hindustan Aeronautics Limited(HAL), and Bharat Electronics Limited (BEL) are research organizations that have working in the development of UAVs with ISR, targeting, and guidance capabilities. The Rustom-II is a medium altitude long endurance UAV dedicated for ISR missions and can carry different types of payloads (EO, SAR, Maritime Patrol Radar MPR, radio altimeter, COMINT/ELINT payloads, and satiation awareness payloads) up to a weight of 350kg. Rustom-II is a runway-launched and recovered UAV.

DUE TO COPYRIGHT RESTRICTIONS,

IMAGES ARE NOT INCLUDED

IN THIS ELECTRONIC EDITION.

Figure 13. Classification of Indian Unmanned Aerial Vehicles

Source: Janes 2018.

India has built an experience in the development of different categories of UAVs such as the tactical UAV Nishant, the mini UAV Imperial Eagle (IE), the quadcopter Netra, and the MALE UAV Rustom. The future projects of the DRDO consist of improving some of its current platforms, develop other versions of the Rustom MALE UAV (Rustom II and Rustom-H as an unmanned combat air vehicle) (Janes 2018).

Although the Indian DRDO has a remarkable experience in developing UAVs, especially small and medium categories, India still depends on the drone market to face the increased demand of its Armed Forces. The Indian plan for the next ten years includes purchasing more than 5000 UAVs (over 3 billion $ of spending) of different categories: Mini/micro, tactical, vertical take-off and landing, MALE, and HALE UAVs (Noronha 2017). Moreover, India and the UK are ranked the significant importers of Unmanned Aerial Systems internationally. (according to the SIPRI's arms transfers database and Statista). From 1985 to 2014, India holds 22.5% of the world drone imports, but this percentage decreased to 13.2% in the years from 2010 to 2014 due to the private investments in the field of UAVs (New America).

Currently, India does not seem to influence the drone market even though it is investing more and more in building its UAV industry.

Pakistan: like its neighbor, Pakistan is seeking to build its UAV industry to face the emerging threats on the region. The difficulties in procuring MALE and HALE UAVs such as the US MQ for strategic reasons influence the Pakistani ambition in the drone industry. The major manufacturers of drones in Pakistan are NESCOM and SATUMA. NESCOM is the developer of four types of drone that include a CUAV, and SATUMA is the producer of seven other models, but it focuses more on the target UAVs. In addition to these two major companies, Global Industrial Defense Solutions (GIDS) develops four other UAVs dedicated for the Pakistani Armed Forces to use in ISTAR missions. The future program for the GIDS is to design the MALE version of the UAV Shahpar, which can perform ISTAR missions, situational awareness, and disaster managing missions. The famous Pakistani drones are the Burraq of the NESCOM, a Combat UAV armed with a laser-guided missile, the Uqab II of the GIDS, a tactical short-range UAV that can reach 10000 feet of altitude and 150 km of range (Zwijnenburg and Postma 2018).

Iran: Iran has used the captured UAVs from other countries like the USA in their two types of drone captured, the RQ-170 captured in December 2011 and Scan Eagle captured in September 2013 as models to copy and launch its drone industry. The Iranian UAVs currently in use by the Air Force are the Ababil, a tactical UAV dedicated to surveillance missions at short to medium range, and the Shahed-129, a MALE UAV that is likely copied off the US Predator MQ-1 (Zwijnenburg and Postma 2018). Iran has also developed the Mohadjer UAV series to include the armed version named the Mohadjer-6 that can carry and fire four guided bombs. The Mohadjer-6 is believed to be similar to the US RQ-170 Sentinel.

Turkey: The Turkish government policy set an objective to reduce the dependence on external powers. In the case of the Turkish Armed Forces, the orientation is to build a private industry that can equip the forces with the necessary equipment. The government gave authorization to a program that expands the UAV program and permits the production of powerful drones. The ambition of Turkey does not stop at the level of equipping the Armed Forces, but it boosts its efforts to join the world's major UAV producers (Zwijnenburg and Postma 2018).

The famous UAV systems manufactured in Turkey are: the MALE Bayraktar TB2 (see figure 13) which is an armed drone that can fire smart small munitions as well as anti-tank missiles, the UAV fixed wing Alpagu and the UAV rotary wing Kargu which are classed with the category of loitering munitions able to conduct Kamikaze attacks on light vehicles and personnel. The advantages of these small UAVs are their limited time needed for deployment with only one operator and their ability to detect-track-identify targets.

Figure 14. The Turkish Armed MALE UAV Byraktar TB2

Source: Zwijnenburg and Postma 2018, 28.

South Africa: South Africa has been developing drone technology since 1970 when the Council for Scientific and Industrial Research (CSIR) developed the small surveillance UAV named Champion, which is a small UAV used for surveillance. South African current UAVs are the ATE Vulture: designed by the Advanced Technologies and Engineering also known as the Paramount Advanced Technologies, the Vulture can be operated without requiring a runway for flight and recovery and is a fully automated UAV in terms of launch, operation, and return to base. The Seeker 400: used mainly for ISTAR missions but can also perform tasks like artillery fire support, EW, and ELINT with a possibility to mount 25 kg precision-guided munition.

Russia: The Russian development of UAVs is currently limited to small and tactical UAVs dedicated to surveillance missions. The development of MALE and HALE UAVs is presently in the phase of prototype production for the Altair and the Altius UAVs and in the testing phase for the Orion-E which is expected to be ready for use by 2020. Sukhoi, a Russian arms producer, lead another ambitious plan that consists of the development of the Okhotnik inspired by the US X-47B. The approximate time for this plan to be realized is also by 2020.

The RPAs' Market

Main Sellers

As we stated before, the USA, China, and Israel are dominating the UAVs market. Israel alone holds around 60 % of the world UAVs' supply between 1985 and 2014 (Stockholm International Peace Research Institute). (see figure 14)

In total, Israel exports drones to at least 42 countries such as Canada, China, India, Indonesia, Russia, Germany, France, Brazil…etc.(see Figure 15)

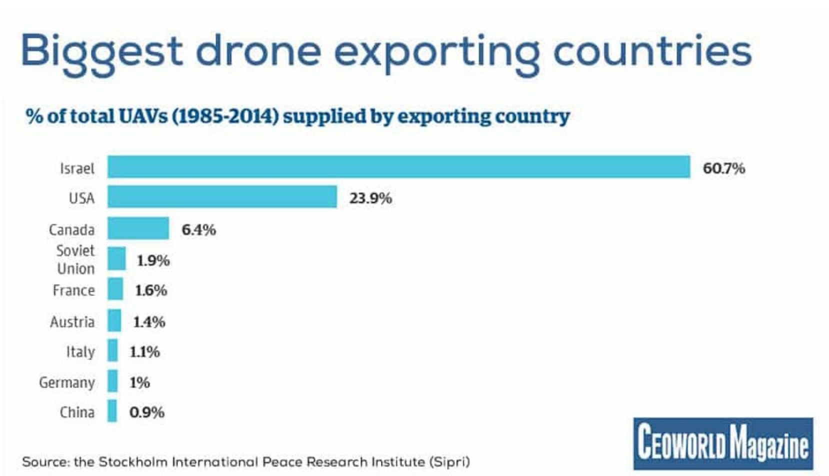


Figure 15. Biggest Drone Exporting Countries

Source: The Stockholm International Peace Research Institute.

Figure 16. Countries that Export UAVs

Source: New American.

The United States comes the second in terms of drone exporting by 23.9 %, followed by Canada by 6 %. In the list of the first ten drone exporters, China is rising with its evaluating technology, especially in small UAVs.

Main Buyers

The United Kingdom and India head the list of main buyers of UAVs. The United Kingdom is importing around 33.9% of the total world drones (from 2010 to 2014) and is one of the leading importers of Israeli drones. Although the UK produces small UAVs, the base of this production is on the imported Israeli drone Hermes 450. Also, the UK is the only country that exports the US armed Reaper and is working on arming a MALE UCAV, developed under a contract signed with the US General Atomics company, with the UK manufactured missiles Brimstone2 and laser-guided bombs Paveway IV (www.newamerica.org n.d.).

India comes second in the list of UAVs importing countries with 13.2% of importation. This percentage used to be around 22.5% between 1985 and 2014, but it was decreased in the statistics measured between 2010 and 2014 because India started to build its UAV industry and successfully tested its Rustom-II MALE Unmanned Combat Arial Vehicle in 2016(see Figure 17).

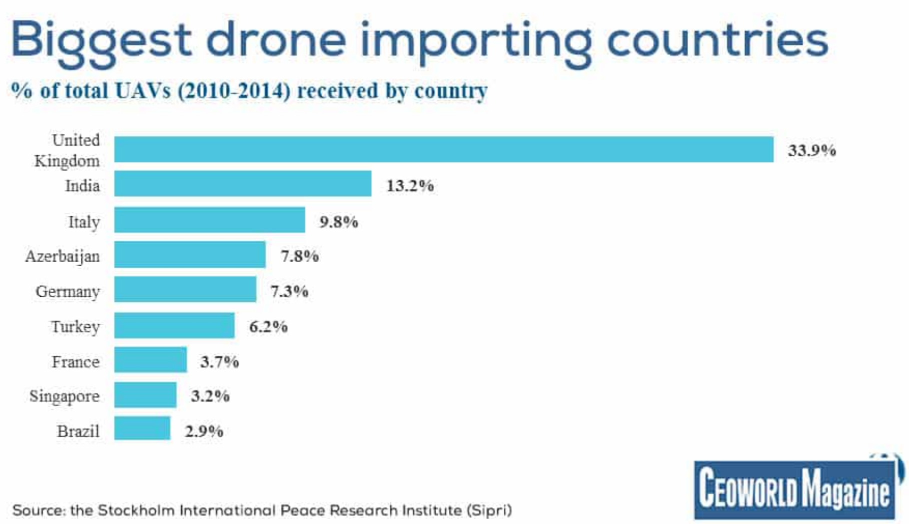


Figure 17. Biggest Drone Importing Countries

Source: The Stockholm International Peace Research Institute.

The following table recapitulates the list of both exporters and importers countries:

Table 2. Drones Importers and Exporters

Drone Exporters	Drone Importers
Armenia-Australia-Austria-Belarus-Canada-China-Estonia-France-Germany-Israel-Japan-Malaysia-Netherlands-Russia-Singapore-South Africa-South Korea-Sweden-Turkey-United Arab Emirates-United States	Algeria-Angola-Australia-Austria-Azerbaijan-Belarus-Belgium-Bolivia-Botswana-Brazil-Burundi-Canada-Chile-China-Colombia-Croatia-Cyprus-Denmark-Ecuador-Egypt-Estonia-Ethiopia-Finland-France-Georgia-Germany-Greece-Hungary-India-Indonesia-Iraq-Italy-Ivory Coast-Japan-Jordan-Kazakhstan-Kenya-Lebanon-Libya-Lithuania-Malaysia-Mexico-Morocco-Myanmar-Netherlands-new Zeeland-Nigeria-Pakistan-Panama-Peru-Philippines-Poland-Qatar-Republic of Serbia-Romania-Russia-Saudi Arabia-Singapore-South Korea-Spain-Sir Lanka-Sweden-Switzerland-Taiwan-Thailand-Turkey-Turkmenistan-Uganda-Ukraine-United Arab Emirates-United Kingdom-United States-Uzbekistan-Vietnam-Zambia

Source: Created by author.

Non-State Actors

The drone technology cannot be limited to certain users due to its low prices and easiness of use. In addition to many governments, several non-state actors owned small UAVs and used small commercial drones in surveillance missions and had armed them to deliver IEDs to designated locations.

ISIS: in addition to a lot of weapons, ISIS also conducted arms traffic in the category of unmanned aircraft and recruited young engineers to introduce some modifications on drones like quadcopters and small fixed-wing UAVs to attach small munitions to them. Unlike other extremist groups, ISIS currently has access only to small commercial UAVs and not to military ones. In 2017, the military headquarters of ISIS established a new unit responsible for drones and its use against some targets. As an example of the use of commercial modified UAVs, in October 2016 ISIS used small drones armed with explosives against Kurdish forces in northern Iraq. Although the Kurdish forces shot down the attackers' drones, they couldn't stop them from detonating and killing two of their soldiers. The incident happened when the soldiers tried to tear down a captured drone assumed to be just a surveillance UAV, but it blew up in their hands, killing two of them (Schmidt and Schmitt 2016).

Houthi Rebels: unlike ISIS, the Houthi Rebels group received small military UAVs from Iran and used them alongside with some commercial modified drones in intelligence missions and attacks against the Arab Coalition Forces and the Yemeni government. The latest attack occurred in January 2019 and targeted a government military parade in Al-Anad airbase north of Aden to kill seven and injure 11 people.

The UAV named "Qasef-1," a copy of the Iranian UAV "Ababil-2," is a suicide drone that the Houthis Rebels use against Saudi led coalition, and it can carry 30 kg of explosive. In addition to the Iranian help, the Houthis claimed that they had manufactured their drones (four types of drones) to use in surveillance and suicide missions.

Hezbollah: was the first non-state actor to use UAVs for surveillance in the Israeli airspace in 2004. Their first military UAV was named the Mirsad1 and is a short-range surveillance drone. In 2006, Hezbollah launched the armed Ababil UAVs that was shot down by the Israeli forces. Hezbollah also used commercial drones armed with small munitions for suicide missions against rebel groups in Syria. Besides ISIS, Hezbollah, and the Houthi rebels, other groups claimed their possession of UAVs or at least commercial small drones to use in surveillance missions. These groups are Jabhat al-Nusra in Syria, Libyan Rebels, the Kurdish Peshmerga, Faylaq al-Sham, and the Revolutionary Armed Forces of Colombia.

In conclusion of research part 2, we can say that UAVs are now a very accessible technology and its proliferation is at least hard to completely stop since many countries entered the field of manufacturing as the first step and exporting as a second step. The drone market is getting more abundant with new emerging unmanned ambitions such as India, Iran, South Africa, and other countries. Indeed, the proliferation of all types of UAVs and especially of small ones will have impacts on both current and future warfare.

Research Part 3: Impact of RPAs' Proliferation in Current and Future Warfare

In this research part, we will focus on the possible impacts of the UAVs' proliferation in modern as well as future warfare. At the end of this research part, we should be able to come up with a relevant conclusion about the real threat that goes with the proliferation of UAVs and an understanding of the future complex environment that planners should take into consideration.

Impact of UAVs Proliferation in Modern Warfare

In the study of the impact of UAVs in modern warfare, we will focus on the advantages they added to armed forces as well as the disadvantages they also have to finish with highlighting the change they caused to modern warfare.

Advantages

As an emerging technology, the UAV technology offered many advantages to both ground and air forces. The main advantage consists of reducing the pilot's life risk which is an advantage for an air force that has reduced the number of the dangerous reconnaissance missions they used to conduct using rotary and fixed-wing crewed aircraft. Related to the life risk-reducing, the use of UAVs also allowed ground forces to perform tasks under continuous surveillance that provides a real-time video of situational awareness which gives them a position of relative advantage over the enemy. Additionally, UAVs can be used in dangerous, contaminated (CBRN), and close areas to the enemy's well-defended points (Glade 2000).

The new generations of Combat Unmanned Aerial Vehicles CUAVs have many beneficial capabilities such as target acquisition, laser designation, and range finding. These capabilities give the air and ground forces significant superiority over the enemy and can also limit collateral damages by finding, tracking, and engaging the desired target. Moreover, for a soldier, a small UAV (Group 1 and 2) can be very useful to the point of being a lifesaver, especially while conducting recon in unfamiliar areas. As an example of the use of drones, the US special forces have employed drones in Afghanistan to have permanent surveillance over some suspect buildings to track all movements in and out of them. This tactic proved efficiency in monitoring and engaging "Taliban bomb-making networks." (Drew 2010)

Conducting such a mission with a crewed aircraft would be very dangerous and could risk the crew's life besides possible collateral damages in case of engagement and difficulty in attending the desired results for the US forces.

The UAVs from Group1,2 and 3 are hardly detectable by air defense radars and can carry small munitions, which gives an advantage for the user to utilize them in close range to conduct surveillance and attack missions. Small drones' swarm is an example of the use of this type of UAVs.

The long list of UAVs advantages does not mean that this emerging technology does not have disadvantages.

Disadvantages

First of all, UAVs operate in a known range of communications (known from the manufacturer without the precision of the working frequency) that can be jammed using cheap software. Second, large UAVs which are relatively expensive can be detected by AD radars and can even be shot down and destroyed. Also, in some cases, if a UAV is captured, there is a possibility that the enemy copies it and build his manufacturing of drones. Another disadvantage of UAVs is that most of them are of light weights and cannot resist to tough weather thing that can limit their capabilities and reduce their reliability.

Some of the large rotary wing UAVs are noisy and can be detected and heard from the ground. Also, small electrical-engine UAVs have low endurance and can only operate under eyesight of the operator.

Lastly, although the use of armed drones has reduced collateral damages, their use in the counterterrorism war is still creating tension among the population, especially when mistakes happen in target designation or engagement.

Change in Modern Warfare

The use of UAVs and UCAVs, like other technologies, has played a significant role in shaping modern warfare. It is evident that 21st-century warfare has differences from previous combat. The advance in technology pushed many countries to think about changing their way of engaging the enemy. For instance, the use of unmanned combat aerial vehicles in the current war on terror is a new way of closely engaging the enemy without risking soldiers' lives. This way is believed to be cheaper and less risky than the use of crewed aircraft (Rousseau 2012).

The drone technology has a crucial role in the change of the strategies used in modern conflicts. A new range of maneuvers emerged with the manufacture of a variety of UAVs that can provide planners with a multitude of solutions to tactical problems. The relatively new solutions include different ways of information collection, continuous battlefield surveillance, and high-value targets engagement. Some argued that new technologies could only change the "face of warfare" and not its fundamentals (Guest 2011).

This point of view can be confirmed by the theory of the Revolution in Military Affairs (RMA) noticed after the Gulf War consisting of a necessary change in the conduct of war. The example of the US can clearly illustrate the role of RMA and precisely the part of the new technology of drones and armed drones such as the Reaper, in shifting the conduct of warfare offering more choices for strategists to wage war with more precision and less collateral damages (Guest 2011).

Moreover, the UAV technology presented the key to success for the US forces in the operation they conducted to find and kill "Osama Bin Laden." In addition to the change drone technology had added to modern warfare from a strategic perspective, another change consists of the cost of war. The use of UCAVs limited the costs of missions in terms of personnel and equipment and also time and decisiveness.

Impact of UAVs Proliferation in Future Warfare

Characteristics of the Future Operating Environment

The study entitled "the Operational Environment, 2035-2050: The Emerging Character of Warfare" named the period of future that goes from 2017 to 2035 by "the Prelude Period" and characterized it by the race between strategic competitors in weapons and new operational concepts to utilize them in the emerging conflicts. The study mentioned that the presence of more ideological motivation that creates terrorists and empowered people would accentuate the OE's complexity. The evolution of the off-the-shelf commercial technologies and computer-based industry will increase the proliferation of weapons (TRADOC 2017). By 2035, the competition between countries about limited resources will be growing remarkably (DCDC 2015). Also, the increasing of terror-attacks sponsored by states, proxy wars, and cyber-attacks will impact the complexity of the OE. Another factor that will continue to shape the operating environment is that of the non-state actors, along with multinational partnerships and NGOs. Differently, from the current situation, cooperation between states and non-state actors will take place due to shared interests. Now in term of the operating environment, the urban environment will gain more complexity always due to widespread of new technologies. Technology will also continue to drive military ambitions of both state and non-state actors, and the fields of increasing innovations will be primarily the Artificial Intelligence AI.

Furthermore, the biological race will be something to worry about along with the innovations in nanotechnology (Rousseau 2012).

The main characteristics of the future operational environment are mainly derived from the trends of the current operational environment and consist of competitions in almost all domains (the word competition is the light version of saying conflicts) due to the high ambitions of actors in one hand, and the diminution of resources in the other hand. Additionally, the development in technology characterizes future OE by a fantastic speed that goes beyond what an average human can bear. Battles will be very fast to conduct using laser systems, robots, and other computer-based weapons. But because of contested domains, decisiveness will not be guaranteed for any part of conflicts. Another characteristic of future OE will be the unstoppable proliferation of Weapons of Mass Destruction. Although the current situation of nuclear weapons, the significant WMD so far, is not changing remarkably; we can expect more ambitions of some countries besides Iran and North Korea to possess atomic and non-nuclear mass destructive weapons. As we are now at the beginning of the era of hybrid conflicts, we expect them to be one of the essential characteristics of future OE. The contested domains and the increased competitions over limited resources will influence the combination of regular and irregular combatants.

Impact of Drone Proliferation

In a report for the JCS published in June 2018, Jeffrey Smith- a Managing Editor of National Security- stated that the efforts to control the increasing proliferation of UAVs through the control of exports has failed and the development of new types more powerful of drones is drastically increasing. The number of countries that develop and export UAVs is rising very quickly. The proliferation of drones capable of carrying WMD is not the only issue that we should worry about, especially when we know that the spread of small UAVs is also increasing more easily and quickly due to low prices and the possibility of transforming commercial drones to military ones. Adding the fact of the unstoppable proliferation of drones to the characteristics of the future EO we have mentioned above, we can guess how important will be the role of UAVs in the future. The first impact will be the use of drones' swarms already tested by countries like China and used by non-state actors like ISIS against a Russian air base in Syria in January 2018. Second, with the expected complication of the urban environment, UAVs will play a crucial role in surveillance and attack of empowered individuals and leaders. The race for nanotechnology in the future climate will push forward the development of Nano-drones harder to detect and able to carry and deliver chemical and biological substances.

As part of the future technological development, UAVs and intelligent UAVs will play an essential role in shaping future warfare through more sophisticated capabilities. This research part analyzed the impact of UAVs proliferation in modern and future warfare in order to gather all data needed for planners to start considering radical changes in their planning methods based on known inputs and external factors, to finally reach the desired end-state which is "plan in a complex OE characterized by a vast proliferation of UAVs".

Research Part 4: How should we plan for operating in a complex battlespace with a vast proliferation of RPA technology?

Based on the research part 1 about the categories of drones, the immediate threat seems to be on the first two groups that hold small UAVs. This does not mean that larger

UAVs aren't a threat to our forces on the ground and sensitive facilities. But what makes the risk a bit limited is the fact that small UAVs are hardly detectable by radars and air defense equipment. In this research part, we will attempt to find a coherent answer to the first research question, which is how planners should plan in a complex battlespace with the vast proliferation of UAVs?

The first step for us to answer the research question is to build an understanding of the threat for both commanders and subordinates, and then the second step is to try to propose a way of mitigation of the danger. Finally, we will conclude this research part by a transition to finalized recommendations for the CDM in chapter 5.

Understanding the Threat

What Leaders and Soldiers Need to Know

Maneuvering and static forces usually can't know if someone is watching them from above or not. So UAVs can use this opportunity to do full-time surveillance and deliberately attack ground forces. The quick proliferation of Small UAVs due to their low cost will make things more complicated, and if we consider conventional forces or non-state actors, there will be no significant difference except for more training for conventional forces although extremist groups are now attracting engineers and well-educated people that can easily accept training in drones' operations.

In the market, commercial drones that are sold range from cheap toys to sophisticated small UAVs, but also relatively inexpensive. Moreover, for a few hundred dollars, you can order your drone from Amazon or other sellers. There is no real control on the market that limits selling or buying this technology, but in some countries owning drones is somehow controlled via registration.

To understand the threat, we should be able to know what types of drones, users, payload capabilities, and cybersecurity we are facing. The danger will be variable and goes from no threat, minimum to medium, and high risk. The data presented in figure 18 can be helpful to understand the UVAs' threat more.

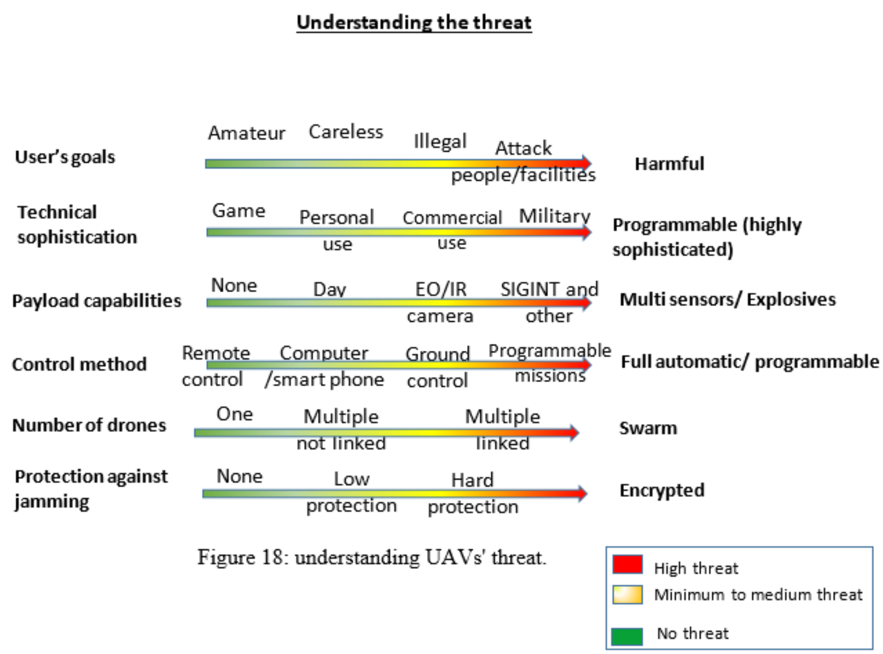


Figure 18. Understanding UAVs' Threat

Source: Created by author.

Possible Challenges

Planners need to be aware of many challenges related to drones' characteristics to succeed in countering the threat of UAVs. Among these challenges, we can list the following:

1. Small UAVs can fly in low altitude and are not detectable by AD assets because they are sometimes confused with large birds;
2. Soldiers can have less awareness about searching for UAVs flying above them;
3. Many soldiers are not trained on drones' recognition, which makes the mission of early alerting formations difficult. The vast proliferation and the race for manufacturing small UAVs will create more challenge in their identification due to the emerging new designs;
4. The counter-UAVs training is not a priority for every unit, and the plans for opposing hazards is not updated to include new generations of drones.

How can UAVs threaten our bases?

In this paragraph, we try to define all possible ways of threat a UAV is capable of: ISR: the primary mission of a UAV is to provide intelligence, surveillance, and reconnaissance using the method of "Orbiting" over the target while carrying sensors like cameras, SIGINT, radars…etc. Small drones are also able to deliver sensors to designated places to provide permanent information to the owner.

ISR can be provided by a drone before the execution of a mission, during an attack in the form of coordination and target designation, and after completion of an offense for battlefield assessment.

Electronic War: UAVs can be used to conduct EW and jamming of sensitive communication stations.

Conventional and non-conventional weapons' delivery: Small UAVs can carry and deliver munitions and explosives to designated locations. The most dangerous threat of UAVs is that they can carry chemical, biological, radiological, and nuclear agents, which can cause massive panic and perturbation to the military bases and the public.

Additionally, there are some considerations that a commander needs to know about the UAVs' threat:

1. A UAV does not work separately, but it is linked to a Ground Control Station, and it transfers data via different ways of communications that can be either encrypted or unencrypted;
2. A UAV can be used as a Kamikaze that is assigned a mission to disrupt, delay, or destroy targets;
3. Most UAVs depend on GPS for positioning and targeting and utilize Radio Frequencies bands for communication and commands receiving.

Small drones usually fly in a limited range, and for a low endurance, for this reason, they will be flying not far from the operator or the GCS (Lamport and Scotto 2012).

Mitigation

In this part, we will use the method of Operational approach that lays together the current state and the desired End-state, with the problem solving presented in forms of lines of efforts LOEs that converge to objectives.

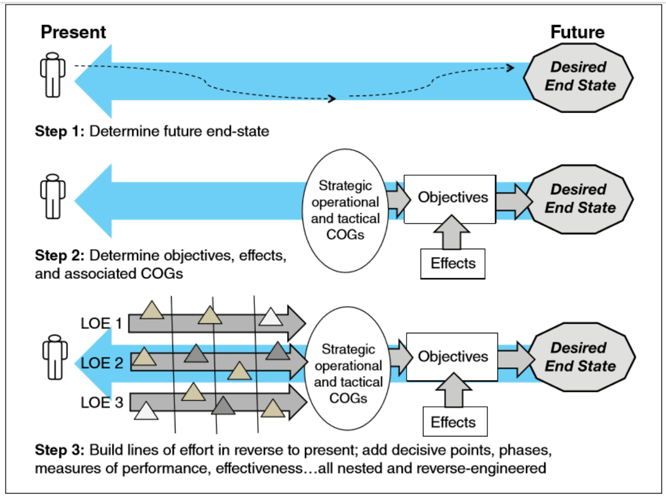


Figure 19. Operational Approach Explanation

Source: Zweibelson 2016, 29.

The first step consists of determining the desired End State then the partial objectives that will lead to its achievement. These partial objectives are the Ends of each line of effort, and the lines of effort can be determined based on the understanding of the current situation and the possible shortfalls and gaps.

We will start filling this graphic backward from the desired End State.

End state: planners can develop an effective plan in a complex environment characterized by a vast proliferation of small UAVs.

LOE#1: Doctrine: include C-UAS in the joint doctrine; build a new agile and responsive concept of operations that employs counter-UAV systems; emphasize C-UAS intelligence.

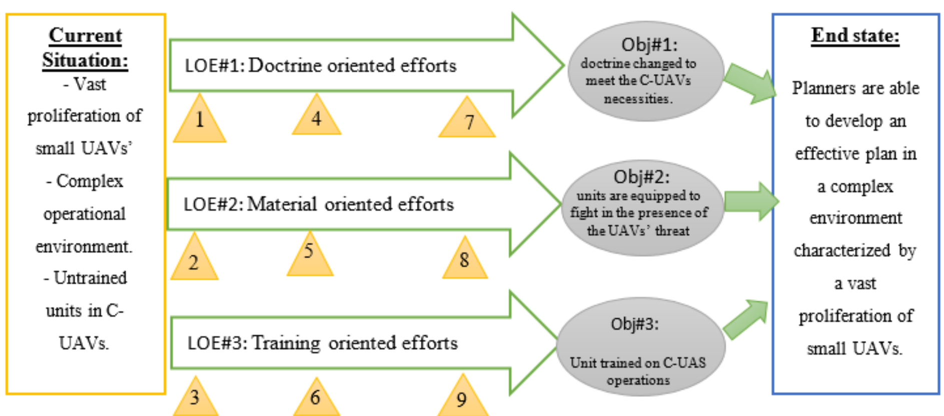
Obj#1: Doctrine changed to meet the C-UAVs necessities.

LOE#2: Material: procure liable counter UAS systems; Equip vulnerable facilities with early UAV's detection systems; equip maneuvering units with counter drone systems.

Obj#2: units are equipped to fight in the presence of the UAVs' threat and vulnerable facilities are protected against undetectable UAVs.

LOE#3: Training: Introduce a C-UAS training to vulnerable units' training programs, Introduce and emphasize UAVs' recognition training from company level above, Train trainers and participate in multinational exercises.

Obj#3: unit trained on C-UAS operations and soldiers are able to earlier recognize an enemy UAV.



1: include C-UAS in the joint doctrine 2: procure liable counter UAS systems 3: Introduce a C-UAS training to vulnerable units' training programs	4: build a new agile and responsive concept of operations that employs counter-UAV systems 5: Equip vulnerable facilities with early UAV's detection systems 6: Introduce and emphasize UAVs' recognition training from company level above	7: emphasize C-UAS intelligence. 8: equip maneuvering units with counter drone systems. 9: Train trainers and participate in multinational exercises.

Figure 20. UAVs' Threat Mitigation Operational Approach

Source: Created by author.

Summary and Conclusion

This chapter aimed to answer the primary research question and provide the CDM with coherent recommendations. Chapter 4 was divided into four research parts; each one of them is related to a research question. The first three research parts provide the reader with an answer to the three secondary questions. The necessity of answering the questions related to definition, categories, impact in modern warfare, and impact in the future warfare of UAVs is that it could help to narrow down the subject and to understand the real threat of UAVs. In the last research part, we tried to answer the primary research question: how can planners plan in a complex environment where there is a vast proliferation of UAVs? The answer started from an understanding of the threat where we put forward some challenges and considerations; then it was ended by the mitigation part where we used the method of Operational Approach that presents the current situation and the desired End-state connected by three lines of effort. The summary of the whole research paper, as well as the final recommendations, will be presented in chapter 5.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Evaluation of the Research Questions

The purpose of conducting this research was to answer the first research question, which is: How should planners plan in a complex battlespace with a vast proliferation of UAVs?

To answer this question and all the secondary questions, we conducted a review of the existing literature and analyzed the findings relative to each question. We divided the research into four research parts, and each one covered a research question. The analysis that we have done in chapter 4 started from broad to narrow: from general information about UAVs to specific information related to their impact in modern and future warfare. Based on the conclusions made in each part, we framed the problem and fixed an End-state to reach after the mitigation of the threat of drones' proliferation.

The conclusions of all research parts will be presented in this chapter (chapter5), followed by a summary of the recommendations made to the CDM to help him mitigating the current and future threat relative to the vast proliferation of UAVs. It is evident that the recommendations presented will not cover all possible risks, therefore, a suggestion for further research will be necessary at the end of this research.

During the research part 1, we attempted to provide the reader with a good definition of an Unmanned Aerial Vehicle so that he can differentiate between the subject of this research and other types of unmanned vehicles such as crewless ground vehicles. Also, we provided the reader with a coherent categorization of drones using that one presented by ATP-03-1-8. This categorization divided the UAVs into five groups based on size, endurance, altitude, and payload capability. The relevance of this research part was that we were able, after a study of each category, to narrow the research and focus on the first two groups to limit the threat to specific types that can present more risk than the others.

Following research part 1, we started research part 2 by gathering data about the UAVs' market and the leading manufacturers, exporters, and importers to clarify the picture of drones' proliferation around the world. We also highlighted the non-state actors that are known to possess and use UAVs. This research part gave us an idea about the drones' market leaders that are mainly three countries: The United States, Israel, and China. However, some other countries like India, Iran, and South Africa are seeking to enter the race of Unmanned technology by their ambition to build their own drone's industry. The answer to the second question about UAVs' manufacturers and the market will give us more depth in the study of the impact of UAVs in modern and future warfare subject of the third research part.

In the study of the impact of UAVs' proliferation in modern warfare, we highlighted the advantages and the disadvantages of the use of UAVs so that we can figure out the possible changes in modern warfare. UAVs have many benefits such as reducing the pilot's life risk, offering an extensive range of mission capabilities, and providing real-time surveillance for ground forces as they maneuver. However, UAVs have some disadvantages, such as the operation in a known range of communications that make it vulnerable to jamming operations. Also, some types of UAVs are detectable by AD radars and can be captured and even copied by the enemy. Another essential disadvantage, especially for small drones, is the weather sensitivity because of their lightweight, which can limit their reliability.

The use of UAVs implied changes in modern warfare by giving commanders the capability to closely engage the enemy even in hazardous OEs such as contaminated areas and to have continuous surveillance that provides the needed intel for IPB. Moreover, the option of target acquisition and engagement offered by UCAVs has good implication in terms of limiting collateral damages and accomplishing strategically valuable operations. As a change in modern warfare, the use of UAVs helped governments reduce the cost of the war in both money and lives compared to the use of crewed air vehicles.

After examining the impact of UAVs in modern warfare, we studied the possible effects of UAVs' proliferation in future warfare. Our research started by giving the reader an idea about the characteristics of the future Operational Environment which will be characterized by an increased race to possess sophisticated technologies, a high ambition of state and non-state actors to use unmanned technology, and an unstoppable proliferation of Weapons of Mass Destruction. Along with the increased technology development and the spread of new types of technology, new types of small drones able to carry and deliver small munitions will emerge in the market and will be available for both state and non-state actors. Small UAVs will play a crucial role, especially in a complex urban environment with their ability to provide real-time surveillance and High-Value Targets engagement. The importance of this research part is to give the reader with a clear vision about the role of drones in modern warfare and its possible role in the future war, considering the possible changes in the operational environment.

The last research part aimed to answer the first research question, which is: how should planners plan in a complex battlespace with the vast proliferation of UAVs?

We started this research part by an understanding of the threat as a base of solving any problem. The research and review of the existing literature led us to some vital conclusion about the nature of the danger we are facing. In fact, not every drone flying can be considered a threat to our forces and facilities and units should be able to judge whether the risk is high, medium, or low. The judgment depends on the type of payload, number, and sophistication of drone used, the intent and type of user (amateur/professional, intel collecting plan). Also, a part of understanding the threat is knowing the possible challenges that commanders may face in countering drones. The answer to the primary question was conducted using the method of "Operational Approach," which starts from a current situation to reach a fixed End-state. The mitigation part consists of the lines of engagement LOEs that lead to set objectives. To narrow the research, we only used Doctrine, Training, and Material from DOTML-PF. We will present the recommendations in the next part of this chapter.

Recommendations

The table below recapitulates the recommendations concluded from the research parts studied in chapter 4.

Table 3. Recommendations for the Chief Decision Maker

DOTMLP-F		Short term (2 to 5 years)	Long term (more than 5 years)
Doctrine	Must do	Review of joint doctrine to include the use of C-UAS systems in the current anti-terrorism doctrine.	Rewrite the doctrine to meet future challenges and changes in warfare
	Should do	Develop an agile and responsive concept of operations to employ counter-UAV systems.	
	Nice to do	Emphasize the role of intelligence in the C-UAS doctrine.	
Training	Must do	Introduce a C-UAS training to vulnerable units' training programs.	Train every soldier on C-UAS.
	Should do	Introduce and emphasize UAV recognition training from company level above.	Train and build a quick response team against UAVs' threat in every unit
	Nice to do	Train trainers, participate in multinational exercises that involve counter drones operations	integrate c-UAS courses in military schools such as NCOs' schools, military academies, and staff colleges (field grade officers).
Material	Must do	Equip vulnerable facilities with early UAV's detection systems: Radars, sensors, UAVs, cameras…	Equip maneuvering units with counter drone systems.
	Should do	Build an autonomous systems of alert.	Keep an up to date about unmanned technology and the suitable C-UAS technologies.
	Nice to do	Minimize smuggling of small Drones and cut the routes of supply for VEOs.	

Source: Created by author.

Suggestions for Further Research

This research paper focused on understanding the UAVs' proliferation threat and attempted to present some recommendations to mitigate the problem related to this threat.

With the rapid increase in the development of drone technology, the development of Counter-Drone systems is also increasing. Indeed, the best way to mitigate the risk of UAVs attack is to install autonomous systems of early detection and awareness that can buy time for forces to engage or at least to take cover. However, opening fire on a "kamikaze UAV" will be useless and even dangerous in case it carries Chemical or Biological substances. Jamming might be an option but needs to be executed automatically because any delay will complicate the situation.

Further study will be required in the area of choosing the most suitable solution among the existing C-UAS systems in terms of effectiveness. When will engaging an assaulting drone be useful? What type of C-UAS systems could be effective at least for short and mid-term planning? What is the best way to oppose a drone swarm in an urban environment? These questions can be subjects for further researches, from both technical and tactical point of view. The most dangerous situation regarding small drones' attacks is the "Drones' Swarms" (add to definitions) which defined as an attack using many UAVs together controlled by a unique GCS or many GCSs linked together. Previous studies have been conducted about drones' swarms, but this risk still needs further concern especially with the appearance of new capabilities of payloads that could give more solutions to the attacker and fewer opportunities to the defender.

My Lessons Learned

During the year I have spent in SGCS, I learned many lessons in both my general course and my MMAS research.

First, during the general course, I learned that a leader needs many things to be a good leader and his skills and talent that he might have, should be emphasized with the leadership theories that he has to learn. Also, from the History classes, I learned how to look at historical events from a tactical lens and evaluate important decisions that famous leaders made in critical situations. The fact that History classes brought up two different types of school-thoughts, those of Clausewitz and Jomini, is very beneficial because it mixes different thoughts and helps to use critical thinking and fixed principles in decision making.

Second, during my MMAS research, I learned how to manage time between gathering data and writing the thesis effectively. Also, a fundamental lesson that I learned is related to possible biases that could hinder the research process. In fact, in my research, I certainly had a bias related to the subject of my study, and I couldn't progress in writing the thesis before I got rid of it.

Conclusion

Although UAVs have many advantages that can contribute to mission success for commanders and subordinates, the threat related to their unstoppable proliferation is tremendously increasing as new off-the-shelf drones are becoming more and more available for both state and non-state actors. The real problem is related to the spread of small UAVs that can carry and deliver small munitions and IEDs. Precisely, being undetectable is the issue about these small drones that planners should take into consideration. In the end, we can say that we should worry about drones' proliferation, and we should be prepared to face the changes in the future operational environment, which is getting more and more complex.

REFERENCE LIST

Aeronautics Group. 2019. "About Aeronautics. " https://www.aeronautics-sys.com

Bento, Maria de Fátima. 2008. "Unmanned Aerial Vehicles: An Overview." *InsideGNSS:* 54-61.

Birmingham Policy Commission. 2014. *The Security Impact of Drones: Challenges and Opportunities.* Edgbaston, Birmingham: University of Birmingham.

Boyle, Michael J. 2015. *The Race For Drones.* Philadelphia, PA: Foreign Policy Research Institute.

Creswell, John W. 2014. *Research Design.* Thousand Oaks, CA: SAGE Publications, Inc.

Development, Concepts and Doctrine Centre (DCDC). 2015. *Strategic Trends Programme Future Operating Environment 2035.* United Kingdom: Ministry of Defence.

Drew, Christopher. 2010. "Drones Are Playing a Growing Role in Afghanistan." *The New York Times*.

Ewers, Elisa Catalano, Lauren Fish, and Michael C. Horowitz. 2017. *Drone Proliferation Policy Choices for the Trump Administration.* Washington, DC: Center for a New American Security.

Fladeland, Matt, Susan Schoenung, and Mark Lord. 2017. "UAS Platforms." White Paper prepared for NCAR/EOL Workshop-Unmanned Aircraft Systems for Atmospheric Research, February.

Franke, Ulrike Esther. 2014. *Drone Proliferation: A Cause for Concern?* Switzerland: International Relations and Security Network.

Glade, David. 2000. *Unmanned Aerial Vehicles: Implications for Military Operations.* Maxwell Air Force Base, AL: Air University.

Guest, Jenna. 2011. "Advancing Weapons Technology and the Future of Warfare: Strategic, Legal and Ethical Perspectives." Master's Thesis, University of Canterbury, Christchurch, New Zealand.

Hallen, Travis. 2016. *Drones and the Future Air Warfare (Review).* New York: Routledge.

Headquarters, Department of the Army (HQDA). 2017. Army Techniques Publication 3-01.81, *Counter-Unmanned Aircraft System Techniques.* Washington, DC: Government Publishing Directorate.

Hsu, Kimberly. 2013. "China's Military Unmanned Aerial Vehicle Industry." Staff Research Backgrounder, U.S.-China Economic and Security Review Commission, Washington, DC, June.

Istituto di Ricerche Internazionali Archivio Disarmo. 2017. *Military Drones: Proliferation Or Control?.* Rome: Istituto di Ricerche Internazionali Archivio Disarmo.

Janes. 2018. *Flying High: India's Indigenous UAV Programmes.* Englewood, CO: IHS Markit.

Kania, Elsa. 2017. *The PLA's Unmanned Aerial Systems New Capabilities for a "New Era" of Chinese Military Power*. Maxwell AFB, AL: Air University.

Kanner, Lise. 2016. *The Efficacy and Legality of Drones in Modern Warfare*. ePublications.

KappenMan, Jeffrey. 2008. "Army Unmanned Aircraft Systems: Decisive in Battle." *Joint Force Quarterly*, no. 49 (April): 20-23.

Kardasz, Piotr, and Jacek Doskocz. 2016. "Drones and Possibilities of Their Using." *Journal of Civil & Environmental Engineering* 6, no. 3 (January): 1-7.

Kreuzer, Michael P. 2016. *Drones and the Future of Air Warfare: the Evolution of Remotely Piloted Aircraft.* New York: Routledge.

Lamport, Jeffrey, and Anthony Scotto. 2012. "Countering the UAS Threat from a Joint Perspective." Joint Deployable Analysis Team, Eglin AFB, FL.

New America. 2019. https://www.newamerica.org.

Noronha, Joseph. 2017. "The Age of Drones: All You Need to Know about India's Attempts to Produce Unmanned Aerial Vehicles." *Swarajya*. February.

Pant, Atul. 2018. *Aerial Drone Swarms: The Next Generation Military Weapon.* New Delhi: Institute for Defence Studies and Analyses.

Rousseau, Richard. 2012. "Modern Warfare and Its Evolving Weapons – Assumptions and Inherent Contradictions." *Eurasia Review*.

Scharre, Paul. 2014. *Robotics on the Battlefield Part II The Coming Swarm.* Washington, DC: Center for a New American Security.

Schmidt, Michael S., and Eric Schmitt. 2016. "Pentagon Confronts a New Threat From ISIS: Exploding Drones." *The New York Times*.

Singer, Peter Warren. 2013. “The Proliferation of Drones Changes in Size, Intelligence Reframe Questions of Use.” *Internationale Politik*: 8-14.

Stjelja, Mirela. 2013. *The Case Study Approach: Some Theoretical, Methodological and Applied Considerations.* Australia: Land Operations Division.

U.S. Army Training and Doctrine Command (TRADOC). 2017. *The OE Environment 2035-2050 The Emerging Character of Warfare*. Fort Eustis, VA: U.S. Army Training and Doctrine Command.

U.S. Army UAS Center of Excellence Staff (CoE). 2010. *U. S. Army Roadmap for Unmanned Aircraft Systems 2010-2035: Eyes of the Army*. Fort Rucker, AL: U.S. Army UAS Center of Excellence.

Wen, Gerald Goh Qi. 2015. “Unmanned Aerial Vehicles and the Future of Airpower: a Technological Perspective.” *Pointer, Journal Of The Singapore Armed Forces* 43, no. 2:45-57.

Zwijnenburg, Wim, and Foeke Postma. 2018. *Unmanned Ambitions: Security Implications of Growing Proliferation in Emerging Military Drone Markets.* The Netherlands: Open Society Foundations.