THE SOUTH AFRICAN AIR FORCE (SAAF), UNMANNED AIRCRAFT SYSTEMS AND NATIONAL SECURITY: AN EXPLORATORY STUDY

By

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DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own original work, that I am the sole author thereof (safe/save to the extent explicitly or otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Elizabeth May Allworth
March 2021

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Dear God,
I want to take a Moment, not to Ask for Anything,
But Simply, to Say
Thank You

Any errors of fact or interpretation that may be contained in this study, are entirely my own.

ABSTRACT

The proliferation of unmanned aircraft technologies, whether unarmed or armed, and the ease at which military, non-state actors, terrorists, extremists groups and organised crime syndicates can acquire drone technologies, are becoming an increasing threat on a global scale. Drones are here to stay, and will remain in the public eye for many years to come. The use of unmanned aircraft systems, referred to as drones is a highly relevant and emotionally debated topic all over the world. Most debates focus around the types of unmanned aircraft systems (UAS), unmanned aerial vehicles (UAVs) or drones available to various role players throughout the global community, whether they are armed or unarmed, the various ways in which they are used, the opposition expressed by various humanitarian groups, the lack of international regulations regarding the use of unmanned aircraft, the extreme pace of proliferation of technologically advancements in drones, artificial intelligence (AI) and 3-D technology, and the 4th industrial revolution (IR).

Of equal importance is the impact, threats and challenges which unmanned aircraft systems could possibly have on South Africa's national security, and on its neighbouring regions such as the Southern African Development Community (SADC). This, as background, compounded by the severe operational budget cuts with the implication that operational infrastructure, training and a military's capabilities cannot be maintained. The SAAF, like the SA Navy, is technology driven and requires the best technology money can buy to be an effective and efficient force multiplier. Taken the above budget restrictions and challenges into consideration, it is questioned whether the SAAF could provide prepared and supported air defence capabilities for the defence and protection of South Africa. Similarly, should unmanned aircraft systems in future pose a threat to SA, would the SAAF have the appropriate counter-measures to counter such threats?

This study explored the above-mentioned aspects regarding unmanned aircraft systems seen from a global and national level. The military, industrial and commercial aspects of unmanned aircraft systems are discussed. The aim of this study was to explore unmanned aircraft systems within the 21st century, and to identify the current gaps with regard to unmanned aircraft systems employment. In conclusion, the thesis presents recommendations for doctrine, policy and aviation safety in general.

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LIST OF ABBREVIATIONS / ACRONYMS

AI	artificial intelligence
AMAA	Aviation Management and Accountability Authority
ATE	Advanced Technology and Engineering (company)
AUAVs	armed unmanned aerial vehicles
CMR	civil military relations
COLREG	international regulations for preventing collisions at sea
CONOPS	concept of operations
COTS	commercial off-the-shelf technology
DOD	Department of Defence
DRC	Democratic Republic of Congo
Drone / UAV	drone and UAV (unmanned aerial vehicle) can be used interchangeably
ED	employment doctrine
EEZ	exclusive economic zone
GDP	gross domestic product
IHLs	international humanitarian laws
IOT	internet of things
ISR	intelligence, surveillance and reconnaissance
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
MOD&MV	SA Minister of Defence and Military Veterans
NATO	North Atlantic Treaty Organization
NGO	non-governmental organisation
OEM	original equipment manufacturer
PSO	Peace Support Operations
RPAS	remotely piloted aircraft systems
SA	South Africa
SA CAA	South African Civil Aviation Authority
SADF	South African Defence Force

SANDF	South African National Defence Force
SMEs	subject matter experts
UAAV	unmanned armed aerial vehicle (UAAV) that carries a payload
UAS	unmanned aircraft systems
UAV	unmanned aerial vehicle
UCAS	Unmanned Combat Aircraft Systems (American terminology for unmanned armed vehicles that carry a pay load)
UN	United Nations
US (USA)	United States of America
UUVs	unmanned underwater vehicles
WMD	weapons of mass destruction

DEFINITION OF MAIN CONCEPTS (GLOSSARY)

In the course of this thesis, numerous concepts and definitions are relevant. In order to assist the reader, I chose to introduce the reader to the main concepts and definitions that frequently appear in the course of the discussion.

The concepts and definitions to be used for the purposes of the study are the following:

”Cat 9 "Unmanned aerial vehicle" ("UAV") – Any "aircraft" capable of initiating flight and sustaining controlled flight and navigation without any human presence on board.” (Wassenaar Arrangement (WA) Secretariat, 2018: 235).

4th IR – is the Fourth (4th) industrial revolution. “The fourth industrial revolution is a vaguely defined term used to refer to a variety of technological changes and innovations that have occurred since the beginning of the 21st century, with potentially dramatic effects on economy and society. It is characterised by increased automation of working practices, effecting both low and middle skill jobs, greater connectivity, machine learning and developments in new and emerging technologies, occurring at a considerably faster pace than in preceding industrial revolutions” (Ward, 2016: 2).

Aircraft – The South African State Aviation Safety Programme (SASP) defines an ‘aircraft’ as “any machine that can derive support in the atmosphere from the reactions of the air, other than the reactions of the air against the earth’s surface” (SA CAA, 2017: 3).

Armed drones/UAVs – “Armed Unmanned Aerial Vehicles (UAVs), often referred to as drones, are defined as aircraft designated to operate without a pilot on board. Armed UAVs carry ordnance and are remotely controlled by a human from the ground and are not fully autonomous” (Geneva Academy’s Weapons Law Encyclopedia).

Belligerent – hostile and aggressive. A nation or person engaged in war or conflict, as recognised by international law.

CAA or SA CAA – is the South African Civil Aviation Authority (SA CAA) which is South Africa’s national aviation authority. It governs investigations for aviation accidents and incidents and has an oversight function over civil aviation. (South African Civil Aviation Authority).

CMR – Civil Military Relations – “encompass the whole array of interactions and relationships between the Armed Forces and different segments of society in which they co-exist and operate” (Ngoma, 2006: 4).

Extremist – is a person who holds extreme political or religious views, especially one who advocates illegal, violent, or other extreme action.

FAA – the Federal Aviation Administration (FAA) is the United States' national aviation authority. It controls all civil aviation aspects such as air traffic management, airports and certification of aircraft and personnel (Federal Aviation Administration).

ICAO – is the International Civil Aviation Organization (ICAO) of the United Nations. It is located in Canada and oversees the total framework for international air navigation (International Civil Aviation Organization).

IEDs – An improvised explosive device (IED) is a type of unconventional explosive weapon that can take any form and be activated in a variety of ways. They target soldiers and civilians alike. In today's conflicts, IEDs play an increasingly important role and will continue to be part of the operating environment for future North Atlantic Treaty Organization (NATO) military operations. NATO must remain prepared to counter IEDs in any land or maritime operation involving asymmetrical threats, in which force protection will remain a paramount priority. Improvised explosive device (IED) (NATO, 2018).

IOT – The internet of things, "commonly abbreviated as IoT, refers to the connection of devices (other than typical fare such as computers and smartphones) to the Internet. Cars, kitchen appliances, and even heart monitors can all be connected through the IoT. And as the internet of things grows in the next few years, more devices will join that list" (Meola, 2018).

ISR – "Intelligence, Surveillance and Reconnaissance is a broad category of activities designed to support the battalion's intelligence development, planning, and decision-making. Intelligence, the product gained by analysing combat information for its relevance to the unit's mission, has always been critical to successfully accomplishing the mission" (www.globalsecurity.org).

ISTAR – Intelligence, Surveillance, Target Acquisition and Reconnaissance capabilities.

JARUS – Is the Joint Authorities for Rulemaking on Unmanned Systems The group aims at proposing harmonised regulation to cover all aspects of UAS operations (International Civil Aviation Authority).

Military – means relating to the armed forces of a country (https://www.collins-dictionary.com/dictionary/english/military)

Non-state actors – are the influential organizations or even individuals having the potential to influence the actions of state actors, but not allied to a state.

Remote warfare – "Western state-led operations which mark a shift away from 'boots on the ground' deployments towards light-footprint military interventions, involving a combination of drone strikes and airstrikes, special forces, private contractors, and military-to-military (M2M) training teams on the ground" (Demmers and Gould, 2018: 365).

Remote warfare – is also referred to as “liquid warfare”. “We see a resort to ‘liquid warfare’ as a form of military interventionism that shuns direct control of territory and populations and its cumbersome order-building and order-maintaining responsibilities, focusing instead on ‘shaping’ the international security environment through remote technology, flexible operations and military-to-military partnerships” (Demmers and Gould, 2018: 364).

RPA – is a 'remotely piloted aircraft' that means an unmanned aircraft which is piloted from a remote pilot station, excluding model aircraft and toy aircraft. (Department of Transport - Civil Aviation Act, 2009 (Act No. 13 of 2009) – Eight Amendment of the Civil Aviation Regulations, 2015 (RSA, 2015a).

RPAS – a remotely piloted aircraft system (RPAS) is the sum of the components required to deliver the overall capability and includes the pilot, sensor operators (if applicable), the aircraft, a ground control station, associated manpower and support systems, satellite communication links and data links (International Civil Aviation Organization).

RPAS – is a “remotely piloted aircraft system” which means a set of configurable elements consisting of a remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other system elements as may be required at any point during flight operation. (Department of Transport – Civil Aviation Act, 2009 (Act No. 13 of 2009) – Eighth Amendment of the Civil Aviation Regulations, 2015 (RSA, 2015a).

State actors – are the ruling governments of a state or a country

Terrorist – is a person who uses unlawful violence and intimidation, especially against civilians, in the pursuit of political aims.

Transnational threat – Any activity, individual, or group not tied to a particular country or region that operates across international boundaries and threatens United States’ national security or interests. (JP 3-26) (Office of the Chairman of the Joint Chiefs of Staff, 2020: 220).

UA – is an unmanned aircraft (UA which does not carry a human operator) (SA Civil Aviation Authority).

UAAV – is an unmanned armed aerial vehicle (UAAV) that carries a payload (International Civil Aviation Organization).

UAS – is an unmanned aircraft system (UAS) which is defined as a system, whose components include the unmanned aircraft and all equipment, network and personnel necessary to control the unmanned aircraft (ICAO).

UAV – is an unmanned aerial vehicle (UAV) which is a type of aircraft that operates without a human pilot onboard (Sometimes it is also referred to as a “drone”) (SA Civil Aviation Authority).

UAV – remotely piloted vehicle (RPV) – Drone. Unmanned aerial vehicle (UAV) – a powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload (Miasnikov, 2005: 6).

Researcher's definition of UAVs

Note: For the purposes of this study, the researcher defines drones, unmanned aircraft, or unmanned aerial vehicles (UAVs), or any other definition as is used globally in a military context, as an unmanned aircraft system (UAS).

CHAPTER 1: INTRODUCTION

1.1 Background

Drones or unmanned aircraft are here to stay, and will remain in the public eye for many years to come. During this study, the researcher became aware that the use of unmanned aircraft, referred to as drones is currently a highly relevant and emotionally debated topic all over the world. Most debates focus around the types of drones available to various role players throughout the global community, whether they are unarmed or armed and the various ways in which they are used. These debates further comprise the opposition expressed by various humanitarian groups, the apparent lack of international regulations, the lack of arms control regarding the use of unmanned aircraft (or drones), the extreme pace of proliferation, the technologically advancements in drones and the ease of access to drones. Compounding the issue of drones is the radical improvement in computer sciences such as artificial intelligence (AI), digital technology innovations such as 3-D technology, the internet of things (IOT), cyberwarfare, the advent of the 4th and 5th industrial revolution (IR) and the numerous other challenges related to cyber security, which became evident during the researcher's study.

The proliferation of unmanned aircraft technologies (unarmed or armed) and the ease at which the military, state actors, and non-state actors, terrorists, crime syndicates, extremist groups and belligerent forces can acquire drone technologies are becoming an increasing threat on a global scale. Sayler (2015: 5) stated that "we are living, increasingly, in a drone–saturated world" and further mentioned that "in recent years, drones or unmanned aerial vehicles (UAVs), have proliferated rapidly around the globe in both military and civilian spheres". Kreps (2016: 160) stated that the world is becoming inundated with drones and that it is a phenomenon that would keep increasing in the military, commercially and for recreation purposes.

Friese, Jenzen-Jones and Smallwood (2016: 10) from the Armaments Research Services (ARES) supported Sayler's and Kreps' views by stating that "the past decade has witnessed an explosion in the popularity, availability, variety and capability of small, remotely-piloted aerial vehicles designed and produced for the commercial market". The use of these technologies can provide non-state actors with advanced capabilities which offer tactical flexibility without the requirement for a complex support network, making them ideal force enablers for asymmetric and 'hybrid' conflicts". Gagaridis (2018) is similarly of the opinion that, besides their military application, drones can be used for asymmetric warfare and terrorist activities.

"In most cases, commercial off-the-shelf (COTS) small UAVs have been used by non-state actors to support intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) missions and information operations. This is partially due to a lack of strong communications and intelligence infrastructure amongst many armed groups, with UAVs offering a comparatively accessible and cost-

effective alternative to traditional military intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) platforms and systems" (Friese et al., 2016: 10).

Clarke (2018) is of the opinion that armed UAS/drones is increasingly becoming a concern for the present, and not only for the future. The fact that weaponised drones are used for combat by numerous countries, small groups or individuals, increases the likelihood that these sophisticated UAS/drone technologies can fall into the wrong hands. Countries which have used armed UAS/drones are for example Pakistan, Nigeria and Turkey (as indicated in Appendix A.1 and A.2). Furthermore, Clarke (2018) believes that with the dawn of artificial intelligence, UAS/drones may well become programmable, and smart enough to no longer require human involvement. Clarke (2018) is further concerned that commercial off-the-shelf technology that is freely accessible to the general public could be used for malicious purposes. One "nightmare" example cited and dreaded globally, "is the use of a small drone to deliver chemical or biological agents in an attack, to disperse deadly agents or viruses over a sports stadium or public gathering place" (Clarke, 2018). Such kind of UAS/drone attacks could cause psychological trauma, albeit there not been many casualties.

Friese et al. (2016: 57) indicated that sometimes the drones can be modified for direct offensive use when converted to carry improvised explosive devices (IEDs) or other arms and munitions. A wide range of these systems (IEDs) have in recent years been employed in conflict zones such as the Middle East and Ukraine. The drone itself can becomes the weapon, or the "small yet dangerous flying bomb" (Gagaridis, 2018). An example of such an IED attack is a previously reported incident where the Venezuelan president, Nicolaas Manduro, was attacked with an IED drone on the 5th August 2018 (Clarke, 2019; Gagaridis; 2019 and Griffin, 2018). Another example of improvised explosive devices are those that were used in 2016 "when Hezbollah used an explosive drone to attack an Israeli warship" (Gagaridis, 2018). One of the first incidents of a drone disrupting a public appearance by a head of state, dates back to September 2013, when the German Chancellor, Angela Merkel, was confronted by a drone from the opposing political party for a publicity stunt (Griffin, 2018).

Previously, drones (UAS) were "exclusive military technology" and "militant-controlled drones did drop bombs in Syria" (Franke, 2016). Franke mentions that civilian drone usage has increased rapidly and that non-state actors are flying these systems "across the world's hotspots" and that "ISIL has begun to pack its drones with explosives" (Franke, 2016). Franke is of the opinion that, as these flying IEDS become more sophisticated in future, they will continue to provide non-state actors with greater operational capabilities, and make it far more difficult for militaries to intercept in future (Franke, 2016). As stated by Griffin, with "flying IEDs (almost like a poor man's cruise missile), this is a whole new paradigm for security, and sadly, the era of drone terrorism has truly arrived" (Griffin, 2018).

Villasenor (2011) stated that "drones are already being developed and used in dozens of countries, and that global spending on the technology is expected to approach $100 billion over the next 10 years". According to Friese et al. (2016), "global arms sales for small UAVs for commercial and

consumer use had increased so dramatically, that global sales of civilian unmanned aircraft systems were expected to approach $5 billion USD in 2021" (Friese et al., 2016: 10). Kirve (2018) mentioned that "the global small drone market could reach $13.4 billion by 2023, according to an Allied Market Research" project which was conducted. Ludwig (2018) specified that commercial use of drones "has exploded over the last few years, and it's clearly on a trajectory to continue. Its global market is estimated to skyrocket to $127 billion in 2020". Reuters (2019) indicated that studies revealed that "the worldwide non-military drone market, dominated by manufacturers in China, will triple in size to $14.3 billion in sales over the next decade". Irrespective of the different growth rates, speculated in terms of drone sales, as mentioned by Villasenor (2011), Friese et al. (2016), Kirve (2018), Ludwig (2018) and Reuters (2019), it seems that there is a collective consensus between the authors that sales of global drones are likely to escalate in the years to come, which could conceivably create further national and international security risks.

All of the above-mentioned aspects currently do, and will continue to have, unremitting and far reaching effects worldwide. This could affect most global, national and local aviation communities. These aspects raise serious security concerns for South Africa, especially when considering the possible uses of weaponised UAVs or drones by businesses, civilians, state actors and non-state actors against South Africa (SA). A country can never be too assured that it will not be attacked by non-state actors, terrorists, extremists and belligerent forces, or not be prone to any criminal activities. Globally, the ease of access to cheaper more technological advanced drones from COTS products makes it easier for non-state actors and belligerents to acquire this sophisticated technology, and in so doing, are creating an increasing challenge and threat for governments around the world.

In this study the researcher addresses imminent and real future problems or threats that we are currently facing, or could face in the South African National Defence Force (SANDF), the South African Air Force (SAAF) and in South Africa, with regards to unmanned aerial vehicles or drones, as is currently the case globally.

1.2 Problem statement

In the future, South Africa could possibly face many challenges and threats from emerging technological developments in the global community, where militaries and other state actors have the required access and funding to develop their weapon systems. The fact that unmanned aircraft are so easily accessible to various actors, whether it is inexpensive COTS acquired technologies, or whether it is high-end military equipment being sold to non-state actors, should in itself be of major concern to South Africa. Across the world, and in South Africa, defence budgets are being cut. The SAAF has on numerous occasions encountered severe challenges regarding its operational budget, which was severely cut over the previous few years. The implication thereof is that operational infrastructure such as runways cannot be maintained appropriately and that only limited aircraft

spares can be purchased, which is of major concern to the SAAF. The SAAF's aviation fuel requirements have been cut by more than 50% and the lifespan of the Air Force's equipment has been shortened due to the fact that upgrades cannot be done on ageing aircraft. Similarly, aviation training and maintenance are also compromised. The problem faced by the SAAF is that depleted funding from National Treasury over the years has resulted in the SAAF having to 'juggle' priorities to make ends meet, consequently it is in a position where it has to focus on maintaining current assets/capabilities 'just in time' to keep functioning as a credible South African Air Force. This depleted funding leaves very limited room for research and development within the SAAF environment with regards to the uses and application of advanced technologies (Jacobs, 2019). The researcher is of the opinion that this is a very precarious position for any air force in the world to be in.

Similar sentiments are shared by the Military Balance (International Institute for Strategic Studies (IISS), 2019: 445) who states that, "years of economic underperformance" in South Africa has resulted in defence spending plummeting and that the "most significant cuts has been to those of the air force and the navy". This view is confirmed by Ramokgadi, Beukes and Liebenberg (2020: 149ff). The Military Balance further indicates that "the primary challenge facing South Africa's armed forces remains the mismatch between funding and commitments. It also makes it difficult to maintain equipment and facilities properly, let alone, close strategic capability gaps or replace old equipment" (IISS, 2019: 449).

An inadequate defence budget will in all probability result in a serious deterioration of South Africa's defence capabilities, according to Van Rensburg (2019) who reported that the Minister of Finance, Tito Mboweni, announced in his budget speech on the 21 February 2019 that he is planning to further decrease spending in government. His reasoning for taking this step was to focus on health and social development. Of the departments said to be cut are the security clusters of which the SANDF is one (see Figure 1.1). Figure 1.1 illustrates the budget allocations awarded to SA government departments and indicates the challenges that SA as a developing country is faced with. Of the 40 government departments in the public service in South Africa, the lowest paid department is that of higher education and training, followed by the Defence and Military Veterans who are the second lowest paid department on National Treasury's estimate of annual expenditure list. The Police Services are the third lowest paid government department (Van Rensburg, 2019). In the past, and presently, these "current funding levels, place in question the ability of the SANDF to meet the objectives of the review's first planning milestone – to arrest the decline in critical capabilities" (IISS, 2019: 447; Republic of South Africa (RSA), 2015: 9-14 and 9-16), let alone ensuring peace and security for Southern Africa, Africa and an unstable Southern African Development Community (SADC).

As mentioned in the SA White Paper on National Defence (RSA, 1996a: 20), the Constitution mandates the SANDF with the primary function "to defend South Africa against external military

aggression". The Chief of the South African Air Force is mandated "to provide prepared and supported air defence capabilities for the defence and protection of South Africa" (Department of Defence (DOD), 2018: 129). The South African Air Force (SAAF), like the South African Navy (SAN), is technology driven, and requires the best technology money can buy to be an effective and efficient force multiplier. Taking the above budget restrictions and challenges into consideration, the question is, would it be possible for the SAAF to deliver on its mandate? Or subsequently, should new alternatives (i.e. doctrine, policies and technologies) that adhere to the mandate, taking the continuous budget cuts into account, not be considered?

One of the greatest concerns is that of losing one's military capabilities, expertise and technologies, and becoming an obsolete and non-credible force in uncertain times. One can never be certain of what the future holds. As stated in the SA White Paper on Defence (RSA, 1996a: 17-18), "the SANDF has to maintain a core defence capability because of the inherent unpredictability of the future. Deterrence requires the existence of a defence capability which is sufficiently credible to inhibit potential aggressors. Such capability cannot be created from scratch if the need suddenly arises. Although South Africa is not confronted by any foreseeable external military threat, this capability cannot be turned on and off like a tap. It is therefore necessary to maintain a core defence capability".

The SA DOD Annual Performance Plan (DOD, 2018: 4) for the year 2017 similarly remarked that the "persistent disconnect between government's Defence expectations and the resources allocated to Defence, eroded capabilities to the point where the Defence Force will be unable to fulfil its Defence commitments". Based on the current poor economic situation, crime and corruption in South Africa, one could ask, is South Africa's human and national security not being threatened?

The problem escalates when the Department of Defence (DOD) is not financially equipped to adhere to its mandated roles. In addition, is the concern that advanced technologies like unmanned aircraft (unarmed or armed) are so easily accessible to various actors and non-state actors. This should be of primary concern to South Africa.

This study has attempted to answer the questions: How are UAVs (unarmed or armed) employed in the defence role internationally, and how could the future employment of UAVs in South Africa, in the SAAF, contribute to National Security? Consideration was given to counter-measures required by South Africa and the SAAF for possible threats emanating from foreign countries and non-state actors possessing armed UAV capabilities. As mentioned by Franke (2014: 121), countries with armed UAVs "remain more exclusive" and that it is only, according to her, the United States, the United Kingdom, Israel, China and Iran who have armed UAVs. Since 2014, this situation has changed with many more countries procuring drones. Taking budget constraints, proliferated technological advances, the 4th and 5th industrial revolutions, artificial intelligence, robotics and the new 5th dimension to warfare into account, the question to be answered is whether the use of UAVs or drones could be a cost-effective approach for South Africa and the SA Air Force, or not?

1.3 Aim of the study

This study explored the uses for unmanned aircraft (unarmed and armed) in a military role internationally as well as how unmanned aircraft can be used in South Africa by the SAAF in a defence capability and for national security purposes to counter possible threats, taking the changing nature of warfare, global asymmetric threats, irregular warfare and transnational threats into account.

1.4 Research question

The main research question was: How can the use/employment of unmanned (unarmed and armed) aircraft by the South African Air Force (SAAF) contribute to South Africa's national security?

In support of the question on how unmanned aircraft can contribute to South Africa's national security, the following questions supported the main research question:

- What is the international and domestic legal context that the SAAF should consider for the employment of drones/UAS? This question closely relates to main research question.
- Is there a significant domestic industrial base for drone development and production which the SAAF can draw on if they decided to employ drones? This question closely relates to the main research question.
- What threats/challenges could international proliferation of UAS technology (unarmed/armed) pose for South Africa's national security?
- Should UAS (unarmed/armed) pose a threat for South Africa, will the SAAF be in a position to counter such threats?

1.5 Research objectives

The objectives of this study were as follows:

- To explore the international and domestic legal context that the SAAF should consider for the employment of drones/UAS?
- To explore whether there is a significant domestic industrial base for drone development and production which the SAAF can draw on if they decided to employ drones?
- To explore what threats/challenges international proliferation of UAS technology (unarmed/armed) could possibly pose for South Africa's national security.
- To explore if UAS (unarmed/armed) pose a threat for SA and whether the SAAF is in a position to counter these possible threats.

1.6 Research methodology

1.6.1 Central theoretical statement

The employment of UAVs internationally and their use by the South African Air Force to assist with national security formed the basis for the central theoretical statement. This study analysed the use of UAVs in the military role internationally and where applicable explored security threats arising from the commercial use of drones. It further identified the various uses of UAVs to contribute to national security as an extension of the required capabilities of a defence force. In terms of the employment of UAVs in SA, national security was firstly explored, whereafter the role of UAVs in the SANDF was evaluated regarding its various employment capabilities to contribute to national security. The research questions were answered by means of a qualitative, descriptive and exploratory approach.

When defence matters come to the fore, the relations between a state and other states (i.e. especially where states pose a threat) are of great importance. The defence force of a country is the instrument employed to support foreign policy and to ensure security and defence diplomacy, as and when required (Liebenberg, Kruijt and Paranjpe, 2020: 11ff, 128ff, 131ff). As states are the main role players here, the theoretical foundation/assumption of this study was based on the theory of realism.

1.6.2 Execution of the research process

This research was approached from a realist point of view. South Africa and the South African Air Force should view the world around us with new eyes, from a new and fresh paradigm, as the increasing complex global environment we live in is creating more and more challenges and threats to our society and to the quintet of our national security.

According to Breakfast, Bradshaw and Haines (2015: 224-225) “there are two methodological approaches, namely qualitative and quantitative methodologies”. These authors further referred to research by Neuman (2006), who agreed that when using both methods (mixed-methods) the triangulation can be used to complement each method’s weaknesses and strengths. Babbie (2010) agreed that triangulation is “a valuable research strategy and in the best of all worlds, your own research design should bring more than one research method to bear on the topic” (Babbie, 2010: 118). The methodology used by the researcher was descriptive, qualitative and exploratory. Research was conducted utilising literature studies as secondary data. Interviews were conducted as primary data to support and/or to refute the literature findings. It was reckoned that interviews may end up snow-balling. Purposive sampling was chosen in the execution of this research project as the researcher wanted to interview knowledgeable people/experts/expert practitioners in the field (Babbie, 2010: 193). For this reason the researcher identified and selected such persons.

According to Neuman (2006: 196), “qualitative researchers consider a range of data sources and employ multiple measurement methods” to give fair, honest and balanced accounts by engaging different authors’ opinions on the research topic in order to ensure the data is truthful, valid, authentic

and not biased. The researcher attempted to create a close comparison between her ideas and understanding and the statements made by various authors as well as what is occurring in the social world, by means of deductive reasoning. Mouton (2005: 117) stated that deductive reasoning in science can take the form of conceptual explication where literary work is analysed to reveal its meaning. The researcher however used inductive reasoning for this study. As Neuman (2006: 60) stated, “to theorise in an inductive direction, you begin with observing the empirical world and then reflect on what is taking place, thinking in increasing more abstract ways, moving towards theoretical concepts and propositions”. The researcher conducted this study based on “observations on the ground” as indicated by Neuman (2006: 60) and in terms of what is occurring globally with unmanned (unarmed and armed) UAVs or drones.

An extensive literature study was conducted. The literature study was complemented by a qualitative research process through the execution of a series of personal interviews and focus groups depending on their availability.

Focus groups were used to gather a deeper understanding of the topic and to harvest more data on the topic. The value added by the focus groups as a qualitative research technique, is that members with different levels of expertise and disciplines could informally interact with each other. As a group, they could clarify specific complex questions/issues asked by the researcher which emanated from individual interviews. Furthermore, detailed explanations and understanding were provided, as members queried one another on specific topics (Neuman, 2006: 412).

The data which was gathered was divided into main themes and is discussed before presenting the conclusions.

Academic material and reputable internet sources were used, such as the Institute for Security Studies. Sources included books, chapters to books, accredited articles in subject related journals, reviews, reports and official documentation (where available and provided that these are in the public domain). Newspaper articles, defence journals and publications on the status of UAVs or drones, and their uses, were used for illustrative purposes.

The researcher aimed to interpret the data that was collected as indicated in the research methods by means of an exploratory approach and to describe challenges and/or threats which could emerge. Neuman (2006: 160) mentioned that a “qualitative researcher gives data meaning, translates them or makes them understandable”. Neuman (2006) stated that qualitative research focuses on real events. First, second or third order interpretation may be used to assign significance to the researcher theory. The researcher followed a qualitative approach by collecting as much relevant data as possible, interpreting it and giving it meaning. As stated by Mouton (2005: 148), qualitative studies aim to provide in-depth descriptions of a group of people or community. “Such descriptions are embedded in the life-worlds of the actors being studied” (Mouton, 2005: 148).

Basic fundamental research was used to build and expand the knowledge base regarding UAVs. Literature research, documents or textual data and personal interviews were used to obtain the required information. Maree (2018: 88) stated that “when you use documents (textual data) as a data gathering technique, you will focus on all types of written communications that may shed light on the phenomenon that you are investigating”. In this case, drones or UAVs comprised the phenomenon of research project.

Mouton (2005: 55) stated that “a research design is a plan or blueprint of how you intend conducting the research.” Creswell (2009: 3) similarly mentioned that designs are plans for a study and how the researcher’s project must be planned. Lategan, Lues and Friedrich-Nel (2011: 64) stated that the “research design refers to how one will approach the research project informed by the research problem and based on the existing research methodologies” or tools required to do the research. Babbie and Mouton (2001: 74-75) and Breakfast et al. (2015: 224) asserted that “research design is a blueprint of how you intend conducting the research”.

1.6.3 Data collection

The focus of this research was on relevant and credible literature studies. Information obtained from the different literature sources was compared for similarities and for contrast. The literature that was reviewed for information comprised open sources, published peer review articles, journals, published books and open and credible websites. No classified documents were used and only sources in the public domain were exploited. Sources used were from the library, the internet, books, journals, credible websites and various government publications.

1.6.4 Population sampling

The information was obtained from open sources and credible websites. The indications currently are that there are more subject matter experts (SMEs) outside the SANDF, with much wider knowledge than in the military. The latter was to be used if deemed necessary.

Specialist focus groups that were considered involved the entities who could be interviewed as part of the fact finding process. The list of possible interviewees was based on the time allowing for this, during the SDSP studies. The researcher had decided if the latter was not possible, only literature research would be done.

The following were considered as possibilities:

- The South African Air Force [The Chief of the SA Air Force (CAF), Air Force Command Post (AFCP), Directorate Command and Control (DC&C), and Directorate Aviation Safety (DAS)]
- The SA Navy (Naval Operations)
- Civil Aviation Authority (CAA)
- Paramount Advanced Technologies (PAT)

- Denel Dynamics
- Council for Scientific and Industrial Research (CSIR)
- Milkor (Pty) Ltd.

To prevent bias, the researcher strove to obtain different perspectives from individuals with different expertise and different viewpoints and experience. She trusted that this would add intersubjectivity and internal validity to the process and the end product.

1.7 Ethical considerations

By applying for, and received ethical clearance from the university, the researcher committed herself to abide by the international norms for ethical research as exercised by the scientific community and the university.

Before discussing the use of military UAVs in the SAAF, clearance was required with regard to the depth and width of detail that could be shared in this study. Once approval had been obtained through Defence Intelligence and the SAAF, discussions in this regard continued.

Ethical clearance for interviews with research participants was applied for at Stellenbosch University.

The norms of the international scientific community were adhered to and no individuals or institutions were harmed or hurt during this study.

During the research, only open (publicly available) sources were used. No classified documents were submitted. This study was restricted to the above material so access to this material can be obtained for future studies, if so required, at a later stage.

A confidentiality agreement as well as informed consent to use the data for publication was signed with all participants. Participants could join the process on a completely voluntary basis.

Individual's privacy was not violated, and the strictest anonymity/confidentiality was maintained if so required. Participants were granted the freedom, if they so chose, to withdraw from the project at any given time.

All individuals contributing to this research study have been acknowledged in cases where anonymity is not required.

Data will be safely stored for five (5) years (safekeeping of data), whereafter it will be destroyed.

Data was recorded in an appropriate and honest manner.

During interviews care was taken to record the candidates answers correctly.

Data was not be fabricated or manipulated during the research.

During the study and the reporting of the findings all ethical considerations were adhered to.

Permission from the employer and from the SU ethics committee was obtained before the researcher proceeded with the research (Defence Intelligence and SU approval will be sought).

Plagiarism has been avoided and all sources consulted and used are properly referenced as required by the norms and ethics of the international scientific community.

The researcher strove to be objective and report findings as objectivity as possible. Integrity was maintained throughout the research and findings were reported in a truthful and unbiased manner.

1.8 Limitations

- The limited publications available. One example is that only sources in the public domain could be used and no classified material is included.
- The excessive costs involved in obtaining credible sources of information from international books, journals and media houses.
- The limited research available in South Africa with regards to this unique perspective within a South African context.
- UAVs documentation and development are often classified. (Note: No classified documents were used. Only open source information available in the public domain was used).
- Language – only English documents could be researched.
- The lack of information from the military environment (due to the sensitive nature of projects) regarding the application or uses of UAVs in the SANDF. (Note: No classified documents were used. Only open source information available in the public domain was used).
- The research required for this thesis was limited by the timeframe allowed for by the SDSP Programme and added SDSP activities (limited time to do research).
- The possible envisaged planned and scheduled interviews (unstructured) by the researcher, with specialists and subject matter experts (SMEs), were dependent on the non-interference by the SDSP activities.
- The availability of the research participants in terms of their own work involvement and activities also posed challenges.

1.9 Significance of the study

The results of this study will contribute to an increased knowledge and understanding regarding the uses/application of UAVs or drones within South Africa's national security context. By identifying possible challenges and threats to South Africa, it could assist the SANDF (specifically the SAAF) to develop and employ the required rejuvenated doctrine via an Aviation Management and Accountability Authority (AMAA) – in the author's words, her own working definition. These results will allow the DOD, the SANDF and specifically the SAAF to evaluate the feasibility of employing

UAVs or drones as part of their revised strategic mandate and future military strategies. Similarly, the results could contribute to the countering of UAVs or drone threats to form part of the DOD's, SANDF's and the SAAF's revised strategic mandate and future military strategies.

This study is important specifically for the Air Force, which should be the controlling authority and custodian of tactical, operational, and strategic unmanned aerial assets, in the light of its air operations capability, and taking new, increasingly, proliferated global technological developments into account. The study is vital especially with regard to the SAAF and the SANDFs limited budget forecasts, the requirement for providing and/or establishing possible alternatives and maintaining a certain level of strategic capability. As stated earlier, of essence, is that South Africa requires an existing credible defence capability, one which "cannot be turned on and off like a tap" (RSA, 1996b: 17-18).

As stated in the Defence Review (RSA, 2015b), "an immediate intervention is required to arrest critical areas of decline in the Defence Force and to create a firm foundation against which an appropriate defence capability can be developed, to be able to sustain ordered commitments and have the capacity to respond to nascent challenges in the strategic environment" (RSA, 2015b: 9-14). And as stated in the Defence Strategic Trajectory, Milestone 4, "this must be pursued as the appropriate end–state for the Defence Force" in order that South Africa may be secure from strategic risks.

This study explored the impact that defence budget deficits could have on the defence aviation industry, the arms industry and the civil aviation industry. Cost advantages and opportunity costs could be implied for having such advanced UAV or drone technology as opposed to the opportunity costs the SANDF would encounter should it not have the capabilities and resources to defend itself against adversaries.

With regard to South Africa's national security, the protection of its citizens, its borders, and its exclusive economic maritime zone (EEZ), this research could assist with the recommendations/proposals for countering UAVs or drone challenges/threats to South Africa, thus improving the National Security environment of South Africa.

The findings and recommendations of this research project could be a significant contribution and of strategic value to the SAAF and to the national security of South Africa.

This study may also assist to point out gaps within this field of study, which may require further in-depth research.

As this was an exploratory study, a further study regarding the detailed and specific proliferated uses and consequences of unmanned aerial vehicles and unmanned aircraft systems (unarmed and armed) will be required.

This study may also indicate its “passé” by the time of publication, due to the rapid and proliferated rate of advances in unmanned aircraft systems, unmanned aerial vehicles, or drone technologies throughout the world.

In Chapter 2, the employment or uses of unmanned aircraft systems (UAS) within an international context is discussed.

Best-paid government departments

According to budget documents the average pay of public servants at national level varies massively. By 2022 staff at the economic development department will displace science and technology as the best paid. South Africa's long suffering university and college staff will remain the worst paid

Figure 1.1: Budget allocations for each SA department

Courtesy Van Rensburg 2020

CHAPTER 2: INTRODUCING DRONES IN A COMPLEX ENVIRONMENT

2.1 Introduction

In Chapter 1, the researcher introduced the concerns and challenges posed by the extremely fast-paced proliferation of unmanned aerial vehicles, or drones, which are available to virtually any member of the public. Mention was made of the consumer-off-the-shelf (COTS) products, which when combined with highly advanced technologies, have near endless uses and applications – positive or nefarious. It is evident that a country's or state's national security, or global security, could be threatened or be at risk. Knowledge of these increasingly advanced technologies needs to be embraced as a matter of priority. This chapter deals in detail with drones in a military setting on a regional, country-specific and global scale before international law issues are discussed. It is important to take note of the global drone environment and the latest developments to ensure a fuller picture or broader collage, for the reader as the international legal environment is not divorced from ongoing developments.

Imagine a scenario where "swarms of undersea, surface, and aerial drones are hunting submarines hidden in the vastness of the ocean. Or imagine, hundreds of airborne drones darting through New York City, seeking out targets, using facial recognition and dosing human targets with nerve agent" (Kallenborn and Bleek, 2019). Imagine micro insect drones tracking high value targets by attaching themselves to these individual's clothes or vehicles, or imagine listening to an "enemy's most sensitive conversations", or even worse, being injected with poison by a mosquito drone or wasp drone, while you are asleep. Imagine the "ultimate in low collateral damage stealth weaponry" (Aviationintel.com, 2012) where a swarm of mechanical mosquito drones could take out a high value target (HVT), instead of using Hellfire missiles to blow up a building, thereby hopefully minimising collateral damage. "These imaginary scenarios are not yet reality, but they are quickly becoming so" (Kallenborn and Bleek, 2019).

What are unmanned aerial vehicles or drones? What are they used for, and to what degree of innovation have they proliferated on a global scale? Before discussing the uses of unmanned aerial vehicles or drones in an international context, it is essential that the terminology to be used for unmanned aerial vehicles or drones, throughout this study, be placed in context.

2.2 Defining unmanned aerial vehicle or drone terminology

The terminology used for defining (unarmed and armed) drones, unmanned aerial vehicle (UAVs), unmanned aircraft systems (UAS), unmanned aircraft (UA), unmanned air systems (UAS), remotely piloted aerial systems (RPAS), remotely piloted aircraft (RPA), remotely piloted vehicle (RPV), or unmanned combat aerial vehicle (UCAV) or an unmanned armed aerial vehicle (UAAV) – can differ from country to country as a study of the literature has revealed.

According to the Centre for Security Studies in Zurich, the term ‘drone’ refers to all unmanned powered aircraft which can be used repeatedly (unlike missiles). De Neve (2013: 2) stated that the term ‘drone’ refers to all engine-driven unmanned aircraft that can be used several times (unlike flying projectiles). Abid et al. (2014: 2-3) state that unmanned aerial vehicles (UAVs) or drones, should not be referred to by these names, as most drones are not “vehicles” or are they “unmanned”. The author believes that the public should be made aware that drones do have human’s piloting them. For this reason they should be referred to as “remotely piloted aircraft or RPAs” (Abid et al., 2014: 2-3). Kock (2015: 116) stated that remotely piloted aircraft systems (RPAS) are popularly referred to as drones. In recent years, due to its military deployment in for instance Afghanistan and Somalia, the term drone conjures up images of deadly air strikes. In technical terms, Rouse (2019) describes drones as unmanned aircraft, although drones should correctly be termed as unmanned aircraft systems (UASes) or as unmanned aerial vehicles (UAVs). In essence, drones, or flying robots, are equipped with GPS, onboard sensors, embedded software systems controlling their flight paths, and onboard sensors that can allow drones to fly autonomously or be controlled remotely by a human on the ground (Rouse, 2019).

Franke (as cited by McKay, 2019), defined a drone “as an airborne vehicle which does not carry a human operator, and may be piloted remotely, follow a pre-programmed flight path, fly autonomously, or a combination of all three”. Drones can carry lethal or non-lethal payloads and can be recoverable. The distinction between (recoverable) drones and non-recoverable drones or vehicles, is that non recoverable vehicles such as artillery projectiles, ballistic vehicles or cruise missiles are not seen as drones (Franke, as cited by McKay, 2019). McKay (2019) stated that according to Franke, “drones are unmanned systems, that are mostly, not exclusively airborne”. Franke further indicates that a drone system consists of four elements, namely, the air vehicle, the support systems, the infrastructure and the operator or pilot. Firstly, the air vehicle carries the payload (i.e. camera). Secondly, a drone requires a ground control stations, an apparatus with which it can be launched, and a recovery system, as part of its support structure. Thirdly, for drones to function effectively, air bases, satellites and relay stations are important provisions for the infrastructure. Fourthly, operators or pilots are required to remotely pilot the vehicle, operate its payload, collect data or programme the drone’s flight path (McKay, 2019).

The Free Dictionary (Farlex, 2005), Miasnikov (2005: 6) and Tice (1991) have very similar definitions. They define UAVs as “a powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can carry a lethal or nonlethal payload, can be expendable or recoverable” (Farlex, 2005). Farlex (2005) agrees with Franke’s (McKay, 2019) distinction concerning non-recoverable vehicles. He includes semi-ballistic vehicles, which is similarly not seen as an unmanned aerial vehicles (Farlex, 2005). Tice (1991) states that UAVs are “designed to carry nonlethal payloads for missions such as reconnaissance, command and control, and deception”. When UAVs carry deadly payloads, they

are referred to as “stand-off weapons” (Tice, 1991). Tice (1991) indicates that UAVs can be pre-programmed, be directed by a ground-controller, or an airborne-controller. He states that when UAVs are controlled by humans, they are referred to as “remotely piloted vehicles (RPV)”. Tice (1991) additional mentions that UAVs come in different sizes and designs. These vehicles/drones can range from the size of a Boeing 747, to a vehicle/drone that is tiny enough to fit in a person’s backpack. Designs can range from “model airplanes to missiles to ball-shaped vehicles with helicopter blades” (Tice, 1991).

Brown (2013) stated “that in the past unmanned airborne targets were referred to as drones and that the term ‘drone’ is not used in the Air Force. He further stated that “the Royal Australian Air Force refer to Unmanned Air Systems (UAS) as ‘a weapons system in its own right’. It delivers a multitude of effects and is a complex mix of sub-systems that include the platform, payloads, ground control elements, a command network, and launch and recovery teams. Alongside these, are data processing elements, a workforce of intelligent analysts, as well as supporting sub-systems involving training and maintenance”. Brown (2013) argued that the term UAV is also used, yet “this term refers to the platform, rather than the capability”. ICAO (2005) defines a UAV as *“*a pilotless aircraft, in the sense of Article 8 of the Convention on International Civil Aviation, which is flown without a pilot-in-command on-board and is either remotely, and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous” (ICAO, 2005, Slide 5).

For the purposes of this study, the researcher defines drones, unmanned aircraft, or unmanned aerial vehicles (UAVs), or any other definition as is used globally, as an unmanned aircraft system (UAS). Unmanned aircraft systems, in the researcher’s view, are not merely a vehicle but a combination of all the technologies, systems, entities and teams of people that work together to form a complex, holistic and interactive capability. In the researcher’s view, a UAS can vary in size, utility, application and capability, has no human being on board the platform, is aerodynamically powered, can fly autonomously or semi-autonomously, by means of computers onboard the system, or via a human who is remotely controlling it from a specific base station, whether it be on land, via a mobile or stationary vehicle, or from an airborne aircraft, or be it from a naval vessel out at sea. A UAS has a command network, communications systems and data processing elements on board the airborne platform (i.e. flight control, information processing, weapon fire control and a guidance monitor). The UAS can be unarmed and carry a sensor payload such as cameras, for various surveillance, reconnaissance, loitering and intelligence roles, or the UAS may be armed with munitions for target acquisition and selection, or carry IEDS, or biological and chemical weapons for mass destruction.

2.3 The evolution of drone warfare

Warfare is as old as time and has evolved through the ages as new technological and revolutionary developments all over the world have created entirely new dimensions to warfare. “Although UAS’ highly publicized missions may convey the impression that UAS are a recent technological

innovation, the use of unmanned flight pre-dates human-piloted flight" (Watts, Ambrosia, Hinkley, 2012: 1671). Unmanned aircraft systems (UASs) in their various designs, types and descriptions "have a lengthy military pedigree that reflects their long-recognized potential in supporting warfare efforts" (Watts et al., 2012: 1671-1692). According to literature studies, UASs have been used in warfare over the ages, but where did it all start?

Drones or UAVs were initially developed as a significant form of airpower. Their uses were specifically for military reconnaissance, surveillance and intelligence during the early 20th century (Kaplan and Parks, 2017: 3). Watts et al. (2012: 1671-1692) alleged that in 1849, Venice was bombarded with unmanned hot-air balloons, and that "similar balloons were used during the American Civil War" (1861–1865). Later, military reconnaissance missions were flown with photographic equipment, when this technology became available. As illustration, an example is cited of a "Corporal Eddy of the US Army, who used remotely-triggered cameras, aboard kites during the 1898 Spanish-American War" (Watts et al., 2012: 1671-1692) to perform reconnaissance missions.

During World War II (1939–1945), the United States "began arming experimental aerial drones (UAVs) with bombs and missiles in efforts to compete with Japanese kamikazes" (Kaplan and Parks, 2017: 3). The Germans used unmanned armed aerial vehicles (UAAVs) like the V-1 Flying Bomb to devastate London and other British cities (Baker, 2012: 1). The V-1 differed though in one respect. It was armed, directed from the ground (unpiloted), it flew to the target and exploded, completing its mission. At the time the Japanese were also looking at unmanned flying bombs. At this stage during World War II they used flying bombs with a pilot steering it towards its target. It could not be used again.

Watts et al. *(*2012) mentioned that during the Cold War (1947–1991) progress in UAS reconnaissance capabilities led to scientists experimenting further with unmanned aircraft to mitigate the risks that manned aircraft posed. The United States (US) UAS for reconnaissance and surveillance missions and targeted attacks were continuously used throughout the Vietnam War (Imperial War Museums (IWM), 2018: 1; Kaplan and Parks, 2017: 3). "But, perhaps the conflict which truly thrust UAVs into the modern era was the so-called Yom Kippur war of 1973 in which Israel used them in a coordinated assault alongside piloted aircraft in air-to-air combat" (Baker, 2012: 1).

During the modern warfare era, the US purchased a number of unmanned armed aerial vehicles (UAAVs). The UAAVs, used by the US, namely the Hunter and Pioneer systems, were byproducts of the Israeli Air Forces models, usually researched and developed with monetary assistance from the USA (Baker, 2012: 1). According to Baker (2012: 1), it is noted in a May 1991, Department of the Navy report, that the first 'UAV war,' was the first Gulf War (Baker, 2012: 1). Baker further stated that during Desert Storm a minimum of one UAV was in flight at all times, and since then UAVs have been used in all conflicts by the US since the Gulf War, especially with their global war on terrorism (Baker, 2012: 1). According to Burt (2018: 3), "unmanned Aerial Vehicles (UAVs), commonly known

as drones, are likely to be the military system which develops into the first truly autonomous weapons systems, powered by advances in artificial intelligence (AI), machine learning, and computing". Burt (2018: 3) further indicated that development will advance to such a degree that drones will not only fly themselves, but be able to identify, select and destroy targets without human involvement. He believes that with the growing use of remote controlled drones, armed drones can lead to the development of autonomous weapon systems, more so as we enter the 4th industrial revolution and the development of artificial intelligence (AI).

An article from the Centre for Security Studies (CSS) (Mahadevan, 2010: 1-2) states that drones are representing an evolution in warfare, and that drones have the advantages of being used for tasks "which are inherently less suited to manned aircraft" (Mahadevan, 2010: 1-2). This resonates with Watts et al.'s (2012) views that the initial emphasis for using UAS was to support the so-called "three Ds" (i.e. the dull, dirty, or dangerous missions) where a human pilot's life would be at risk (Watts et al., 2012: 1672).

Is proliferated drone technology a friend, foe or threat? Unmanned aircraft systems are becoming increasingly popular and freely available to the general public. According to Kreps (2016: 160), the world is becoming inundated with drones and that it is a phenomenon that would keep increasing in the military, commercially and for recreation purposes. Sayler (2015) stated that "as this technology continues to proliferate, simple weaponised drones carrying explosives or chemical or biological agents will be increasingly within the reach of virtually any state, non-state actor, or individual" (Sayler, 2015: 5). Bowden quoted Richard Pildes stating that, "drones are the most discriminating use of force that has ever been developed. Drone attacks and targeted killings serve these principles better than any use of force that can be imagined" (Bowden, 2013: 1).

The counter argument to Bowden and Pildes is also true. Many human rights groups, environmental groups and activists are against the proliferation and employment of UAS. For example, research indicated that "there has been a lot of criticism of the US drone program among the German public and even in the political realm. German public opinion is largely against military drones, mainly because of their use for extra-judicial targeted killings by the US government" (Knight, 2017a). However, according to Franke's research for the European Council on Foreign Relations (ECFR), around 90 countries have military drones, and 12 of these countries have armed drones, and "they don't all carry out targeted killings with them" (Knight, 2017a), Franke stated.

Another criticism launched is about the "concerns raised by civil liberty groups (in the US) who worry that drones raise potential privacy issues in the digital age" (Kreps, 2016: 129), and especially when it comes to government surveillance (Kreps, 2016: 128). Collisions between commercial airliners and unmanned aircraft is another contentious issue that people are concerned about, as well as the need for improved regulations, and drone pilot training and assessments on the use of unmanned aircraft (Kreps, 2016: 131).

Gusterson (2016) spoke of fears raised against drone strikes, for example in Pakistan, at public protests near to US Air Force bases in America and elsewhere. Further criticism launched comprises the arguments “that drones make it too easy for Presidents to act unilaterally and unaccountably” (Gusterson, 2016: 129). He also alluded to groups in the US who have protested against drones which have killed more non-combatants than insurgents (Gusterson, 2016: 126). These groups have by the same token, spoken out against the fear and “high rates of post-traumatic stress disorders” that the children in Pakistan’s tribal areas are suffering from, due to drones flying above them, and people not sure when there will be another strike or another possible dismemberment (Gusterson, 2016: 126-127).

Divergent to the above civil society reproaches, Kaplan and Parks, and Gusterson (2016) spoke of the adverse effects on the drone operators themselves. These authors refer to the stress disorders that the drone operators can suffer, and their “psychologically scarring” should they struggle to shake off the “intense visual images” of their remote targeted (drone) killings (Gusterson, 2016: 79-81). Kaplan and Parks (2017: 289) stated that “with the increasing use of military drone aircraft, there have been numerous anecdotal reports of increasing stress levels of their operators”. According to them, two factors had contributed to these stress factors. Firstly, “the psychological complexity of moving back and forth, on a daily basis, between remote combat operations in a foreign land, and domestic and family life in the suburbs” and secondly, “the intimate nature of the video surveillance that these operators conduct” (Kaplan and Parks, 2017: 289).

The question to be asked is whether the proliferation of unmanned aircraft systems in the private and commercial spheres could create a national security threat and challenge to South Africa, the SANDF and its regions? Should this threat or challenge become a reality to South Africa, would the SANDF and in particular the SAAF be in a position to counter such possible threats? “As UAVs, or drones continue to proliferate (whether unarmed or armed), it will be vital for policy makers to understand the underlying technologies and capabilities which these technologies provide to various actors. Current drones vary widely in affordability, accessibility and capability – from inexpensive, commercially available systems flown by short-range joystick controls to multimillion-dollar, high-end military-grade systems that require substantial training and infrastructure to produce and/or operate them” (Sayler, 2015: 5). This increasing availability of a wide range of variants at differing costs, different levels of sophistication and the potential of multi-layered functions and roles in which drones can be used, complicate the picture both in civilian and military and security terms.

2.4 Background: Characteristics of UAS in an international context

As stated above, the researcher has become aware that the levels of sophistication and importance of UAS can, among others, be ascribed to their wide-range of capabilities, configurations, weight, sizes and classifications in both the civilian and military sphere. Over the decades, the uses for UAS have changed from merely unmanned aircraft surveillance roles, to armed payload missions for

destroying enemy targets, to possibly, and debatable, becoming fully autonomous weapons in future. Internationally, there are countless possibilities regarding UAS, thus a brief overview at this point in the study could add value and understanding.

Udeanu, Dobrescu and Oltean (2016) argued that the uses of UAVs are classified according to their characteristics, i.e. their roles, endurance, weight, engine type and the maximum altitude they can reach, to mention a few. UAVs have, and are being used for radar and communication relays for low level surveillance, and for aerial supplies of small cargo items like food and ammunition. The unmanned combat aerial vehicles (UCAV) that were used in air to air combat roles, were very manoeuvrable and delivered weapons with precision (Udeanu et al., 2016: 200, 201 and 204).

Watts et al. (2012: 1673-1686) stated that UAS comprise different components such as the ground control system, the aircraft itself and the sensor payloads. Usually the smallest UAS can be controlled by components carried with the UAS and with the laptop (i.e. its ground control station). These small UAS can be transported in people's backpacks, on boats or via small vehicles. Depending on the mission required and the type of platform (and configuration) used, the ground control station can be operated by one person. Alternatively, for safety reasons, two people would operate the small UAS, i.e. one person being the pilot, and the other being the "spotter" who visually follows the UAS's flight path. Larger UAS are usually carried on trailers or on vehicles "to enable close proximity to UAS limited by range or communication capabilities" (Watts et al., 2012: 1673-1686).

Mahadevan (2010) indicated there are three types of drone usage, or categories, namely strategic, operational and tactical. Strategic drones are used for long-range reconnaissance, and operational drones are used for reconnaissance and attack purposes. Tactical drones are operator controlled and used by the operator, for example for border surveillance (Mahadevan, 2010: 1-2). Miasnikov (2005) and the US Government Accountability Office (US GAO, 2012: 3-4) divides UAVs into mini, tactical and strategic categories as indicated in the Table 2.1 below. They distinguish between military and civilian applications, and between different categories such as altitude, endurance and range. They indicate that militaries use UAVs for gathering intelligence, for armed attacks and for electronic counter-measures. Civilian uses are intended for law enforcement and for agricultural purposes (Miasnikov, 2005: 4-5 and US GAO, 2012: 3-4). Meredith stated that "the performance figures per category (altitude, range and/or endurance) are not rigid, but serve as a guide. An example is the South African manufactured Denel Dynamics Seeker II, which falls within the 'Tactical' category, but which has a range figure in excess of the specified limit" (Meredith, 2011: 11-7–11-8). Table 2.1 below depicts these categories and illustrates the basic attributes required for mini, tactical, or strategic UAVs.

Table 2.1: Three major categories of (UAVs): Mini, tactical and strategic

Category	Mini	Tactical	Strategic
Altitude	Low	Low to Medium	Medium to High
Endurance	Short (about an hour)	Medium (up to several hours)	Long (ranges from hours to days)
Range	Close-range	Limited to line-of-sight (approximately 300 kilometers or less)	Long range
Example	Raven  Courtesy UAS Vision	Shadow  Courtesy UAS Vision	Global Hawk  Courtesy Deagel.com

Sources: Adopted from US GAO 2012, UAS Vision and Deagel.com).

McKay (2019) quoted Franke who stated that drones vary so extensively when it comes to their uses, that sweeping statements cannot be made. Drones uses will depend on their different capabilities, the payloads which they can carry, and the range they can travel (McKay, 2019). Ryver (2016) referred to drones as “aerial, aquatic, submersible, ground-based and those that can adhere to walls and ceilings” (Ryver, 2016). Friese et al. (2016: 14-15) stated that the majority of UAS may be characterised as either fixed wing or rotary wing aircraft, according to their configurations. Fixed wing aircraft can develop lift from different aerodynamic forces on the ground, whereas rotary wind aircraft can achieve lift by rotating against aerodynamic surfaces. According to Smith (2019), rotary wing can be “quad (4), hexa (6) or octo-copter (8). Fixed wing UAS are characterized by/as size, altitude and endurance” (Smith, 2019). Smith’s rotary classifications indicate similar specifics as alluded to by the unmanned systems technology website (Smith, 2019).

One type of unmanned aircraft system that provides uninterrupted intelligence, surveillance, and reconnaissance capabilities and situational awareness is the tethered drones. The tethered drone has a permanent physical link to a solid surface, via a cable or a flexible wire, from which it cannot fly away. This link provides power and communication capabilities between the drone and the physical base on the ground or vehicle, via fibre optics or microfilament capabilities. The advantages of a tethered drone are that it has a continuous supply of power from its base station, is more secure with fibre optic data transmissions, and cannot be jammed as there are no radio frequencies (RF) between the tethered drone and its physical base station (Unmanned Systems Technology, 2019b).

Research indicated that lighter than air (zeppelins/airships) technology can apparently also offer many advantages to the military, and civilian society. For example, according to Allman (as cited by Piesing, 2019) the Hybrid Air Vehicle [HAV] Airlander can keep very large payloads in the air for much longer, and for much cheaper than a small UAS (or drone) can. Furthermore, Allman (2019 as cited by Piesing, 2019) believes the endurance of the airship/zeppelin can be increased by adding helium to the existing technologies. This he believes could provide the military with a cost advantage as it would cost less to keep the airship in the air for many days. Boyd (2019 as cited by Piesing 2019), on the other hand pointed out that airships have environmental-friendly advantages as they produce very little pollution compared to large manned aircraft. He stated that airships can transport personnel and heavy cargo to remote areas with little or no infrastructure, therefore providing safe and sustainable solutions for these populations. Besides transporting heavy cargo, airships can assist with the extraction of natural resources and humanitarian relief missions (Piesing, 2019). In summary, despite their disadvantage of lower speeds than many manned aircraft, the main advantages of zeppelins (or airships) are their ability to maintain high altitudes, they are fuel efficient, can travel at relatively high speeds with large cargo, assist with military re-supplies and do not require an airfield to land on (OLM Contributor, 2014: 1-2). This is a much debated point, based on sufficient risk assessments and lessons learnt from the Hindenburg disaster in 1937, improvements in latest technologies, newer safety features and further research. Airships/zeppelins have been mentioned for the inclusiveness of this study and are not discussed in detail.

As illustration to the above, tethered unmanned aircraft systems have been used in the past, by the United Nations (UN) in peacekeeping missions in the Central African Republic (CAR) and the eastern Democratic Republic of the Congo (DRC) as mentioned by Ladsous, the Head of the UN peacekeeping missions (Africa Renewal, no date). The use of tethered UAS for border control and maritime surveillance, as a potential “force multiplier” is possibly a consideration available to the SA Air Force, the SA Navy and the SA Army, especially in light of the declining SANDF budget, as mentioned in Chapter 1. The point is that it cannot be damaged or destroyed while conducting surveillance missions.

As indicated above, numerous categories and classifications of UAS exist. So too do world opinions vary across both the civilian and military sectors, regarding UAS, since there are currently no shared world-standards or regulations for UAS.

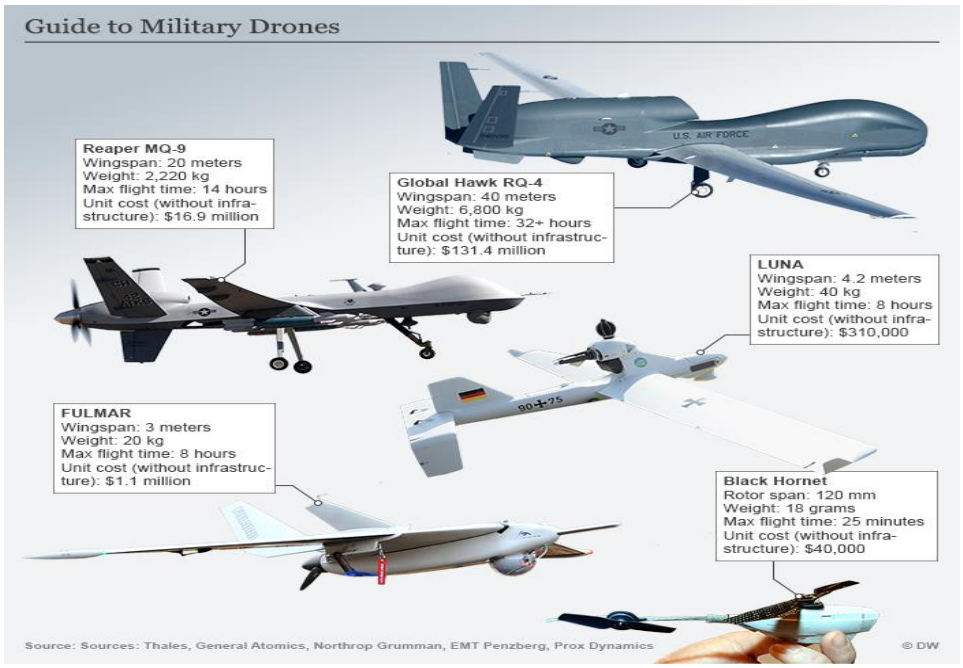


Figure 2.1: Guide to military drones

Sources: Thales, General Atomics, Northtrop Gruman, EMT Penzberg, Prox Dynamics - from in DW

Figure 2.2 provides a brief glimpse of a few types of military drones in use at the moment, and the differences in terms of their sizes, wingspans, weights, maximum flight times and unit costs. According to the military factory website, approximately 204 military UAS entries were recorded in 2019, from various countries across the globe. In 2020 these figures increased to 214 entries across the globe. Unmanned combat aerial vehicles (UCAV) have also increased to 71 entries across the globe (Military Factory, 2019 and 2020). Based on these figures, and as previously indicated by various authors, it is evident that unmanned systems will continue to proliferate across the world.

According to Franke (2014 as cited by McKay, 2019), “the smallest military drone system in use at the moment is the Black Hornet, a small helicopter drone with a 12cm wingspan. The biggest military drone is the Global Hawk, a system whose 40m wingspan rivals that of commercial airliners. Drones’ raison d’être, Franke (2014) stated, is carrying payloads, which range from surveillance systems to armaments and beyond” (Franke, 2014 as cited by McKay, 2019). Both the Black Hornet and the Global Hawk are portrayed in Figure 2.1 above.

Knight (2017b) described another type of category in terms of UAS. According to Knight (2017b), there are micro-and nano-drones, small tactical drones, medium-sized reconnaissance drones and large combat and surveillance drones. Besides these categories, UAS can be further categorised into UAV performance classifications as indicated in Figure 2.2.

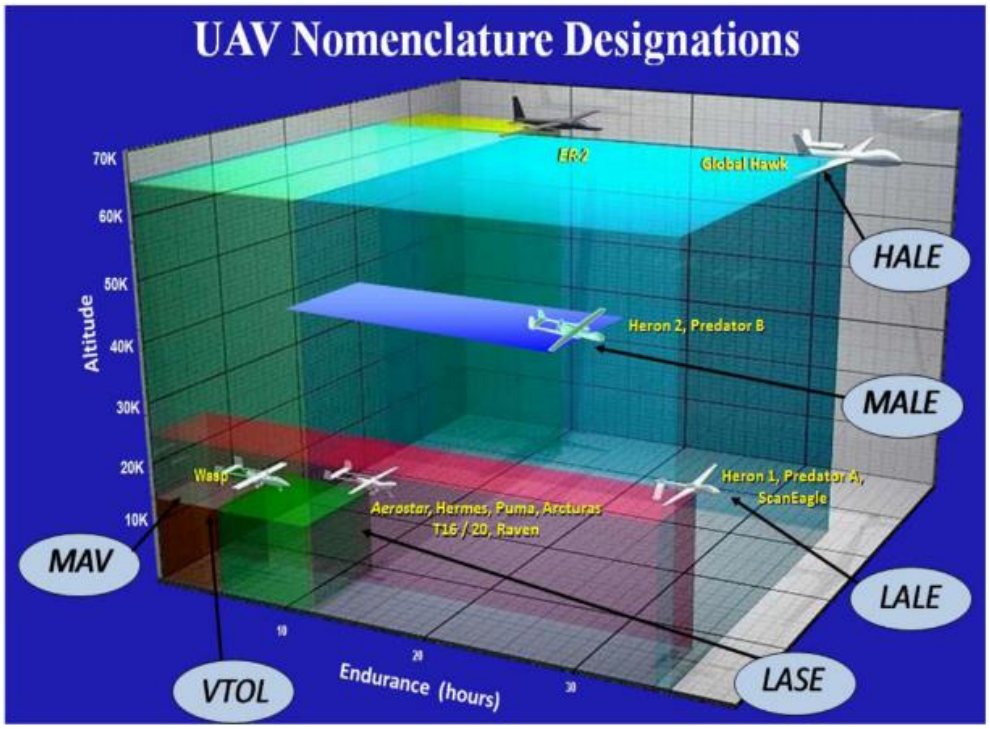


Figure 2.2: Generally accepted UAV performance classifications

Source: Image courtesy of US Department of Homeland Security

2.4.1 Performance classifications

The different UAS classifications are divided as follows: micro– and nano-drones, vertical take-off and landing (VTOL) UAS, low altitude, short-endurance (LASE), LASE CLOSE and low altitude, long endurance (LALE) UAS, medium altitude, long-endurance (MALE) UAS and high altitude, long endurance (HALE) UAS. The different performance classifications are briefly discussed next. (Note: the specific detailed technical aspects will not be covered in this study, as it would comprise a study of its own).

2.4.1.1. Micro-and Nano-drones (MAVs and NAVs)

Nano Hummingbird	Black Hornet
	
Courtesy AeroVironment (AV), Inc.	Courtesy ADRB Defence

Figure 2.3: Micro– and Nano-Drones

Micro (or miniature) UAVs (MAVs) or Nano UAVs (NAVs), are usually the smallest of UAS (such as for example the Wasp MAV drone, the AV Nano Hummingbird and the Black Hornet Nano-drone)

(see Figure 2.3). “MAV (Micro (or Miniature) or NAV (Nano) Air Vehicles) are so called because of their size, which typically enables military versions of these aircraft to be transported within individual soldiers’ backpacks” (Watts et al., 2012: 1673). These tiny UAS operate at low altitude, usually below 330 meters. They have very limited flight times, in the region of five to 30 minutes, due to the limited capacity of their tiny batteries. These small micro and nano UAS are used in confined spaces in hostile and sensitive environments, where they usually cannot be observed during short situational awareness or surveillance missions. The movie, “Eye in the Sky”, illustrates how a dragonfly insect drone is remotely controlled to fly undetected into a room to relay images back to the operational headquarters, of the activities of the suicide bombers inside the room. This example demonstrates the inconspicuous reconnaissance tasks which these small insect-type drones can perform (Movie: Eye in the Sky). The concern noted here is that should these type of drones be used in a South African context, would we be aware of these “spy drones” in our immediate environments?

The AV Nano Hummingbird looks like a small bird and has a 16 cm wingspan. It weighs less than 20 grams and “can climb and descend vertically, fly in all horizontal directions, is equipped with a small video camera, and has a flight endurance of approximately 8 minutes” (Watts et al., 2012: 1673-1686). Knight refers to these “small drones as insect-sized spy machines that have been used in battlefields for several years” (Knight, 2017b).

The Black Hornet is an example of a Nano-helicopter drone. It is approximately 2.54 cm by 10cm, can be carried on a soldiers belt and can be controlled from a small terminal which the soldier carries in his/her hand. It has three cameras (capable of infra-red and night-vision) from which the soldier can view these images. This tiny drone can hover in the air for approximately 25 minutes and has a 1.6km digital data link to its terminal (Knight, 2017b). Both Franke (2014) and Knight (2017b) indicated that since 2013, the “British Soldiers have used the Black Hornet Nano-drone to look over walls and around corners in their wars against Afghanistan” (Franke, 2014 as cited by McKay, 2019; Knight, 2017b). “Micro- and Nano-drones are becoming increasingly sought after due to the latest developments in 3-D technologies, artificial intelligence and sophisticated digital systems” (Kirve, 2018 and Jackson, 2017). The FLIR Black Hornet is the smallest operational unmanned surveillance system in the world and has been used extensively in combat operations by NATO forces over several years. “Described by its users as a “Game Changer” and a “Life Saver”, it has created a new standard and class for the smallest UAS” (FLIR as cited in Unmanned Vehicles (UV), 2018: 7). The researcher’s question remains, could these type of drones possibly create a significant threat for human and national security, especially in developing countries like South Africa and the SADC?

Kaplan and Parks (2017) indicated that with the advent of 3-D technology, relatively cheaply manufactured and sophisticated drone swarms are being developed. Drone swarms can take on the physical forms of dragonflies, “robobees,” houseflies, and other insects” which can be deployed by the thousands or even millions “to create a fog of war” on the battlefield (Kaplan and Parks, 2017: 275). Simply stated, a “fog of war” refers to a situation of confusion and miscommunication on the

battlefield, an unfavourable position for any military to find itself in, where one's own forces can fire at each other (i.e. "friendly fire"). The point being made here is that because of their small size, yet exceptionally sophisticated technologies, these drones could pose a serious security breach, or a grave security threat, especially if they were to go unnoticed, whether in an urban or a rural setting.

2.4.1.2 Vertical take-off and landing UAS (VTOL UAS)

		
UMS Skeldar V-200 VTOL UAV Courtesy unmannedsystemstechnology.com	UKRSpecSystems Hybrid VTOL UAV Courtesy unmannedsystemstechnology.com	UAVOS UVH-120E VTOL Helicopter Drone Courtesy unmannedsystemstechnology.com

Figure 2.4: VTOL UAVS

Source: Unmanned Systems Technology (UST), 2019a

Vertical take-off and landing UAS (VTOL UAS) have specialised capabilities as they can be used in restricted terrain, or remote areas, where no runways are required. VTOL UAVs usually have multi-rotor designs with four or more propellers, based on helicopter designs, to ensure sufficient lift and propulsion (UST, 2019a). VTOL aircraft (UAS) are very portable platforms that fly mainly at low altitudes, yet depending on the mission, they can also fly at varying altitudes if so required. VTOL UAS are used mostly for line-of-sight (LOS) operations. They usually cannot hover over an area for more than an hour and subsequently they are usually used for "quick-look" analysis (i.e. over the hill, or around a building). Due to the power required for the VTOL UAS to hover, flight duration is reduced significantly. The military usually prefer VTOL UAS for "rescue operations in complex urban environments" (Watts et al., 2012: 1676) due to their manoeuvrability in confined urban spaces, such as narrow streets and buildings.

2.4.1.3. Low altitude, short-endurance (LASE), LASE close, and low altitude, long endurance (LALE) UAS

Fulmar	Raven	Aladin
		
Courtesy Aerovision Fulmar	Courtesy UAS Vision	Courtesy EMT Pentzberg

Figure 2.5: LASE and LALE UAS

The Fulmar, Raven and Aladin (as depicted in Figure 2.5) are examples of small tactical drones. The Fulmar and the Raven (small tactical UAS) can be carried in soldier's pockets and be used for intelligence, surveillance, target acquisition and reconnaissance (ISTAR) missions when tossed into the air (Knight, 2017b). These small, light surveillance drones can be airborne for approximately 12 hours at a range of approximately 15 to 90 kilometers.

Low altitude UAS are divided into three categories, namely, LASE (low altitude, short-endurance); LASE Close; and LALE (low altitude, long endurance). LASE UAS are used for field deployment and recovery. These tiny UAS do not require any runways and may be launched by hand, or from a mini catapult system. The tiny UAS has a wingspan smaller than 3 meters and typically weighs between 2 to 5 kg. LASE Close small UAS require runways and can remain airborne at altitudes of up to 1,500 meters for several hours. (Watts et al., 2012: 1674). LALE (Low Altitude, Long Endurance) UAS are the larger of the low altitude UAS which can carry several kilograms of payloads, and can be airborne for extended periods of time (Watts et al., 2012: 1674). The LASE/LALE hand-launched platforms are fairly easy to operate, allow for small crews and have relatively simple ground-control stations, similar to remote-controlled aircraft. They use small, basic, black and white, or colour video cameras for streaming during the day. Surface objects can be imaged, by means of infrared black and white videos. The concern pointed out here is that these UAS are fairly easy to operate, and can be used by small groups of non-state actors, or even extremist and terrorist groups, if so required, thereby posing a security risk to a country.

2.4.1.4. Medium-sized surveillance and reconnaissance drones

Heron Drone	Luna Drone
	
Courtesy In Depth DW.com The Israeli-made Heron drone	Courtesy In Depth DW.com The German-made LUNA drone

Figure 2.6: Medium Sized UAS

Medium Altitude, Long-Endurance (MALE UAS) platforms play a significant role in strategic operations in the defence community. Medium-sized drones are used for medium altitude, long-endurance (MALE) and high altitude, long endurance (HALE) surveillance missions. MALE UAS are much larger than the LASE and LALE group of UAVs. They can operate from hundreds of kilometres from their ground stations, for many hours, at altitudes of up to approximately 9,000 meters (Watts et al., 2012: 1674).

The Predator B, the Heron and the LUNA (as depicted in Figure 2.6 above) are examples of UAS which are used for medium or high altitude flights. The Heron tactical drone, is a very important drone in this MALE UAS class and is used for reconnaissance missions. According to Knight (2017b), the Heron drone can fly at approximately the same altitude as commercial aircraft, for close to 52 hours, at an altitude of 10, 000 meters. The Heron has a wingspan of more than 16 meters and a flight endurance range of approximately 52 hours. Knight (2017a and b) pointed out that besides the 12 countries around the world who possess drones with weaponised capabilities, Morocco, Canada, Turkey, Australia, the US, and India have procured the Israeli-made Heron drone, which has weaponised capabilities (Knight, 2017a and b). The LUNA reconnaissance drone, which is considerably cheaper than the Heron drone, is operated by Pakistan, Saudi Arabia and the German military (Knight, 2017b). Knight further stated that since 2000, the Bundeswehr has employed the LUNA reconnaissance drone for missions in Kosovo and Afghanistan. Though its range is approximately, a mere 100 kilometers, it was successfully employed in flight for several thousands of hours, in Kosovo and Afghanistan (Knight 2017b).

2.4.1.5. Large combat surveillance drones

	
The Global Hawk is the biggest military drone, used mainly for surveillance Courtesy In Depth DW.com	The US uses Predator drones for extra-judicial killings Courtesy In Depth DW.com

Figure 2.7: The Global Hawk

The high altitude, long endurance (HALE) UAS "are the largest and most complex of the UAS, with aircraft larger than many general-aviation manned aircraft" (Watts et al., 2012: 1674). Some HALE UAS can fly longer than 30 hours, at heights of approximately 20,000 meters or more, especially for missions extending over immense kilometres (Watts et al., 2012: 1674). Knight (2017b) stated that the largest of the combat and surveillance drones are the Predator, the Reaper, the Global Hawk and the CH-4 (Knight, 2017b). The US Predator and the newer combat US Reaper are the most expensive and best known UAS. The Global Hawk can fly above an altitude of 18,000 meters, above commercial aircraft. It is specifically for signal surveillance and has excellent ISTAR capabilities, even though it commonly flies over battle zones. It can for example scan mobile phone calls, as mentioned by Knight (2017b). According to Knight, these UAS are "used for controversial extrajudicial killings in countries where the US is not officially at war" (Knight, 2017b). As indicated and discussed in this study, there has been a global outcry, against these type of killings.

In summary, Sayler's classifications of the characteristics of UAS are perceived by the researcher as the easiest comparison for the different categories (see Figure 2.8 below). Sayler (2015: 8) divided drones into four categories, namely (1) Hobbyist drones, (2) Midsize military and commercial drones, (3) Large military-specific drones, and (4) Stealth combat drones. This is based on their underlying technologies, performance and capabilities (Sayler, 2015: 8).

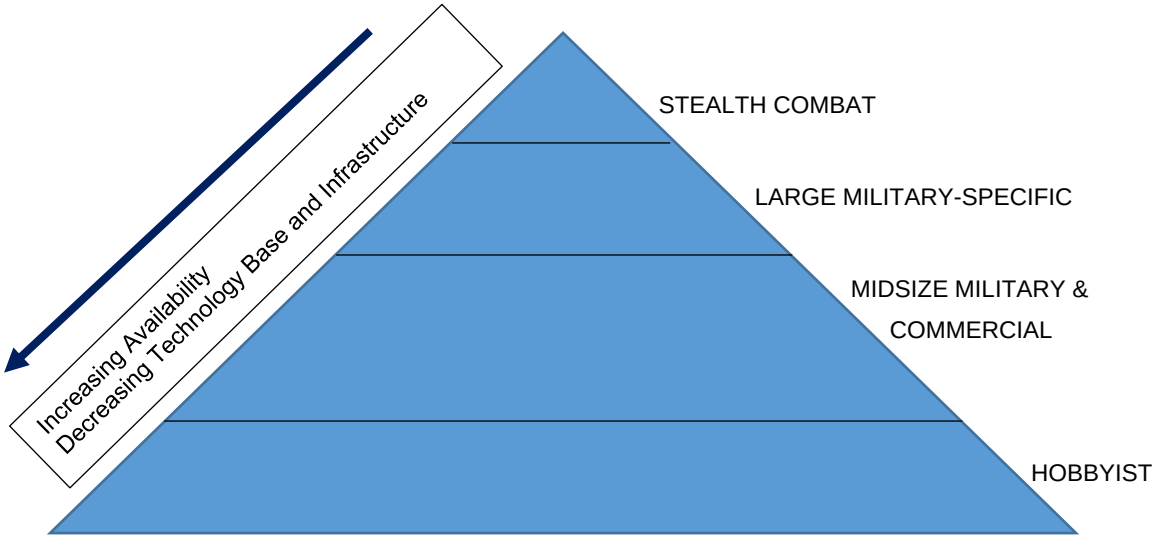


Figure 2.8: UAS: Accessibility and technology-base and infrastructure requirements

Source: Sayler, 2015: 9.

Table 2.2 below lists the various performance capabilities in each category provided by Sayler (2015: 9).

Table 2.2: Categories of drones – Performance capabilities

HOBBYIST	MIDSIZE MILITARY & COMMERCIAL	LARGE MILITARY-SPECIFIC	STEALTH COMBAT
Limited payload capacity Limited range/persistence High-definition imagery/ video transmission Autonomous GPS and waypoint navigation	Moderate payload capacity Moderate range/persistence Advanced radar Encrypted, high-bandwidth data links Limited jamming/electronic warfare Target identification and designation Communications relay function	Larger payload capacity Long range/persistence Low-probability-of-intercept radar Enhanced jamming/ electronic warfare Beyond line-of-sight communications Releasable missiles/bombs	Low observable features Low-probability-of-intercept/ low-probability-of-detection data links Higher resistance to adversary jamming

Source: Sayler, 2015: 9.

In essence, (1) Hobbyist drones are pre-assembled and readily available for purchase and requires formal training. (2) Midsize military and commercial drones are usually not available to private individuals due to their high costs and the infrastructure required. Nevertheless, these systems can

be sold to non-state actors and foreign militaries. (3) Large military-specific drones are generally only accessible to major military forces as they can be armed, and require extensive infrastructure within which to operate. (4) Stealth combat drones “contain highly sophisticated technologies” (Sayler, 2015: 8) and are not accessible to all UAS manufacturers. Based on the above information, indications are that the hobbyist drones and midsize military and commercial drones will be more freely available to the general public and be more sought after. This could infer that the greater security risk to a country could lie in these two categories. A point for much deliberation.

Considering the diverse and sophisticated range of UAS as discussed above, the question raised is, what risks could these various UAS pose on a global scale, and especially to developing countries such as South Africa and the SADC regions? In terms of National Security, is the SANDF and specifically the SAAF prepared for such possible future threats? Does South Africa and the SAAF have sufficient counter-measures in place, when considering these sophisticated technologies? Even more importantly, the pace at which micro-and nano UAS are developing is adding to the existential threat as these “insect-type” UAS often go unnoticed in everyday life. With the above-mentioned introductory background regarding the various types and characteristics of UAS, international trends are explored next.

2.5 International trends

Internationally there has been a myriad of uses for UAS in both the military and civilian spheres. States have employed drones in three important military contexts, namely for armed conflict, lethal operations and for peacekeeping operations (McDonald, 2018: 6). Wen (2017) is of the opinion that with militaries across the world, “drone warfare will be the next bound in the evolution of airpower” (Wen, 2017: 48) and that “airpower will comprise the use of flying vehicles to support a nation’s security interest” (Wen, 2017: 45). At an Air Power Symposium in Canada, Kainikara (2014) stated that UAS “have become ubiquitous for the efficient employment of air power” and that UAS will always be viable in military operations. On the other hand, Kainikara (2014) is of the opinion that the manner in which UAS can be applied in future defence roles “could be inhibited by a world facing infinite resource issues” (Kainikara, 2014: 97-112). “Challenges such as costs, research and development, mission systems and national budgets of various countries could contribute to the shift in their development and innovation” (Kainikara, 2014: 97-112). What is argued above needs some qualification: the availability of funding, or prioritising defence and security needs, may impact the (future) use and availability of UAS?

Knight (2017b) similarly stated that “every military specialist agrees that unmanned aerial vehicles or drones, are the future of warfare” (Knight, 2017b). He is of the opinion that “the research and development (R&D) departments of the world's defense companies have barely begun to explore all the different uses for Unmanned Aerial Vehicles (UAV), or drones. And governments, aware of this, are growing increasingly keen to find out what else they can do” (Knight, 2017b). This point perhaps

needs some reflection. The researcher is tempted to enquire whether the South African defence industries and the SAAF are sufficiently aligned, with similar amounts of sophisticated research and development (R&D) into UAS, as is done globally, in order to protect our national security interests. And if indeed, at which level of global R&D does South Africa as a developing country fit in, compared to the rest of the world? And most importantly, are we sufficiently funded to do proper R&D? Are the politicians and policy makers in South Africa aware of the vital necessity for such capabilities? In the words of Sayler (2015: 8), "it will be vital for policy makers to understand the underlying technologies and capabilities these technologies will provide to various actors" (Sayler, 2015: 8).

Schwab (2017, Preface) argues that will be the 4th industrial revolution will be totally different and more complex than any preceding revolutions. He states that the new array of technologies are rapidly resulting in the biological, physical and the digital worlds merging. The consequences of these developments is that governments, economies, and industries are directly affected by this. And in the researchers mind, national security across the globe too. Schwab (2017, Preface) defends his viewpoint by providing examples emanating from artificial intelligence developments seen all around us, such as 3D printing, drones, tiny microchips, DNA sequencing and supercomputers. However he believes, "this is just the beginning" (Schwab, 2017, Preface). This in mind, one needs to consider remote warfare which is more and more a reality and which will accelerate with the so-called 4th industrial revolution. And what implications will new technologies have on our national security?

Kainikara (2014) believes that a crucial component to the success of military operations are unmanned aircraft systems (UAS). He states that present day Western militaries are rapidly moving away from conventional warfare to information warfare. More so than in the past, these forces rely more heavily on real and immediate information, as regards their forces and those of their enemies (Kainikara, 2014: 97 – 112). Kainikara (2014) recommends "that in future, doctrine and conceptual developments need to stay abreast with technological developments" (Kainikara, 2014: 97 – 112). In the researcher view, an important consideration for South Africa and the SAAF.

Over the past few years, new forms of warfare such as remote (or liquid warfare) and unarmed remote warfare have evolved. These approaches have gained prominence as technology has developed. Demmers (2018: 36) mentioned that "'shaping' the international security environment through remote technology, flexible operations and military-to-military partnerships has been an assemblage approach to liquid warfare" (Demmers, 2018: 36). It seems that these forms of warfare have become more acceptable. President Barack Obama declared during 2013 that instead of sending troops and boots on the ground to Pakistan, "sending drones, the message, is much less controversial" (Franke, 2014: 130).

Following the terrorist attacks on the United States (US) on the 11 September 2001, the US military dramatically increased the tempo of drone usage and significantly transformed the way in which drones were used by them (*Weapons Law Encyclopedia*, 2017). Since 9/11, repeated drone strikes

have been launched by the US military in no less than seven countries, namely Pakistan, Afghanistan, Somalia, Libya, Yemen, Syria and Iraq. The Central Intelligence Agency (CIA) also created a great deal of controversy when it targeted Pakistan, Somalia and Yemen with drone strikes (Drone Wars UK, 2018). Likewise, the USA received a lot of international criticism for the killing of a highly ranked officer from Iran on a visit to Afghanistan in early 2020 under the Trump administration. A significant political outcome of this attack, ignoring rules of conflict and war and international law, significantly raised political tensions in the Middle East. Iran's self-discipline and diplomatic approach prevented an escalation of conflict which could have had dire consequences in the region. And because little international legislation exists on the use of armed drones that can be enforced, the US are using their drone capacity (including offensive capabilities) freely on African soil, asking permission from no one. Despite the strong controversy and opinions against the use of armed UAS, authors such as Udeanu et al., (2016) argued that "many high value targets were eliminated by means of drone/UAVs and many soldiers' lives have been saved" (Udeanu et al., 2016: 204). This point remains a contentious issue.

In 2004, as part of a joint Predator task force between the United States (US) and the United Kingdom (UK), the UK started using armed drones. In 2007, the UK procured its own armed Reaper drones to be used during operations in Afghanistan, and in 2014, armed drones were used in Iraq (Drone Wars UK, 2018). The UK Defence Ministries figures indicate that the percentage of airstrikes in Afghanistan undertaken by British drones rose from 52% in 2009/10 to 82% in 2013/14. It is said that the UK often used armed drones for military operations and for lethal operations where it was warranted as self-defence. US pilots, for example, make use of Europe's infrastructure as a platform to remotely operate its armed drones over the Middle East and Central Asia, by using a satellite linkup, located in Germany. Internationally and currently, "drones are mostly used by states against non-state actors, and vice versa" (McDonald, 2018: 4 and 2-6). Apart from the US and the UK, several other NATO Air Forces such as Spain, the Netherlands and France also operate Reapers. Countries that have joined the group of EU states which use armed drones, are France and Italy (Knight, 2017a).

Boulanin and Verbruggen (2017 citing Stohl, 2015), stated that "the USA is a key exporter but it places restrictions to limit the export of armed UAVs to all but its closest allies" (Boulanin and Verbruggen, 2017: 122). The reason for the US government restricting its exports is due to the government's persistent concerns regarding Chinese UAV proliferation since the year 2013. As a result, the US decided to keep a close eye on China since China wanted to build its own fleet of UAVs (Stevenson, 2018: 3). Since 2015, "the US only began allowing the sale of armed drones, such as the Predator or combat-proven MALE Reaper UAV and the Global Hawk, to foreign countries, such as the UK, Italy, Spain and France" (Hawser, 2017). "However, it is only the UK and Italy that are permitted by the United States to arm their MQ-9A Reaper UAVs for combat" (Hawser, 2017).

Regarding UAS technological developments, it is estimated that ten countries, namely Pakistan, China, Turkey, Iraq, Iran, Saudi Arabia, UK, Israel, Nigeria and the US, possess armed UASs. Eight of these countries, namely Pakistan, Iraq, Israel, Iran, US, UK, Nigeria and Turkey, have used them in armed combat (Hawser, 2017). Of these countries mentioned above, Drone Wars states that "Turkey now appears to be one of the most prolific users of armed drones (after the US, UK and Israel) and has reportedly, carried out hundreds of strikes in the south east of the country and inside northern Syria and Iraq" (Frew, 2019). The country that is the largest exporter of UAS technology across the world is Israel, with an estimated export of 165 UAS between 2010 and 2014. Israel exports UAS military technology to countries such as China, India and the UK (Hawser, 2017). The country that imported the most number of UAS between 2010 and 2014 is the UK. Hawser (2017) supports his statement with data published by the Stockholm International Peace Research Institute (SIPRI) where it is mentioned that the UK imported 6 armed UAS from the US and 55 UAS from Israel. The question raised by these international trends, is what are the import and export trends in South Africa?

It is said that Israel has been assisting more than 50 countries (out of roughly 70 countries) over the past many decades, with military UAV-drone technology transfers, or with the acquisition of drones (The Drone Wars Library, 2018).

McDonald affirmed this viewpoint by mentioning that the number of states that are purchasing drones from Israel and China are likely to increase, partly because "US export controls and regulatory regimes currently prevent the export of armed drones to the states that China is happy to trade with" (McDonald, 2018: 5). According to Defence Web (2018), a report published by "Drone Wars UK" mentioned that "China has sold armed drones to a number of countries around the world" (Defence Web (2018: 1). "Since 2013, Nigeria, Pakistan, Saudi Arabia, Iraq, UAE and Egypt have begun operating armed Chinese drones whilst another four countries (Jordan, Myanmar, Kazakhstan and Turkmenistan) are thought to have recently taken possession of, or be in discussion, about the sale of Chinese drones" (Defence Web, 2018: 1). The Chinese-made rival, the CH-4, which looks very similar to the Reaper, has been bought by Egypt and Iraq (Knight, 2017). Boulanin and Verbruggen (2017) cite Stohl (2015) who view China and Israel as a global market leader for armed UAS (Boulanin and Verbruggen, 2017: 122).

During the study, the researcher noted that the indications for the precise number of UAS available on a global scale differ, and as such, information will most likely, for varying reasons, and secrecy by countries, not be forthcoming. McDonald (2018: 2) and Sayler (2015: 5) are of the opinion that there are approximately 30 countries that are either possessing, operating or developing armed drones for military use. Internationally there are approximately "over 90 nations and non-state groups" that are known to operate drones (Sayler, 2015: 5).

Internationally, the facts and figures for which countries are apparently using, or not using UAS, will always differ quite substantially. However, as stated above, and depicted in the graph in Figure 2.9 below, the trends indicate that the acquisition and or development of UAS will continue to escalate. Countries will increasingly employ UAS, whether it be for military, non-state actor, commercial or hobbyist purposes. And in reality, no country will ever reveal its true or accurate statistics regarding its UAS assets. Sophisticated UAS technologies will continue to proliferate, and one can therefore only imagine what air warfare and airpower will look like in the future.

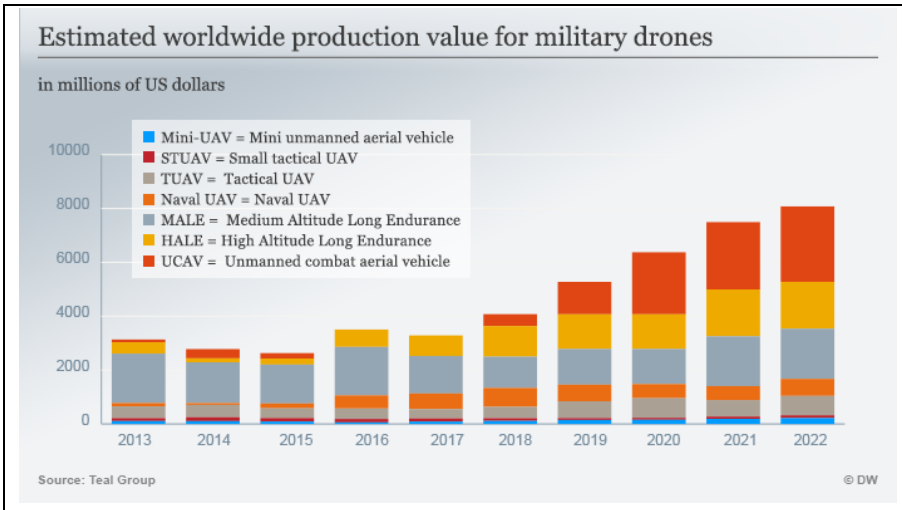


Figure 2.9: Estimated worldwide production value for military drones

According to the graph above, it appears that the worldwide production of UCAV has grown quite considerably. So too has there been growth in the production of mini UAVs and naval UAVs. Tactical UAVs and HALE UAVs also seem to have shown positive growth. The range of UAS have proliferated substantiality, and with new complex sophisticated systems, more and more autonomous systems are being developed, as seen in this study. Consequently, militaries across the globe need to "keep an eye" on these developments, especially in terms of national security.

A United States (US) Government Accountability (GAO) report stated that countries concerned with drone proliferation are developing increasingly sophisticated systems (US GAO, 2012: 9 and Foreword). The transitioning by military forces to an information warfare area, as mentioned by Kainikara, has resulted in UAVs with sophisticated software and newer capabilities, such as long loitering times, to provide real time intelligence, surveillance and reconnaissance (ISR). These images of the areas of operation can then be viewed immediately, thereby hastening decision-making in the battlefield (Kainikara, 2014: 97-112).

The US GAO further stated that "recent trends in new UAV capabilities, including armed and miniature UAVs, have increased the number of military applications for these technologies" (US GAO, 2012: 9). This is seen with the "new digital manufacturing technologies such as 3-D printing, which are providing the impetus for DOD affiliates to develop sophisticated swarms that take on the

physical forms of dragonflies, “robobees”, houseflies and other insects” (Kaplan and Parks, 2017: 275). Swarming as was indicated, when discussing micro–drones and nano-drones, can be an ideal operational concept for creating confusion on the battlefield. With 3-D printing being able to mass produce these swarming drones, together with the shrinking navigational and computing systems and increased mobility, the DOD can deploy thousands or even millions of these relatively cheaply manufactured drones into combat (Kaplan and Parks, 2017: 275). The point made is that “fewer feet on the ground” would be required, which could result in a cost-effective mission.

The Centre for Security Studies (CSS) stated that “drones have come to prominence due to their widespread use” and that drones have played a leading role in counterterrorism and counterinsurgency, and are projected to be of growing importance in future military operations” (Mahadevan, 2010: 1-2). The reasons for their importance in counterterrorism/and counterinsurgency roles are because, with their low noise levels, the enemy cannot detect them easily. Therefore drones can hover over a position for lengthier periods than manned aircraft and fly very low to identify the nature of their targets. Drones further have a low-detection footprint – another advantage for the usage of drones. Drones do not need to follow a projected path and are very adaptable to the situation, unlike satellites that follow a fixed path. These aspects, according to the researcher, make UAS such incredible technologies, but moreover, the most lethal weaponry should they fall into the wrong hands.

Another international trend that came to the fore in 2017, and as indicated by the United Nations Institute for Disarmament Research (UNIDIR), was a call by a variety of actors for increasing transparency, oversight and accountability with regard to armed unmanned aerial vehicles. These roles varied from surveillance in the Vietnam conflict to locating targets which piloted aircraft could destroy in the 1982 Lebanon War, to covert operations by Israeli intelligence agencies in areas outside the military battlefield, as in Yemen, Pakistan and Somalia. Of these 90 countries, at least 28 governments possess armed drones and many other countries are acquiring these capabilities. UNIDIR mentions that globally, the aerial drone market is increasing and that “armed unmanned aerial vehicles are an increasing ubiquitous feature of 21st century warfare” UNIDIR (2017: 2). It is stated that if the acquisition trend for armed UAVs continue, and its use spreads to a wider group of states, it could have an impact on an international level and contribute to international instability. The final reason for calling for transparency, oversight and accountability in 2017 was because states were concerned that UAVs could erode international humanitarian laws (IHLs) required for the protection of civilians and for peace and stability (UNIDIR, 2017: 2-5, 9 and 35). International regulations and laws, in terms of the aims of the study, are discussed in more detail in the chapters to come.

In addition to military operations in an international context, UAS were also used for international peacekeeping efforts. In 2013 for instance, unmanned aerial vehicles (UAVs) as well as tethered balloons were used by the UN in the DRC, Mali, Central African Republic (CAR) and Bangui

respectively, for peacekeeping missions (Tafirenyika, 2019 as cited by Ladsous, 2017: 1). Tsabora (2015) pointed out that when UAVs were used for peacekeeping missions, it created considerable debate, since no relevant IHLs and regulatory frameworks for UAVs/drones employment existed internationally. “Sceptics believed that drones belonged in the military and were not to be used for negotiations to obtain peace. However, military drones did redefine modern warfare and peacekeeping” (Tsabora. 2015: 461-468).

Unarmed military UAS have also proliferated extensively. In 2016, 90 states were reported to have operational unarmed military UAVs in their arsenal (Horowitz, Kreps and Fuhrmann, 2016: 11; UNIDIR, 2017:3). Regarding civilian drones, a number of authors namely, Franke (2014), Mc Kay (2019) and Friese et al. (2016) indicated that “the market for civilian drones has taken off and developed substantially, opening the possibility for non-state actors (from criminal gangs to activists, and from terrorists to drug lords) to access UAV technology and use it for various purposes, such as smuggling, intelligence and conducting military strikes” (Friese et al., 2016; McKay, 2019).

Besides the positive aspects attributed to the civilian commercial environment, where drones can be used to deliver goods or medicine, Franke (2014) raised her concerns with civilian hobbyist drones. She is of the opinion that, with the millions of hobbyist drones sold worldwide, non-state actors have been in a position to use these drones, for example for ISR and propaganda. She further indicated that drones have been used by the Islamic State for various nefarious purposes, either for direct attacks or as flying IEDs (McKay, 2019). “Whilst Daesh’s drones lack the sophistication and firepower of the US, they have been used successfully to kill and maim Iraqi forces” (Hawser, 2017). Hamas has used “what are believed to be “crude” drones or UAVs packed with explosives to conduct missions over Israel, but most of them have been shot down by Israeli security forces” (Hawser, 2017). “In the conflicts in Syria, Iraq and Ukraine, modified civilian UAVs have been used to deliver explosives, thereby functioning as flying IEDs” (Friese et al., 2016; Boulanin and Verbruggen, 2017: 121-131). The concern is that in future, it may only be a matter of time before some of these organisations acquire more sophisticated combat UAV capabilities from more willing exporters like China, or even Iran (Hawser, 2017).

The New America Foundation (as cited in Hawser, 2017) supports MacKay and Hawser’s opinions. They stated that three non-state actors, Hezbollah, Hamas and ISIS (Islamic State or Daesh), have used armed drones in combat. The Geneva Academy includes the Libyan Rebels with the above three mentioned non-state actors that have used drones in armed combat (Weapons Law UK, 2017). Hawser is of the opinion that “almost every country now, if they really wanted to, could acquire an armed drone capability. Of more concern, perhaps, is the fact that armed drones (albeit rudimentary) are falling into the hands of terrorist organisations and non-state actors” (Hawser, 2017).

Franke’s further concerns (as cited by McKay, 2019) are based on drone researchers’ warnings, that “drones are an attractive tool for terrorists because they allow attacking otherwise inaccessible

targets (such as high-level politicians) and spread terror particularly effectively through attacks from the air" (McKay, 2019). Franke's biggest concern, however, is that commercial airliners could come under attack from terrorist drone activities. The use of drones by terrorists for chemical and biological warfare seems to be of less of a concern to Franke (as cited by McKay, 2019).

Tadjdeh (2015) quoted experts when he stated that "in future, unmanned aerial systems will hold even more utility as they become faster, stealthier and more autonomous. At the same time, they will become more accessible to foreign countries and terrorist groups around the world" (Tadjdeh, 2015).

The other side of the debate which is equally relevant to the international context, is the impact that these drones have left on local populations (Tsabora, 2015: 461-467). One concern expressed was that a first-world technology was being exported to developing countries in Africa and the Middle East, by international arms dealers in Asia, Europe and North America. The concern with regard to the use of drones in Africa and the Middle East is that African militant groups can partake in the global arms trade as they know where to purchase such sophisticated weapons such as drones. It could further fuel the conflict in the African states who are receiving weapons from China, Russia and the United States. This illegal arms trade could negatively affect international and regional peace, security and international order and undermine the work of the Security Council. Tsabora (2015) stated that for "Africa, there is a real possibility that the drone will continue to work as a "double edged sword", being a feature of both war and peacekeeping. There is only faith and hope that this military technology will not fall into the hands of militant extremist groups, as this would mean war" (Tsabora, 2015: 461-467).

2.6 International civilian and defence markets

Additional global developments are the merging of the military and the commercial industries, as well as the flourishing developments in the area of artificial intelligence and autonomous systems. Stevenson mentioned that "the commercial and defence markets for unmanned systems have traditionally been relatively siloed, with distinct technologies and vehicle types, falling under one or the other. However, there has been a notable shift in this split, as traditional manufacturers of military systems look to leverage the proliferation of unmanned platforms in the civilian sector" (Stevenson, 2018: 22). There are however, various reasons for the merging of the military and commercial industries. Airspace restrictions are slackening to allow for experiments with different types of unmanned operations, as there are hopes that "the airspace will be truly open one day" (Stevenson, 2018: 22). Likewise, "there is more profit to be gained from large-scale employment of unmanned systems in support of commercial operations, as budgets in the military domain continue to stagnate, pushing manufacturers of defence systems to look for alternative prospects for their wares. An increase in public acceptance of the use of unmanned systems is also contributing to the expansion

of the commercial market, with this type of technology becoming more commonplace in people's everyday lives" (Stevenson, 2018: 22).

Another advancement over the years in terms of UAS is mentioned by Burt (2018: 31). "Military planners are conscious that the civil sector is leading with regard to artificial intelligence and autonomous systems. As such they aspire to take part in and profit from these developments. He quotes Chris Deverell, who stated that "the days of the military leading scientific and technological research and development have gone. The private sector is to determine how they can be applied to defence and security. In particular, and entirely consistent with the future force concept, I believe we need to look at the disciplines of artificial intelligence and machine learning, autonomy (including man/machine teaming), data analytics and visualisation, behavioural sciences, and simulation and modelling, that are now having a huge impact in the civil sector, but on which, I think, most defence departments lag behind" (Burt, 2018: 31).

Looking into the future, the Economic and Social Research Council (ESRC) believes that "human decision-making could present big vulnerabilities in future defensive systems. With the increasing speed and unpredictability of inbound threats we might need to accept autonomous or highly automated response mechanisms" (cited in PaCCS, 2016). Wen (2017) is of the opinion that "autonomous capability is a critical advantage for any military as it allows the system to react to threats faster with faster iterations within the decision-making loop" (Wen, 2017: 46). Wen further states that "access, is no longer restricted to geography, but also includes communications and electronic networks as they play a greater role in warfare today and will, in the future" (Wen, 2017: 46).

The ways in which unmanned aircraft systems (UAS) are to be used in the future, by militaries, the public or non-state actors, will determine the threat level of these automated UAS. As indicated by Drone Wars UK, "the use of an armed autonomous drone may be problematic, but use of a similar drone fitted with a video camera for intelligence gathering, instead of a weapon, might be considered acceptable" (Drone Wars UK, 2018: 18). The implication of the increased proliferation and advances in technology means that policies on UAS need to be updated, regulations need to be strengthened and the public need to be informed of the "dangers, opportunities and complexities of drone technology" (PaCCS, 2016). Currently, and in the future, education concerning the advantages and disadvantages of UAS technology is evidently required.

2.7 Maritime environment

Another important area in which unmanned systems are defining international and national security, are the new technological advances in terms of the maritime environment. During the study, it become evident that not only are UAS redefining modern warfare in terms of aeronautical development, but so too are unmanned maritime systems adding a new dimension to warfare. Hammond, described the first unmanned air system flown on maritime operations in 2014, as a "new

era of aviation and intelligence gathering in the Royal Navy" (Brooke-Holland, 2015: 25). As "the maritime environment is home to a wide range of unmanned technologies, from airborne assets to underwater vehicles, these UAS can be utilised for various operations, from surveillance and reconnaissance, to exclusive economic zone (EEZ) protection, antisubmarine warfare (ASW) and mine detection" (Maundrill, 2017: 40, 41 and 43).

When reflecting on the UAS versatility, its extended flight hours, manoeuvrability, cost-effectiveness and intelligence gathering abilities along sea routes and borders, it could serve as an excellent "force multiplier" for Naval forces. UAS could contribute significantly to "detecting, disrupting and dismantling unlawful activities" (Dikmen, Atalay and Gumus, 2016: 168) such as transnational crimes, illegal activities along sea routes, sea borders, on the open seas, coastal areas, international maritime zones and international borders (Dikmen et al., 2016:168).

Dikmen et al. (2016) are of the opinion that UAS could be one of the most significant tools for maintaining effective maritime reconnaissance and surveillance, due to the many important benefits that UAS can provide during military operations (Dikmen et al., 2016: 164, 165 and 168). As with UAS, unmanned underwater vehicles (UUVs) can carry out missions that are too dangerous for vessels or submarines with crews aboard. (Ford, Sims and Sterman, 2017) "One of the main aims for many navies looking at increased unmanned use is to remove the human from the loop for safety reasons" (Maundrill, 2017: 40, 41 and 43) Consequently, risks to personnel and assets in a hostile environment or out at sea can be minimised (Dikmen et al., 2016: 168) much the same, as would be, with an unmanned aircraft as mentioned in this study.

Maritime reconnaissance and surveillance UUVs can, for example, be used for autonomous missions. Furthermore, as with all technology, UUVs can be used in constructive or destructive ways. A Bluefin-21 UUV, for example, was used constructively in 2014 to search for the Malaysia Airlines Flight 370 which disappeared after taking off from the Kuala Lumpur International Airport (Gady, 2015). On the nefarious/destructive side, Houthi rebels used a semi-autonomous unmanned armed maritime craft to strike a Saudi frigate in the Red Sea, close to Yemen in 2017 (Ford et al., 2017). Consequently, despite some negative applications for UUVs, there are many positive developments in the maritime environment as will be mentioned.

Currently, the maritime mine counter-measures (MCM) sector is leading the way in the use of unmanned systems, with various nations presently working on, or having already put forward, plans for new MCM platforms and programmes that integrate a high number of such vehicles (Maundrill, 2017: 40). Countries such as Scotland, Belgium, Netherlands, Poland, Norway, France and the UK have been experimenting with autonomous naval UUV operations (Maundrill, 2017: 40-43). As regards counter mine measures, the "US Navy is working on an unmanned surface-based vehicle that can detect, identify and neutralise a mine in a single sortie" (Fernandes, 2013: 52). (A "sortie" means executing a single operational voyage with one vessel.)

The US, the UK and Russia have developed UUVs to patrol their shores. These UUVs and drone boats are used for ISR, mine counter-measures, and to act as decoys for manned submarines. They are similarly used to identify possible threats, both above and below the maritime surface (Ford et al., 2017). Fernandes (2013) mentioned that the US Navy for example, as well as the Royal Australian Navy, are working extensively on MCM, as they are aware of the Chinese navy's tactics of delivering maritime mines with submarines as part of its "offensive and blockade operations" (Fernandes, 2013: 52). Australia, a maritime nation, is especially mindful of the strategic importance of UUVs, due to its vast maritime responsibilities (Fernandes, 2013: 50). As indicated, maritime security is vital to the Australian government as it protects Australia from terrorism around its offshore facilities. Maritime security similarly protects Australia's transportation system across the oceans (Potgieter and Pommerin, 2009: 7). Just as with Australia, many other maritime countries like the US, Germany and SA would regard maritime security as indispensable to its nation's security.

From a human security perspective, maritime security is vital in preventing crimes, such as human trafficking, drug trafficking, piracy, arms smuggling and terrorism at sea. For example, "global maritime security" exists in the United States and sea power is seen as of critical importance to US security and prosperity. Security at sea must be created and maintained to mitigate maritime threats such as drug trafficking, piracy, weapons proliferation, terrorism and any other illicit activities (Potgieter and Pommerin, 2009: 6).

Maritime security equally plays a key role regarding economic and trade development among nations, which can affect national security and human security. Potgieter and Pommerin (2009) stated that most countries around the globe rely on our oceans for international trade in the world economy. Over "80% of worlds trade travels across the sea" (Potgieter and Pommerin, 2009: 5). According to Peoples and Vaughan-Williams (2015: 161) the protection of human security, human dignity and human rights is becoming more and more acknowledged across the world. Whether it is accepted across the world or not, it remains "one of the essential objectives of modern international institutions" (Peoples and Vaughan-Williams, 2015: 161).

Based on the increasing threats, risks and challenges at sea, the maritime environment requires new strategies in dealing with non-conventional threats, for example human-trafficking (Dikmen et al., 2016: 165 and 166), which opposes human dignity and human security. The researcher accepts that both UAS and UUVs can play complementary roles regarding international, national and human security. By combining the collaborative roles that UAS and UUVs can provide to Naval Forces, the result can be increased "Maritime Situational Awareness (MSA), i.e. an indispensable tool for maritime security in the foreseeable future" (Dikmen et al., 2016: 165 and 169).

Maundrill (2017: 43) is of the opinion that should crucial unmanned systems be utilised in the maritime environment, legal dilemmas ought to be avoided. Similarly, operating environments should be carefully considered during the utilisation of unmanned systems. The author explains that the UN

Convention on the Law of the Sea (UNCLOS) has customarily been applicable to manned sea-going vessels and most nations have adhered to this Convention. However, unmanned systems could create perplexing legal issues. The reason for this is because unmanned maritime systems have dual use, similar to unmanned aerial systems. This means that aerial and maritime unmanned systems can be modified and different payloads can be attached to them (Maundrill, 2017: 43). With advances in technology and navies requiring more autonomous operations, "companies are seeking to test and approve sense-and-avoid technologies within COLREG, which are *the international regulations for preventing collisions at sea"* (Maundrill, 2017: 40, 41 and 43).

Besides cautioning against collisions at sea, as with unmanned aircraft systems, another concern raised, which affects maritime law, is the aspect of ownership or accountability. Tung, as cited by Maundrill (2017), "argues that there is currently no exact means of identifying the owner of a UV that is operated in the maritime environment" (Maundrill, 2017: 43). For example, in a widely broadcasted case, Tung stated that China had no legal obligation to return a "USN Teledyne Slocum G2 Glider UUV" to the US navy. With this controversial case, "the navy said at the time that the glider, designed to provide low-cost persistent monitoring, was collecting oceanographic data. China has long been wary of military reconnaissance near its shoreline. This incident however, which occurred at the end of 2016, was within the EEZ of the Philippines and 1,000km from China's coast" (Maundrill, 2017: 43). This example, is but one of the many maritime and aviation predicaments that lie ahead, in the absence of sufficient and credible international regulations and controls in both environments.

From the international trends discussed here, it is clear that the unmanned aerial vehicles rapidly evolved over the years, from unarmed intelligence, surveillance and reconnaissance (ISR) capabilities to armed capabilities (armed drones). So too has the development of maritime 'drones', formed part of the latest advancements. With new technological advances, several advantages and disadvantages can result. Villasenor (2011, online) stated, when discussing security concerns with regard to armed drones, that in the hands of a responsible military this capability is a game-changing asset; in the hands of a rogue group it is a chilling threat.

What is new, therefore, is not the recognition that drones pose a security threat, but that the changes and fast paced developments in technology in the last few years have greatly increased the extent of the threat and the challenges of responding to it. Times have changed. "Due in large part to information technology advances, today's drones are in some respects more similar to smart phones than to cruise missiles – both in terms of size, and in terms of how easy they are to acquire" (Villasenor, 2011, online). Aspects such as these therefore need to be considered globally in terms of the use of unmanned aerial vehicles and unmanned underwater or surface vehicles (maritime drones), within a national security context and within international laws, whether the UAVs are armed or unarmed.

When considering the South African context, the question comes to mind as to how are SA and the SANDF managing in terms of their responsibilities for border security, protection and surveillance – both on land and at sea? (viz. Exclusive Economic Zone [EEZ]). This is relevant especially in light of the critical dwindling SA aviation and maritime resources over the past numerous years.

2.8 Integration of unmanned aircraft into civil airspace

Internationally, many countries are also faced with developments and requirements for unmanned aircraft to be integrated into civilian airspace. “The Federal Aviation Administration (FAA) is currently undertaking a comprehensive overhaul of the National Airspace System (NAS) known as Next Generation Air Transportation System (Next Gen). This is due to the fact that the routine integration of unmanned aircraft into non-segregated civil airspace is important to enable a number of current and proposed applications ranging from military and homeland security to a wide variety of research and eventually commercial purposes” (Paczan, Cooper and Zakrzewski, 2012).

The integration of unmanned aircraft into civil airspace in this study is important because internationally, and in South Africa, it has been a debated issue for many years. Likewise are the ramifications in terms of international law. In terms of future technological trends, autonomy, artificial intelligence (AI) and the 4th and 5th IR developments, it is likely to assume that the integration of UAS into civil airspaces could possibly be to a 1st world country’s (economic) advantage, and alternatively pose a threat to developing countries such as South Africa and the SADC regions, if integration does not occur consistently across the globe.

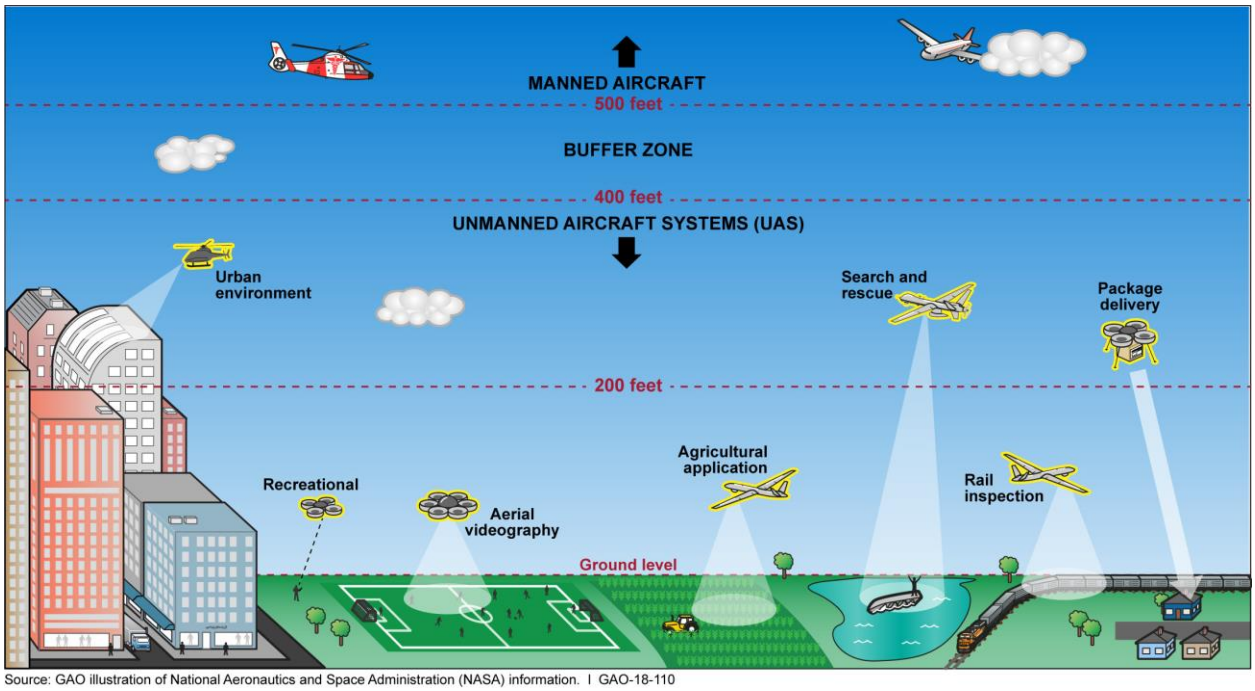
As background, it is important to note how aeronautical safety and management work. In terms of international aviation management and aeronautical safety, the International Civil Aviation Organisation (ICAO) is the governing authority for all the signatories of their charter. This includes all the countries in the world except the USA. The states in the USA subscribe to and are controlled by the Federal Aviation Agency (FAA) regulatory body. The FAA is more practical in its various curriculums and ICAO is more academic, yet they are moving closer to each other. FAA regulates/certifies American aircraft manufacturers and ICAO regulates/certifies all others. American manufactured aircraft operating in ICAO areas are regulated/certified by the local Civil Aviation Authority (CAA) of the country where the aircraft is registered in. FAA audits USA states’ civil aviation operations. ICAO audits the CAA’s and the various CAAs audit the operators in their countries (Steytler, 2019).

Strategic discussions throughout global communities are currently taking place so that organisations can be involved with the access of UAVs into civil airspace, within regulatory frameworks, air traffic, air safety and socio-economic considerations. In 2011, the US revised its Unmanned Aircraft System Airspace Integration Plan to address the multidimensional complexities, such as UAS classes and types, different UAS technologies and mission requirements, regarding the integration of UAS (DOD, 2011: 1-25).

One aspect that currently poses a concern for international UAS integration into civil airspace relates to the fact that global UAS regulations continue to change, with new regulations frequently emerging (Stőcker et al., 2017: 5). Nonetheless, rules were established in the Convention on International Civil Aviation (also known as the Chicago Convention) of 1944 for all manned and unmanned aircraft. Vacca and Onishi (2017: 52) indicates that the intended use of drones (UAS) by the international civil aviation led to Annexes 2, 7 and 13 of the Chicago Convention been revised. According to Article 8 of the Chicago Convention, all unmanned aircraft are forbidden to fly without the required permission, when crossing another states territory. In regions open to civilian aircraft, contracting states similarly need to ensure that unmanned aircraft will be controlled, in order to prevent any threats or hazards to civilian aircraft in those regions. The authors further state that when regulations are issued for state aircraft, contracting states agree that they will have regard for the safety of civil aircraft (Vacca and Onishi, 2017: 52).

Vacca and Onishi (2017: 52) states that it is important to note that Article 3 of the Convention indicates that military aircraft, police aircraft and customs aircraft are all considered as state aircraft which have their own unique set of air rules. Article 3 specifically applies to civil aircraft only, and does not include state aircraft as mentioned above.

In 2013, a concept of operations for UAS Traffic Management (UTM) was introduced by the National Aeronautics and Space Administration (NASA) to enable diverse and routine operations for small commercial UASs. As part of the UTM design, NASA would include other industries, government agencies and local and regional sectors, such as for example, Amazon and Google (see Figure 2.10), to deliver small packages. The UTM concept of operations was designed for operations “below 400 feet and beyond the line of sight” (US GAO, 2018: 34) to allow for “multiple user interactions” (Figure 2.10) (US GAO, 2018: 34). For small commercial UAS to be fully integrated into the national airspace system, the FAA and NASA recommended that a system similar to the “FAA’s air- traffic-control system for manned aviation” (US GAO, 2018: 34) could be used to control access to the national airspace system and to control flight operations.



Source: GAO illustration of National Aeronautics and Space Administration (NASA) information. I GAO-18-110

Figure 2.10: Illustration of a potential model for the National Aeronautics and Space Administration's (NASA) concept of operations for the UAS Traffic Management System

Over the past few years, NASA has been working in coordination with the FAA, academic cohorts, with more than 200 industries as well as many government organisations. The research, development, and testing conducted in this field, for the different technologies that would form the system is being done over four phases with increasing complexity in each stage. The FAA has the long-term vision of fully integrating manned aircraft and small commercial unmanned aircraft into the same airspace. The intention is to use the same procedures and air traffic management systems for this integration. Previously, UAS were required to operate separately from manned aircraft in the NAS. This new approach, will indicate a new paradigm shift in aviation. NASA has held many national and international conferences regarding the UTM. In future, the researcher believes, this will become a highly debated issue and activity across the globe. These activities have already, as example, filtered down to other countries and in South Africa. On the 29 May 2019, the SA CAA held a Drone Integration meeting with all its stakeholders, including the SANDF to discuss the integration of unmanned aircraft into civilian airspace. Other SA CAA study groups are currently also in discussions regarding the integration of unmanned aircraft into civil airspace. The Joint Authorities for Rulemaking on Unmanned Systems (JARUS), an international study group, was formed to gain consensus around regulations to cover all aspects of UAS operations. JARUS experts across the world have the responsibility to ensure that Remotely Piloted Aircraft Systems (RPAS) are operated safely. For this purpose they need to recommend one set of requirements to cover all safety, technical and operational aspects of the RPAS (ALTER Technology, 2019). As mentioned earlier in this study, the term UAS is used by the researcher for "RPAS" terminology.

Suffice to say, the researcher is aware that the integration of UAS into national air space is becoming a critically debated issue and of major concern to the global aviation fraternities in the military, civilian and private spheres of life (as per past discussions with aviation stakeholders). The researcher is of the opinion that the integration of unmanned aircraft into civil airspace could have huge consequences if not correctly integrated and managed by a universally accepted set of international regulations and controls. It is likewise indicated that the integration of unmanned aircraft into civil airspace will make for very interesting research.

2.9 Financial considerations for unmanned aircraft systems

When discussing national budgets of a country, two aspects usually impact on defence budgeting. The first issue, namely whether nations should engage in conventional war, which under the current global economic climate, would be ill-advised as it could cost billions. The second aspect, which relates to the first, is that when defence budgets across the globe are reduced, funds for research and development of new fledgling concepts are often not supported. Reduced funding is then generally used to improve and enhance the performance of existing capabilities, rather than focusing on “cutting edge research into unproven technologies” (Kainikara, 2014: 5). The point made by Kainikara (2014) is that major cost-dynamics arise when defence funding is reduced, and the spread of resources and capabilities could be limited. Often there would be a decline or a stagnation in research and development of cutting edge technology, such as for example UAS. The point made here by the researcher, and as indicated previously in this study, is that with the extreme proliferated pace of the 4th IR developments, AI, cyberwarfare and autonomous capabilities, are declining defence budgets, not becoming an increasing threat to the sovereignty of many countries? Should countries therefore not be searching for alternative solutions for their diminishing budgets and capabilities?

Research has shown that more and more militaries across the world, like the UK, North America, Europe and South Africa are constrained by restricted military budgets (see Appendix C; SIPRI, 2020). The UK has for example pleaded for additional military funding. As reported in 2018, “the head of the British army has warned that the country's armed forces risk falling behind its potential enemies unless there is additional investment” (Reality Check Team, 2018). In South Africa, the Minister for Defence and Military Veterans (MOD&MV) indicated that “the persistent and continued dramatic downward trend in real-terms of the funding allocation to defence has reached a point where the DOD runs the risk of losing more of its essential capabilities, in addition to those already lost” (Reuters, 2017). The MOD&MV maintains that the “Defence should remain mandate driven, and not budget driven as is currently the case” (defenceWeb, 2018a). She further expressed her additional concerns, that “South Africa is on a path of reduced defence expenditure, while some of the countries in the SADC are injecting financial resources to build their military capacity through acquisition programmes” (defenceWeb, 2018a).

The importance of the above statements regarding the deficits of various Defence Forces' budgets across the globe is that one cannot accept that costs are the single most important consideration for defence budgets. According to the researcher, an important aspect to note for example is what the cost advantages could be for using UAS, rather than conventional (or manned) aircraft during the above-mentioned global financial crisis? Another important consideration is the implication of opportunity costs for a country. For example, what could the implications be for a country with old or obsolete technologies, should it have to engage in conflict, or face an adversary, possessing much more sophisticated technologies?

Owing to the unpredictability of the future, the SANDF needs to maintain an essential defence capability. Potential enemies cannot be deterred or be controlled if the SANDF does not possess adequate and credible defence capabilities. In essence, these capabilities "cannot be created from scratch, or be turned on and off like a tap" (RSA, 1996a: 17-18) if the need suddenly arises. Despite the absence of any probable external military threat, the SANDF have the duty to ensure an existing credible defence capability for South Africa, as was stated in Chapter I, and as is stated in the White Paper on Defence, 1996 (RSA, 1996a: 17-18).

Wen (2017), for example, believes that "it may become increasingly impractical to depend on expensive and sophisticated manned platforms to achieve both strategic and tactical objectives' due to the "advent of advanced Surface-to-Air–Missiles, Integrated Air Defence System (IADS), and the introduction of Airborne Early Warning and stealth capabilities" (Wen, 2017: 45). Wen (2017: 53) further believes that "the future is dependent on the willingness of military forces and political governments to expand the roles of UAVs which will in turn drive their research and development, leading to UAVs which will eventually match, and even surpass manned platforms in performance and efficiency" (Wen, 2017: 53).

When comparing UAS's operational uses, relative to costs, the benefits of using UAS during military operations, is much greater (Ronconi, Batista and Merola, 2014: 143). Furthermore, these authors are of the opinion that "the cost-benefit analysis of their use relative to other options – such as the deployment of ground troops – provides a compelling argument in their favour" (Ronconi et al., 2014: 137). Sufficient budgets are needed or alternative strategies could be introduced to exploit the advantages of these sophisticated technologies. Wen further indicated that, while manned aircraft will still play an essential role in the military, UAS will continue to be used for ISR and the "3-D" (dull, dirty and dangerous) tasks in enemy space. Wen (2017) further indicates that it is predicted that unmanned aerial vehicles will in future replace manned platforms. This is thought possible, when unmanned helicopters, unmanned strategic bombers, and technologies for unmanned combat aerial vehicles (UCAVs) have matured sufficiently during the "second half of this century" (Wen, 2017: 53).

Galliot (2016) believes that defence budget figures indicate that the largest overall costs to operate a manned system, comes directly and indirectly from the human resources environment. According

to Galliot (2016), there are many financial advantages for employing UAS. With the increased development of sophisticated software and progressively more autonomous systems, Galliot (2016) believes that an operator can fly up to four unmanned UAS at the same time, as long as the operator does not have extremely challenging tasks to perform (Galliot, 2016: 40). The point made here by the author, is that greater control over a number of systems by a single member can result in reduced manpower, lowered human resource-related costs and decreased overall operational costs for traditional battles.

Another justification for using UAS is because it is believed that training with UAS is cheaper than with manned aircraft. It is said that in contrast to manned aircraft, UAS are largely more automated, thus requiring lower training hours. In addition, UAS technologies can be procured at much lower costs than manned systems, as UAS need not include all the engineering necessities, such as ejection seats, fire suppression systems, and oxygen tanks that are required for manned systems. Manned systems are more expensive as the aircraft is engineered to accommodate the pilot and provide for his safety. This adds to the weight, size and expense of manned aircraft. UAS are usually less expensive, yet not so cheap that they can easily be disposed of. As indicated by Galliot (2016), UAS technology is still in its early stages of development and the long term cost savings cannot yet be determined. Aspects such as compatibility, the reuse of universal parts, and the production of larger numbers of UAS at lower costs, can be indicative of “downstream cost savings” (Galliot, 2016: 40). As illustration Galliot (2016) indicates that “a *Reaper* drone is roughly five times cheaper than an F-22 fighter jet” (Galliot, 2016: 40). The importance of cost comparisons between drones and manned aircraft, is because of the increasing pressure and restrictions placed on financial controllers to curtail defence budget spending, such as in Europe and North America for example (Galliot, 2016: 40). The same can be said for South Africa, and other developing nations.

Kainikara (2014) provided an opposing view. He believes that the latest increased sophisticated technologies add to the costs of UAS. The fact that UAS are increasingly being viewed as mission systems by the military, and no longer merely, as unmanned aerial platforms, demands that these systems are “loaded with a broad range of high-technology sensors and systems that broaden their capabilities” (Galliot, 2016: 40).

Research has shown that as far back as the 1990s the financial and cost benefits of UAS were a debated issue. One cannot compare the costs of training a pilot, or replacing a pilot or an aircraft during war, to the costs of a UAS employed during dull, dirty and dangerous (3-D) missions. Since unmanned aircraft systems have become extremely sophisticated, complex and specialised, a much larger support system is required. It could be possible, that the life cycle costs of consumables and other specialised equipment could cost the same, or more, than manned aircraft. In environments where budgets and resources are strained, as in South Africa, the above-mentioned aspects could be a determining factor for the acquisition and employment of UAS.

Watts et al. (2012: 1688-1689) believes that the years of UAS proliferation has allowed for approved users to exercise unique choices in terms of UAS platforms, capabilities and sensors, despite budget restrictions. Watts et al. (2012) address costs versus miniaturized drone technology, and are of the opinion that aspects such as miniaturized technology and improved reliability could possibly reduce operational costs or acquisition costs. This compared to costs per flight hour or the cost per missions which could be difficult to determine due to varying factors such as the type of sensors, logistical support required, and the different personnel requirements. Despite budget restrictions, years of UAS proliferation have allowed specific sanctioned members to exercise exclusive choices in terms of the capabilities, platforms and sensors they preferred using. Watts et al. (2012) believe that "the continued trend of increasingly miniaturized components promises an era of tailored systems for on-demand remote sensing at extraordinary levels of sensor precision and navigational accuracy" Watts et al. (2012: 1688-1689).

Within South Africa's (SA) prevailing financial climate, and increasing expectations for service delivery, the government's budget has become severely strained. This has led to cuts to SA's defence budget, as well as cutbacks to other government departments' allocations in the public sector, as was indicated in Chapter 1 of this study (Informal discussion at Aerospace Africa and Defence (AAD) Exhibition, 21 September 2018).

This problem is not unique to South Africa, but it is more acute in our case as is with many other smaller powers and their defence environments. Namufohamba (2019) pointed out how for smaller countries, as in the case Namibia, the issue of limited defence budgets remains an import constraint. That is why some countries opt to "contract in" civilian companies to do the job (on the long run, this approach is more expensive, while on the short term it seems – maybe is – cheaper (Namufohamba (2019). In terms of the limited budgets we are currently faced with across the globe, one can definitely relate to Tice's statement, in that, "the bottom line is that we need to increase the combat capability of US armed forces at a price we can afford. UAVs help us do just that" (Tice, 1991: 54). The researcher is of the opinion that militaries increasingly need to think innovatively to move forward from these constraints. When applying this statement to a South African context, even though the SANDF maintains a defensive posture, the policy makers should be educated in this regard, as SA can ill afford not to keep pace with new technological advances, as mentioned in this study.

2.10 Ethical considerations

The study would be incomplete, if the ethics of UAS are not deliberated, whether unarmed or armed UAS are utilised. Human rights groups have called for the banning of UAS as they are of the opinion that these 'aircraft' infringe on their human rights and privacy, especially regarding unarmed UAS with high resolution cameras on board.

Many authors debated the issue of UAS and ethics because it is a highly controversial issue and is likely to become more so. However, only the literature of three authors, namely Benjamin (2013),

Strawser (2013) and Plaws (2013), on the ethics of drone warfare, as reviewed by Franke is mentioned here. Franke (2014: 125-126) mentioned that Benjamin is an activist and that her book, "*Drone Warfare. Killing by Remote Control*", is against UAS (drone) use. Franke cited Benjamin who unequivocally states that "the drone wars represent one of the greatest travesties of justice in our age". She indicated that for Benjamin, "UAVs (UAS) are "death robots", "killing machines" and "killer drones". She further mentioned that Benjamin's book has been one of the most-read books on UAS use and emphasised that Benjamin demands that UAS (drones) are taken out of the hands of the CIA.

Franke (2014: 127-128) further cited Avery Plaw (2013), in Strawser's (2013) book "*Killing by Remote Control: The Ethics of an Unmanned Military"*, and stated that Plaw "concludes the missile attacks have been 'highly effective in eliminating enemy operatives, including key leaders, particularly when these HVTs [high-value targets] are hidden in inaccessible and politically problematic locations like the Pakistan's Federally Administered Tribal Areas (FATA)'". "Furthermore, Plaw (2013) shows that US non-drone operations in the FATA, such as precision artillery strikes or commando raids, have caused much higher civilian casualties than attacks via drones. Therefore, he argues that the issue of proportionality does not provide a basis 'for claiming that US drone strikes in general are either unethical or illegal (although this does not preclude such claims on other grounds'". Franke (2014: 128) stated that the research by Plaw (2013) in this regard has been analysed from data on "the four 'most rigorous and transparent databases that track the impact of drone strikes, namely *The New America Foundation, The Long War Journal, UMass Drone, and the Bureau of Investigative Journalism".*

Franke (2014: 127) is of the opinion that Strawser's book provides impetus for conversations on a "deeper analytical level" concerning ethics and UAS. She further argued that the book addresses many complex and delicate questions concerning UAS, autonomous systems and targeted killings. In the absence of sufficient ethical standards, legislation and policy regarding drones, the researcher suggests that book lovers interested in this topic, can consult Strawser's book.

Based on the complexities of the ongoing debate, ethics will remain a contentious issue. Gusterson (2016) referred to the dilemmas which occur when presidents are not held accountable for their unethical actions involving the uses of armed UAS. The fact that the US are using spy drones in Pakistan and Israeli airspaces, without permission, points to the ethics of their actions. The fact that the US have been involved in war fighting in Africa since the 1950s and that the US are still using armed UAS freely on African soil, and asking permission from no one, is another ethical consideration (Gusterson, 2016: 129). Without clear international legislation, challenges regarding ethics or policies on the use of armed UAS, as mentioned earlier, will continue.

According to the Bureau of Investigative Journalism which is based in London, that has been tracking Drone killings since 2010, US drone strikes have killed between 7584 and 10918 people including

751 to 1,555 civilians in Pakistan, Afghanistan, Yemen and Somalia (US as always claim lower figures) (Press, 2018). The claiming of lower numbers of opponents killed or maimed in attacks in undeclared wars is a general phenomenon and a strategy to maintain the moral high ground. The author's argument here takes in account numbers, but is mainly concerned with the issue of ethics.

Other ethical issues raised by Gusterson (2016: 126-127) were the killing by the US of more non-combatants than insurgents with their fight on the "War on Terror". He further referred to the ethical challenges regarding the fear and "high rates of post-traumatic stress disorders" that the children in Pakistan's tribal areas are suffering from, due to armed UAS which could strike at any moment.

Vacca and Onishi (2017: 62) raised the issue of the misuse of UAS by stating that "private information can be collected by public bodies and private parties without consent", as was mentioned earlier in this study. The point made is that besides the unlawfulness of such actions, such activities are unethical.

Dyndal, Berntsen and Redse-Johansen (2017) referred to the fears and perspectives raised with the maturing and availability of "new types of high-tech weapon systems", such as autonomous UAS. They argued that as "it is almost impossible to assess when these technologies will become widespread, that the difficult discussions on legal and ethical challenges should be dealt with sooner, rather than later" (Dyndal et al., 2017).

Within the global military environments, Galliott (2016: 2) is of the opinion that "there is an urgent and growing need for all those involved in matters of national defence – from policy makers to armaments manufacturers to members of the armed forces – to behave, and to be seen to behave, ethically. The ethical dimensions of making decisions and taking action in the defence arena are the subject of intense and ongoing media interest and public scrutiny".

Aside ethical considerations, psychological aspects with regard to UAS require consideration. In both the films, "Good Kill" (Niccol, 2015) and "Eye in the Sky" (Hibbert, 2016), the drone pilots conducted armed UAS strikes from hundreds of miles from the battlefield. The films illustrate the devastating effects that armed UAS strikes can have on a drone pilots psyche. The UAS operators or pilots often suffer from post-traumatic stress disorder (PTSD), or depression or anxiety, as was noticed in both films (Hawkes, 2015. In another article in the *New York Times*, where a UAS operator was interviewed, the article speaks of the headache, night chills, nausea and chronic digestive problems the operator is experiencing, due to the gruesome images in his mind, following the missile strikes in Afghanistan of "innocent people maimed and killed, their bodies dismembered and their faces contorted in agony" (Hawkes, 2015).

The final question asked here in terms of ethics, is whether the maiming and killing of innocent people, and committing unlawful acts against humanity, with the use of UAS, can be regarded as ethical behaviour? And if not, what steps can the international community take? Likewise, South Africa in its use of drones will have to carefully consider the use of drones.

2.11 Conclusion

This chapter extensively introduced the reader to the world of drones, including their roles and functions and (legal) ramifications. It is clear that the employment of UAS in the international arena has far reaching effects and implications within the global environment, right down to the effects that UAS strikes can have on the pilot or operator behind the controls. Internationally, there are various uses for UAS, both positive and negative. In the interest of national and international security, and human security, the world should guard against the irresponsible use of UAS. Villasenor (2011) stated, with regard to armed UAS, in the hands of a responsible military, this capability is a game-changing asset; in the hands of a rogue group it is a chilling threat. Wen (2017: 53) emphasised that in the future projection of airpower, unmanned aerial vehicles (UAVs) will most definitely play a greater role, despite current challenges, and continue to be "the go-to solutions for many future airpower challenges" (Wen, 2017: 53) because of UAVs many advantages. Examples of advantages of UAVs mentioned by Wen (2017: 53) are flexible design, low unit cost, persistence and autonomy. With no human pilot on board, lives can be saved. Current challenges restricting the wide-ranging uses of UASs during air force operations, are the challenges regarding the integration of UASs into the civil airspace, the complexity regarding political interests, and other UAS system vulnerabilities and management concerns.

The information shared in this chapter on the type of drones and their functions and the use and misuse of UAS also relates to the South African setting. One question in conclusion is what role are South Africa, the South African National Defence Force and the South African Air Force playing in addressing this game-changing asset, or chilling threat? Are we ahead, in line with international militaries, or are we lagging behind? What effect will the diminishing defence budget have on South Africa's national security and its human security, especially in the long term? Will the SAAF (and the SANDF) be in a position to respond adequately and appropriately, should SA face an internal or external threat? How will South Africa within current restraints implement the use of drones within a laden political context and military command under civilian control, which orientate their action in the complex world of international law and other legal restrictions?

In Chapter 3 the national and international legislation regarding unmanned aircraft systems, including international laws and controls mechanisms regarding UAS will be mentioned.

CHAPTER 3: NATIONAL AND INTERNATIONAL LEGISLATION: UNMANNED AIRCRAFT SYSTEMS

3.1 Introduction

In Chapter 2, the different performance classifications, categories, levels of sophistication, and the integration of UAS into the national airspace was discussed. In an environment where great technological advances pose increased aviation, maritime and other border-related threats, as demonstrated throughout this study, various legislation, regulations and rules are required to ensure aviation safety of both manned and unmanned aircraft, and the general public. Coupled to the technological advances, is the Volatile, Uncertain, Complex and Ambiguous (VUCA) world societies are living in. Legislations, regulations and rules are therefore required when utilising unmanned aircraft systems in these environments across the globe. In this Chapter, the national and international legislation regarding unmanned aircraft systems will be discussed, as well as international laws and control mechanisms regarding UAS.

In South Africa, the South African Civil Aviation Authority (SA CAA) is mandated “to regulate civil aviation activities in order to ensure acceptable levels of aviation safety and security within South Africa and among operators” (Kock, 2015: 118-119). This applies to the safety of people and their property on the ground, and for both manned and unmanned aircraft. The national laws regarding aircraft, including UAS, are governed by the 2009 Civil Aviation Act, with specific reference to the regulations in the Eighth Amendment of the SA Civil Aviation Regulations (SA-CAR) of 2015, concerning remotely piloted aircraft (RPA) (as commonly referred to by the SA CAA).

The SA CAA Technical Guidance Material (TGM) for Part 101, provides operational regulations, limitations and prohibitions for RPAS (or UAS as termed in this study). Part 101 is applicable to RPAS (UAS) operations for commercial, corporate, non-profit and private, or individual purposes (SA CAA TGM for RPAS-Part 101: 15). The concern with the current Regulations are that these Regulations are not applicable to military aircraft, and the latter is of crucial importance to this study.

Military aircraft (or state aircraft) are exempted from the Act as well as the Regulations. Currently, no Regulations exist in the SA Air Force either, for the use of military UAS. Draft regulations are in development, and once promulgated, these Regulations will be used by military UAS operators. It is envisaged that these Regulations could be the equivalent of the civilian Part 101 Regulations. Until these Regulations are in place, military UAS operators need to apply to local Authorities (i.e. the SA CAA or the Air Traffic Navigation Services (ATNS), or internally within the SA Air Force, to the Directorate Systems Integrity (DSI), or to the Air Force Command Post (AFCP) when utilising the National Airspace. These special clearances are required prior to every flight to ensure safe operations (Meredith, cited in Helfrich, 2014: 1).

Internationally, the International Civil Aviation Organization (ICAO) “is a United Nations specialised agency, created in 1944 in Chicago upon the signing of the Convention on International Civil Aviation

(Chicago Convention)" (Vilnius, 2017: 23). ICAO assists Member States and aviation organisations across the globe, to develop Standards and Recommended Practices (SARPs). It also provide procedures for Air Navigation Services, to ensure safe UAS operations throughout the world (International Civil Aviation Organization [ICAO], 2011: iii). These international standards and practices (ICAO SARPs) are critically important for global aviation, as countries need to, among others, refer to these regulations, when drafting their own national civil aviation regulations. The point is, these regulations need to be very specific, and be enforceable by law. In short, ICAO oversees 19 Annexes in the Chicago Convention, wherein more than 10 000 SARPs are reflected. These provisions and policies help to ensure that worldwide aviation networks can operate safely, securely and efficiently all over the world (Vilnius, 2017: 23).

As mentioned in Chapter 2, other countries like the United States' national aviation authority, the FAA also have their own Regulatory bodies, and are not signatories to ICAO. As the Civil Aviation Authority in the US, it establishes Federal Aviation Regulations (FARs) for America. In Europe, the European Aviation Safety Agency (EASA) is responsible for civil aviation in Europe. It is responsible to draft aviation safety legislation. EASA is responsible for European regulations, standardisation and certifications, and to coordinate globally with comparable organisations. EASA also assists the EU Member States and the European Commission with technical advice. (European Aviation Safety Agency [EASA], undated: 10). EASA uses a systems approach method to ensure that regulations are standardised and applied in the best possible way, to encourage best and safe aviation practices (Vilnius, 2017: 23).

The Convention on International Civil Aviation, also referred to as the Chicago Convention, was established to ensure aircraft safety, rules of the air and global coordination of air travel. The Chicago Convention contains valuable regulations for civilian aviation, however, clearly excludes military aircraft, as is evident in Article 3(a) (International Civil Aviation Organization [ICAO], 2006: 2). As stated by Milde (2008: 2), the Chicago Convention should clearly specify that it relates to "international **civil** aviation". Since its origin, international air law has excluded military (state) aircraft, and referred to commercial or "civil" aircraft exclusively. Milde (2008) further mentions that the Chicago Convention merely states "what does not apply to military aircraft, or what such aircraft is not permitted to do" (Milde, 2008: 2-3). A concern raised is that, in the past, more attention was paid to the legality of military aircraft operations during armed conflict, than to operations during peace times (Milde, 2008: 2-3). This points to the Convention's vagueness and possible lack of insight.

The Paris Convention of 1919 is considered as the norm for customary international law. It was the "first multinational regulation governing air navigation" (Matignon, 2019). This Conventions' position is equally unclear as it partly includes military aircraft (Article 32) but then further on categorically excludes military aircraft. The concern noted with this Convention is that it is also ambiguous. As illustrated by Milde (2008), the Paris Convention of 1919 draws a clear distinction between military aircraft and private aircraft. In Article 30 (a), military aircraft is explicitly mentioned as State aircraft.

In Article 31, it further indicates that every aircraft which is flown by a serving military member, is seen as a military aircraft (Milde, 2008: 3). However, Article 32 of the Convention provided that “no military aircraft of a contracting State shall fly over the territory of another contracting State nor land thereon without special authorization” (Milde, 2008: 3). Despite the Conventions ambiguity or vagueness, the Conventions are of critical importance to international and national legal frameworks, and to aviation safety across the globe.

From a realistic perspective, national and international Conventions provide vital guidelines for aviation safety across the globe. The concern and critique however, is whether these legislations, regulations and rules will be adhered to by all countries? As illustration, consider the US drone strikes which have raised much concern and policy debate regarding the USs ‘adherence’ or infringement to international laws. Based on research, global legislation has a long way to go. The finest legislations and regulations can be written, yet adherence and execution could be difficult to enforce and fall short of required policy mandates. During this study, it was clear that gaps do exist regarding international legislations and international regulations. These shortcomings could provide for a detailed study for future students.

The researcher is further of the opinion that related to aviation safety and the various legislations, regulations or rules, are the control mechanisms instituted by various countries to ensure adherence to global international laws. In this regard, misuse of UAS could contravene international laws. Excessive and unnecessary accumulation of arms could create national security risks and/or legal concerns. Similarly, such a situation could lead to a potential national security threat, due to weaker states feeling threatened by their neighbours, who have i.e. accumulated excessive armaments in contravention to the Wassenaar Agreement and international stability and security. For this reason, these matters will be discussed later in this Chapter.

3.2 National Context

All aircraft that operate within the National Airspace (NAS) are required to comply with the “rules of the air”, as specified by local authorities (SA CAA) and the International Civil Aviation Organisation (ICAO) (Meredith, cited in Helfrich, 2014: 1). As mentioned, the SARPs provided by ICAO, are technical specifications in line with Article 37 of the Convention on International Civil Aviation. In South Africa, the three main regulations “pertaining to UAS are the South African (SA) Civil Aviation Act, Part 101 of the Civil Aviation Regulations and Part 1 of the Civil Aviation Technical Standards (CATS)” (Cronjé, 2020). The SA Civil Aviation Act is the “backbone” of all flight safety in South Africa (Cronjé, 2020) and applies to all aircraft operating in the NAS.

The South African Civil Aviation Authority (SA CAA) in South Africa, is one of the first bodies internationally in terms of civil aviation and safety which have developed comprehensive RPAS regulations (Motale and Gwebu, 2015). As indicated in Part 101, the 2009 Civil Aviation Act ensures that regulations, controls, safety and security oversight functions are established for aviation. The

Act further ensures that an independent Aviation Safety Investigation Board is established to comply with Annex 13 of the Chicago Convention. The National Aviation Security Program and the Aviation Safety Investigation Board ensure the safety and security of airports and aircraft, and effective control over these areas (RSA, 2009). According to a SACAA March 2015 report, it is illegal to fly UASs if the SA CAA has not granted approval due to the "real safety and security risks presented by his new sector of aviation" (Martin, 2014).

The SA CAA Technical Guidance Material (TGM) for Part 101 provides operational regulations, limitations and prohibitions for RPAS in South Africa. A RPAS may not use a public road for landing or taking off, unless specifically approved by the SA CAA, and may not be operated in a controlled airspace. "No object or substance may be released, dropped or deployed from an RPA, no RPA shall carry dangerous goods as cargo, and no person shall operate a RPA beyond visual line of sight" (2015: 8. SA CAA Technical Guidance Material (TGM) for Part 101). Unmanned aircraft systems (or RPA/RPAS/UAV as they are termed) are not permitted to fly above or adjacent to a nuclear power plant, national key point or strategic installation. Neither may UAS be flown above or adjacent to a crime scene, police station, prison or court of law. UAS may not be flown in swarms or formations. "Unless specifically approved by the SA CAA, no RPA shall be operated above 400 ft above the surface, within a radius of 10 km from an aerodrome, or within restricted or prohibited airspace of airports" (Kock, 2015: 118 – 119). Should operational deviations be required by licensed holders, these exceptions may be approved by the Director of Civil Aviation.

In Namibia, it is legal to fly drones following authority obtained from the Namibia's Directorate of Civil Aviation (DCA). Drones are banned in Madagascar. According to Botswana's national aviation authority, the Civil Aviation Authority of Botswana (CAAB), flying a drone is legal in Botswana. According to Zimbabwe's national aviation authority, the Civil Aviation Authority of Zimbabwe (CAAZ), flying a drone is legal in Zimbabwe (UAV Couch, 2019). From the restricted data obtained, it seems that legislation has a "regulatory gap" in lesser developed countries. For example, in Nigeria, special authorisation is required to fly UAVs.

Regulations with regard to UAS operations differ across the globe. Countries' policies vary in terms of their unique requirements. Most countries have regulations in place for manned-aircraft flights in their airspace. Unmanned aircraft utilise the same airspace and are included as part of the greater regulations but their uses are very restrictive. In most countries, UAS are not permitted to fly near airports, airfields or military air bases, prisons, police stations, national strategic key points, crime scenes, people, property, buildings or roads.

With the above as background, various opinions and writings of other scholars will now be provided.

3.3 International Context

Stöcker et al. (2017: 2 and 26) are of the opinion that many international organisations are putting great effort into formulating universal UAS standards that could be applied globally. Universal

standards which were discussed and recommended are, for example, requirements for pilot licenses, specific technical criteria for UAS, and very specific requirements for UAS operations. Unfortunately, due to the extensive proliferation of UAS technologies, existing UAS regulations and national regulatory frameworks cannot stay up-to-date with the fast-paced improvements of these technologies (Stöcker et al., 2017). The main challenges speak to the continuous necessity "to address new potential harms, risks and negative impacts" (Stöcker et al., 2017: 26). Gilli and Gilli (2019) clarify this point when they state that "military technology has become exponentially more complex", (Gilli and Gilli, 2019: 1 and 2) as current weapon systems comprise many more sophisticated components and subsystems than previously. With Russia and China competing against each other, military technological competition between the Great Powers, is at the core of international politics again. Continuous advances in technology have resulted in possible revolutionary technologies developing within the defence sector. Examples of these technologies are cyber-capabilities, autonomous and unmanned systems, and "quantum computing" (Gilli and Gilli, 2019: 1, 2 and 4).

A challenging aspect regarding UAS and the 21st century, is "the 4th industrial revolution, where technological advancements like artificial intelligence and the 'Internet of Things' mean that humans and digital systems can interact more profoundly than ever before" (Centre of Excellence in Financial Services, 2017: xiii). This aspect, according to the researcher, is more than likely to complicate the establishment of international and universal legislation and prescripts regarding UAS and their associated technologies, especially in light of the proliferated speed at which new technologies are being developed (i.e. autonomous and micro-UAS). It seems clear that 'the emergence of drone warfare in the 21st century appears to have caught the international community off-guard, as the existing laws are not capable of effectively regulating the use of UAVs" (Centre of Excellence in Financial Services, 2017).

The point been made here, is that regulators and policymakers are increasingly faced with uncertainty and challenges as "technological innovation is taking place at unprecedented speed and is disrupting almost every industry in every country around the world" (Geneva Academy, 2015). "This is the challenge for diplomats, military leaders and human rights advocates in the 21st Century" (Geneva Academy, 2015). In a nutshell, one can say that "not only did the 9/11 terrorist attacks change the way the US Military targeted its enemies, it also changed the way international law defined its enemy. This is why drones and the employment of drones as launch vehicles for missiles present such a challenge for international lawyers and human rights advocates. It is not that US drone strikes actually violate international law. Ironically, US drone strikes challenge international law because they (don't conform) to a straightforward legal categorization used in international law prior to 11 September 2001" (Geneva Academy, 2015).

Gruiters (2016 as cited in Friese et al., 2016: 9) states that he and the Armaments Research Services (ARES) are apprehensive with the lack of effective regulations. Gruiters (2016) is concerned that

dual use technology and military technology are rapidly increasing and lacking “any connection with the reality of the booming drone market” (Friese et al., 2016: 9). Stöcker et al. *(*2017) cites the CEO of AscTec UAV, who is concerned that policies and legislation are not keeping up-to-date with technological developments. They also argued that “UAV regulations are still embryonic and that a heterogeneity of national rules and varying levels of implementation can be observed” (Stöcker et al., 2017: 2). Similar opinions were shared six years ago by Abid et al. (2014) who commented that despite several debates held by the United Nations on limiting the use of drones, no clear legislations or unyielding positions could be reached following the numerous debates on the use of drones (Abid et al., 2014: 120). In overviewing global UAV regulations, Stőcker et al. (2017) stated that not one of the UAV regulations “provides a reliable, complete and coherent picture of the worldwide situation” (Stőcker et al., 2017: 5). Even today, research indicates that there still seems to be no clear legislation or policies regarding unmanned aircraft systems. The situation may have improved slightly, but the above-mentioned still applies.

Ryver (2016), on the other hand, is of the opinion that a security context is completely lacking. Ryver (2106) indicates that neither the National Security Agency (NSA) nor the National Institute of Crime Prevention (NICP) has ensured any form of drone software protection, besides those, that exist in the military. Similarly, no framework has been issued by the National Institute of Standards and Technology (NIST) for drone components, hardware or source code (Ryver, 2016). Ryver (2016) points out that of greater concern, is the lack of any type of governance, standards or “or open-source security project related to third-party controls and code bases” (Ryver, 2016). He is of the opinion that in the “very near future” (Ryver, 2016), security measures and standards will be required.

The implementation of such attempts to regulate the use of UAS on the international front are likely to be ignored by self-styled global powers (self-appointed world-policemen) and aggressive regional powers such as Israel. Compare Gwynne Dyer on self-declared world-policemen, possibly turning into what he calls, “dangerous international rogues” (Dyer, 2006); see also Noam Chomsky pointing out several cases where the USA ignored international opinion – even their own allies in NATO (Chomsky, 2007). For similar arguments see Samir Amin on US hegemony (Amin, 2006); see also Uri Davis on Israel’s behaviour in the Middle-East (Davis, 2003).

Vacca and Onishi (2017: 52) are of the opinion that warfare conducted by drones in recent years has become an essential military tool in the war on terror as “international laws lack instruments to deal with this kind of operations”. It is further indicated that with the escalating use of UAS, new legal theories have originated to validate the use of unmanned aerial weapon systems. Correspondingly, different and new meanings were applied to words like “armed attack, civilian, self-defense, and proportionality as war zones had no defined boundaries” (Geneva Academy of International Humanitarian Law (IHL) and Human Rights, 2019). When defining ‘self-defence’ in its global context, what would countries see and define as ‘defence’? Here lies a challenge. Should there be diverse understandings of this very concept, it is likely that diverse interpretations could lead to greater

conflicts in future. Similarly, it could lead to states interfering in the territorial integrity and sovereignty of another state (Geneva Academy of International Humanitarian Law (IHL) and Human Rights, 2019). Taking the US drone strikes against Afghanistan, Iraq, Syria, Libya, Pakistan, Somalia and Yemen as illustration, the ways in which the US have used these drone strikes have raised much concern regarding the adherence to international laws and the legality of such strikes (STIMSON, 2018: 11). “The US’ use of UAVs in the “War on Terror” exemplifies these inadequacies, as the program appears to be illegal in many ways. Despite the repeated use of UAVs with devastating effect, the US government cannot indicate with any clarity its adherence to the principles of necessity and proportionality” (STIMSON, 2018: 11).

Another controversial issue is the question, on which no consensus has been reached yet, What does international law (IL) see as “a battlefield” and what does IL see as “hostile territory”? As pointed out in the past, many of the US “drone” strikes were conducted in secrecy, as in Pakistan for example, and in contrast, to what was seen as a ‘hot battlefield’, according to international law (Geneva Academy of International Humanitarian Law (IHL) and Human Rights, 2019). It is clear that “drone strikes raise an international and human rights debate which involves important issues such as international peace and security and the territorial integrity and sovereignty of states” (Vacca and Onishi, 2017: 52). This point is supported by the concerns and challenges raised at numerous United Nations Institute for Disarmament Research (UNIDIR) symposiums. All states are in agreement regarding the importance of complying with international laws when using armed UAVs, yet governments cannot agree to the explicit international legal standards applicable. International norms and accountability is further challenged by the secrecy in which armed UAVs are used, as well as the self-recognized world powers who do not abide to the international laws (UNIDIR, 2017: 17). The point is that with the employment of armed UAS, most challenges and concerns cannot merely be solved by ensuring stricter controls regarding the transfer or possession of armed UAS (UNIDIR, 2017: 17).

In terms of the various international laws regarding the use of unmanned aircraft systems, whether with unarmed or armed use, there is a danger with UAS proliferation in the interpretation of these laws. Careful cognisance of the important legal frameworks, such as The Hague Rules of Air Warfare, The Geneva Conventions, the Law of Armed Conflict, International Humanitarian Law, and the United Nations Charter, should be taken note of when operating UAS in national and international airspace.

The adherence to these international laws is vitally important. Countries should specifically be aware of the legal and policy implications when using UAS in conflict situations. When used in conflicts and battles, UAS employment is governed by the Law of Armed Conflict (LOAC) and the Rules of Engagement (RoE). Doctrines and controls consequently need to underpin UAS use and alignment to International Humanitarian Laws, principles of military necessity, proportionality, humanity and legitimacy (STIMSON, 2018:11 and Brooke-Holland, 2015: 33-34).

According to the Geneva Academy of International Humanitarian Law and Human Rights article of 2017, there are various countries with armed drones, drones used in combat, developing armed drones, and drones being produced domestically (Geneva Academy, 2015) (see Appendix C). A concern identified in this study is the Second Generation of armed UAS (drone) operators, those who have imported armed UAS and have armed UAS in service, specifically among the non-state actor group (Frew, 2018) (see Appendix A.2). When reflecting on international law in terms of armed UAS, it should be indicated that there are three types of international law which should be understood when employing armed UAS, namely "(i) the law relating to the inter-state use of force (*jus ad bellum)*, (ii) international human rights law (IHRL), and (iii) international humanitarian law *(jus in bello)* (McDonald, 2018: 15; UNIDIR, 2017: 19). The way in which unmanned aircraft weapon systems are used will determine which one of the three laws will apply, and in what way (UNIDIR, 2017: 19). The laws as indicated above are very intricate and require detailed discussions for exact understanding, specifically should militaries be deployed or be involved in any kind of conflict, skirmishes, battles or full blown war. It is not the intention of this study to delve in depth into these laws, but to discuss them within the parameters of the study.

3.4 International control mechanisms

Legislation, regulations and rules alone, cannot deter the use of UAS. The laws, policies and controls governing UAS employment, imports and exports also play a critical role especially when UAS are imported and exported between various countries. Research has ascertained that with the ease of access and proliferation of UAS technologies, most countries, if not all countries globally, need to adhere to international laws and controls and more specifically with regard to armed UAS.

In terms of the imports and exports of drones, a transformation which is taking place is that countries are increasingly procuring UAS from Israel and China, and not from the Western States which have previously dominated the UAS environment and who initiated global UAS norms. In the case of Israel, the country already started research on drones and using drones during the 1970s, some of which were later possibly sold to, among others, the USA and apartheid South Africa, the latter embroiled in the war in Angola (1975-1989). Others claimed that South African drones were home-grown products (Steyn, Van Loggerenberg and Van der Walt, 2005: 20-24). Furthermore, McDonald (2018) indicated that there are an increasing number of states that are procuring UAS capabilities, and are "developing their own home-grown platforms" (McDonald, 2018: 5). McDonald (2018) is of the opinion that part of the reason for this new import and export trend is because of the existing US regulatory regimes and export controls which have prevented states from acquiring armed drones, specifically those who are trading with China. Under the Trump administration, it has been revealed that in response to the increasing procurement of UAS from Israel and China, the US is considering reducing its drone export restrictions so that the US can compete against the Chinese and Israeli manufacturing companies. Analysts, military specialists and civil society groups are of the opinion

that “states should develop open and transparent international standards on the export and subsequent use of armed drones” (McDonald, 2018: 5).

The European Union (EU), like the US, is another group of countries who actively adhere to the global arms trade regulations. Various international agreements, such as the Arms Trade Treaty for example, which covers the trade and transfer of armed UAS, were developed to regulate the production and sales of specific weapons. Other regional and national export controls are also in place to regulate the export of UAS components and armed UAS. Both the Consolidated EU and National Arms Export Licensing Criteria and the Missile Technology Control Regime (MTCR) are important global defence industry and armed UAS regulations. McDonald stated that “some experts argue that they (UAS) should be separated from this regime and be considered as aircraft” (McDonald, 2018: 5). The reason for mentioning this is that there are numerous international laws, regulations and controls which should be considered when discussing, not only global conventional arms deals and their technologies, but also armed UAS, which form part of the dual-use goods and technologies. Appendix C provides a synopsis of the different regulations or mechanisms which are pertinent to having UAS assets and/or exporting them (UNIDIR, 2017: 13).

Despite of the various international agreements and treaties which exist for the trade and possession of armed UAS, there is no comprehensive mechanism that exists to fully address the concerns raised around armed UAS. There are various mechanisms which have been established and adapted to prevent armed UAS from being available for (a) Misuse, among others, and in particular violations of international law; (b) Use as delivery platforms for weapons of mass destruction (WMD); and (c) Contribution to excessive Accumulations of Armaments (UNIDIR, 2017: 13). For simplicity, some of the mechanisms for increasing transparency and oversight of UAS (as per Appendix C) are mentioned here.

3.4.1 Misuse of UAS, in particular violations of International Law

In order to prevent the misuse of UAS, or violations of international law, mechanisms such as the Article 36 of 1977 Protocol I Additional to the 1949 Geneva Conventions; the Arms Trade Treaty (ATT); European Common Position on Arms Export and the Joint Declaration for the Export and Subsequent Use of Armed or Strike-Enabled UAVs were established. In essence, Article 36 of 1977 Protocol indicates that all states are obliged to ensure that the employment of any weapons is not prohibited by this protocol and would not violate any international laws. This includes the “development, acquisition or adoption of a new weapon, means or method of warfare” (UNIDIR, 2017: 15). The importance of Article 36 of 1977 Protocol I is that in terms of UAS, whether remotely controlled or be it an autonomous system, a country may not employ such a weapon system if it could cause inhuman suffering. The Arms Trade Treaty (ATT) is a legal international binding mechanism which requires all 28 EU member states to ensure that no conventional arms transfers or armed UAS transfers would be conducted in contravention of international humanitarian laws, or

any other international human rights laws. It has as highest goal to ensure shared international standards for eradicating illicit trade, and ensuring global peace and security (UNIDIR, 2017: 15). The importance of the European Common Position on Arms Export is that "it imposes stricter criteria than the ATT and also requires states to take into account behaviour of the importing state, for example its relation to terrorism, and the risk for diversion" (UNIDIR, 2017: 16). This legally binding mechanism expects member states to control the export of all military goods and dual-use goods, of which armed UAS are part of (UNIDIR, 2017: 16). The Joint Declaration for the Export and Subsequent Use of Armed or Strike-Enabled UAVs was initiated by the US to provide common standards for Armed or Strike-Enabled UAVs (UNIDIR, 2017: 16). During the DIRCO (focus group) interview (2019), it was stated/mentioned that "in October 2016, 51 governments (including SA) agreed to a Joint Declaration for the Export and Subsequent Use of Armed or Strike-Enabled UAVs. The intent behind this effort is not to constrain or otherwise prohibit indigenous production of these systems, or to establish an entirely new export control regime. Rather, it seeks to promote International Standards that would constitute a political commitment and would focus on transparency and confidence building for exports of armed or strike-enabled UAVs, consistent with the goals of such instruments and regimes as the Wassenaar Arrangement (WA), the UN Register of Conventional Arms (UNROCA), and the Arms Trade Treaty (ATT). These efforts are ongoing" (DIRCO Focus Group interview, 2019).

Unfortunately, this mechanism is not legally binding and has no control mechanisms in place to monitor these systems (UNIDIR, 2017: 16) to prevent the use of UAS, however large or small as delivery platforms for WMD. Three mechanisms, namely the UN Security Council Resolution 1540, the Missile Technology Control Regime (MTCR), and the Hague Code of Conduct (HCoC) were introduced. These were based on concerns by States that UAS could be used for biological, chemical or nuclear warfare. The UN Security Council Resolution 1540 has as its goal to ensure that states do not assist non-state actors to procure any material or technology, such as unmanned delivery systems, which can be used for biological, chemical, nuclear warfare, or for WMD. This Resolution stresses adherence to domestic and export regulations and end-user controls (UNIDIR, 2017: 13).

The MTCR aims to control and limit exports and the spread of ballistic and cruise missiles and other unmanned systems (or UAVs) which are capable of delivering weapons of mass destruction (US GAO, 2012: 4; Brooke-Holland, 2015: 16; DIRCO (focus group) interview, 2019). This informal and voluntary control regime applies to both unarmed and armed UAS. It provides policy guidelines to assist countries to exercise restraints for technology transfers that could contribute towards WMD. The MTCR Annex governs the export of UAS. It distinguishes between complete UAV systems which are highly sensitive (Category I), and between complete UAV systems which could contain more risky components (Category II), depending on the payload and range capability. Category II includes production facilities designed for UAV systems, components and other related equipment (UNIDIR,

2017: 13 and US GAO, 2012: 5) as confirmed during my interview session with the DIRCO (focus group) interview (2019).

US GAO (2012: 5) indicate that the most sensitive UAVs are the Category 1 UAVs. Strategic UAVs which have a 300km or greater range and can carry payloads of 500kg or more, are Category 1 UAVs (US GAO, 2012: 5). Category 1 exports usually only take place when there are binding commitments and agreements between contracting governments for these highly sensitive UAVs. The receiving government is required to provide assurances that the UAVs will be used "only for the specific purpose or end-use as requested, in line with the MTCR guidelines" (Kellerman, 2019). These precautionary measures remain the responsibility of the receiving government. The point here, is that the utilisation of Category 1 UAVs need to adhere to international laws.

"Category II UAVs are considered less sensitive, consisting primarily of UAVs that do not meet Category I criteria" (US GAO, 2012: 5). Category II items have more flexibility and less limitations when transferring these systems. This Category includes dual-use missile-related items, less sensitive components, and other complete systems with ranges of up to 300 kilometres, irrespective of the payload it is carrying (As discussed and confirmed during the DIRCO interview session). These items are usually not subject to the MTCR, yet they need to be assessed by national export control systems. Should the intended technologies be exported for use as weapons of mass destruction, these items need to adhere to the MTCR guidelines (US GAO, 2012: 5). The responsibility for the safe and responsible use of these systems lies with the operator of the system.

There are approximately 35 countries that are members of the MTCR, to mention a few, Australia, Brazil, Canada, Denmark, France, Germany, Greece, India, Japan, Republic of Korea, Russian Federation, South Africa, Switzerland, United Kingdom and the United States (US GAO, 2012: 4 and 5). These MTCR members have contracted to consult each other before exporting any item that one of its other members have indicated as "denied" on their MTCR lists, in accordance with their guiding principles (US GAO, 2012: 5). The challenge remains whether all signatories will keep to this commitment and how to ensure effective and transparent monitoring in this area.

In summary, it is said that the MTCR has not sufficiently limited UAS proliferation and its related technologies. The MTCR has fallen behind with technological advancements, such as i.e. dual-use technologies, as contained in autonomous air-vehicles and ballistic missiles. The huge evolution and increase in production of these technologies have resulted in the MTCR not been in a position to monitoring and control their transfer and exports (DIRCO (focus group) interview, 2019). With this being the point in case, the researcher questions what long-term effects the availability of these sophisticated technologies will have, and who would be owing and using them? What effect would this have on international legislations, and on South Africa's and SADC's national security?

The Hague Code of Conduct (HCoC) was instituted to augment and strengthen the MTCR. It provides practical steps to prevent various missiles being used for WMD (i.e. chemical, biological,

related technology) and has use-related transparency measures. As discussed in this study, it is known that payloads can be attached to UAS to be used as WMD. As of November 2019, there are 140 nations that are members of the HCoC (for member's interested, a list of subscribing states is available on the HCoC website). The HCoC controls or limits the "development, testing and deployment of ballistic missiles capable of delivering WMD" (UNIDIR, 2017: 14). The HCoC guidelines are not legally binding and can be implemented by any country. When discussing international concerns regarding armed UAS, it can be of significance for the required international responses (UNIDIR, 2017: 14 and Center for Arms Control and Non-Proliferation, 2019).

3.4.2 Excessive accumulations of armaments

Several international mechanisms exist to detect and prevent the excessive availability of armed UAS transfer and holdings, and conventional weapons. The three mechanisms used to prevent the destabilising or excessive accumulations of armaments are the United Nations Register of Conventional Arms (UNROCA), the Wassenaar Arrangement (WA) and the 2011 Vienna Doc of the Organisation for Security and Cooperation (OSCE) (UNIDIR, 2017: 14).

The United Nations Register of Conventional Arms (UNROCA), was established by the UN General Assembly to promote stability, serve as early warning for conflict, and build confidence between member states. It aims to promote improved transparency regarding conventional arms assets and their transfers. It is a voluntary mechanism, which encourages its member states to provide information on the amount of arms they import and export, of which armed UAS form part (UNIDIR, 2017: 14).

The Wassenaar Arrangement (WA) on Export Controls for Conventional Arms and Dual-Use Goods and Technologies was the first global multilateral arrangement, which was established in order to contribute to internal, regional and international security and stability (WA Secretariat, 2018; DIRCO (focus group) interview, 2019).

Its purpose is to promote greater transparency (similar to the UNROCA provisions) and accountability for international arms transfer of conventional weapons. It was designed to prevent unauthorised transfers or re-transfers of items contained within two control lists – one for munitions and the other for dual-use goods and technologies in order to protect against destabilising accumulations of certain conventional weapons and dual-use technologies/items, including UAS that can employed for military-end use purposes (Brooke-Holland, 2015: 16; WA Secretariat, 2018; Kellerman, 2019; UNIDIR, 2017: 14).

The WA efforts are specifically directed at the global fight against terrorism and seek to ensure that military capabilities are not developed, in contradiction to the WA's goals. It aspires to prevent any individual terrorists or terrorist groups and organisations from acquiring these dual-use goods and technologies and conventional arms for nefarious purposes (WA Secretariat, 2018: 4).

The WA is an informal export control system. Complementing other existing mechanisms, its main aim is to focus on international and regional peace and security threats, which could arise, should sensitive dual-use goods and technologies or certain armaments be exported to countries posing great threats to other countries. By means of members' shared national restraints' policies and enhanced cooperation, the WA can deal decisively with a state or a region should its behaviour create grave concern to other states/countries. The acquisition of sensitive dual-use goods and technologies and armaments for military-end use may then be denied (WA Secretariat, 2018: 4; DIRCO, 2006).

In line with Article 51 of the UN Charter, the WA "does not interfere with the rights of states to acquire legitimate means with which to defend themselves, nor does it, impede bona fide civil transactions" (DIRCO, 2006; WA Secretariat, 2018: 4).

There are approximately "42 countries that are members of the Wassenaar Arrangement who share the same goal of limiting the spread of certain conventional weapons and sensitive dual-use items having both civilian and military applications" (US GAO, 2012: 4) and Brooke-Holland, 2015: 16). The participating states are Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States (WA Secretariat, 2018; DIRCO, 2006).

It is evident that "international export controls on UAS technology are regulated by two multilateral export control regimes, namely the Missile Technology Control Regime (MTCR) and the Wassenaar Arrangement (WA)" (Brooke-Holland, 2015: 16; US GAO, 2012: 4; Kellerman, 2019; DIRCO, 2006). South Africa is also part of both the MTCR and the WA which are "voluntary, nonbinding arrangements among like-minded supplier countries" (Brooke-Holland, 2015: 16). South Africa also needs to adhere to these control mechanisms when exporting or importing UAS from other countries, as is the case, with the other 41 countries.

The 2011 Vienna Document of the Organization for Security and Co-Operation in Europe (OSCE) is applicable to armed UAS. It covers important defence planning and transparency information, as well as major weapon systems information regarding military forces to complement the various international mechanisms as mentioned in the above paragraph, to safeguard international security and stability (UNIDIR, 2017: 15).

3.4.3 Challenges and restrictions regarding these mechanisms

Despite the institution of the above-mentioned control mechanisms, there are certain challenges and restrictions regarding these mechanisms, when it comes to the availability of armed UAS. Firstly, uniform transparency cannot be ensured. UNIDIR (2017) states that although both the Security

Council resolution 1540 and the ATT (which does not have global membership) impose binding responsibilities on States in terms of export controls, “there is scope for ambiguity that could lead to variation in national implementation” (UNIDIR, 2017: 16). Secondly, the challenge exists in resolving different interpretations of the regulations. In the world of realist politics one can assume that countries, especially the producers and users of offensive platforms would be reluctant - even secretive - about their platforms, the capacity thereof and their respective strategies for the use thereof as well as their planning for the future (strategy). For example, the Wassenaar Arrangement (WA) and the Missile Technology Control Regime (MTCR) provide very specific but not legally binding export control guidelines, in contrast to the broad guidelines stated in the Security Council resolution 1540 and the ATT. One downfall to the MTCR is that it makes no distinction between unarmed and armed UAS and merely addresses technical thresholds, which can be bypassed by designing UAS just below the technical thresholds. As discussed in this study, the innovative sophistication of smaller platforms (i.e. miniature UAS) can compound the concerns regarding technical thresholds as these tiny weapons could be used to deliver WMD. The Wassenaar Arrangement does however control UAS that can fly beyond the operators line-of-sight (UNIDIR, 2017: 16 and 17). Unfortunately, this creates much ambiguity for countries when dealing with armed UAS. Another challenge raised is one of how armed UAVs are defined by different governments or organisations. As illustration, the Security Council Resolution 1540 does not include the various definitions for “unmanned aircraft systems,” unlike the ATT and the United Nations Register on Conventional Arms (UNROCA). The concern raised here is, simply stated, that weapon payloads can be attached to unarmed aircraft systems for nefarious purposes, as was indicated earlier in this study. Lastly, the challenge remains as how to better reconcile concerns regarding armed UAS with different mechanisms or regulations serving different purposes. With the advancement of sophisticated UAS technology, and the distinct challenges of armed UAS, specific mechanisms and standards would need to be implemented in future without distracting from their main objectives and purposes (UNIDIR, 2017: 16 and 17).

3.4.4 Other concerns and threats

Another concern to consider is the fact that, according to Friese et al. (2016: 51), existing export controls on arms and other military material, in general, do not capture consumer-off-the-shelf (COTS) small UAVs “or their electronics, presenting a significant challenge”. This is because they “are not subject to the Wassenaar Agreement’s Dual Use List (9.A.2) covering UAVs though they may be controlled to some degree” through the eight criteria of the European Union’s Common Position on arms exports (Zwijnenburg & van Hoorn, 2015 cited by (Friese et al., 2016: 51). Friese et al. (2016) further indicated that the “use of small COTS UAVs has also created significant problem for civil aviation authorities around the world” (Friese et al., 2016: 52).

In addition, of critical importance are the threats and concerns that revolutionary technologies may pose to developing countries. As the barriers to UAV manufacturing lower over time, governments

of many nations with underdeveloped economies will likely encounter pressure to open their doors to these companies or lose them to competing nations. “Even developed nations are struggling with the rapidly changing UAV environment, with some companies suggesting they are prepared to move business elsewhere if UAV operation and export regulations do not favour them or move quickly enough” (Trotman as cited by Friese et al., 2014). Perhaps a greater challenge still is the need for a harmonised, global approach to export controls in order for such measures to affect non-state armed groups in a meaningful way. With Chinese and Israeli (McDonald, 2018), UAVs constituting a significant portion of the items seen within non-state actors’ arsenals, “efforts to control exports from Western nations alone may have little effect” (Friese et al., 2016: 52). Again, the political/ideological orientation and strategic interests in maintaining or extending (global) power by larger states play a complicated and multi-faceted role here. The same apply to ‘smaller’ states that feel themselves beleaguered, victimised or under pressure from the West – especially the USA – such as Iran and North Korea.

3.5 Conclusion

In this Chapter, domestic legislation (i.e. 2009 SA Civil Aviation Act and the SA Civil Aviation Regulations) and international legislation (i.e. ICAO SARPs, Chicago Convention and the Paris Convention of 1919) were discussed. Rules of the Air and the importance of national and international legislation, or legal frameworks were mentioned. Concerns regarding the gaps in legislation were raised. Important issues relating to the various legislations, rules or laws of a country, such as the required control mechanisms instituted by various countries to ensure adherence to international laws, were discussed. Of importance is that the misuse of UAS could violate various international laws, and therefore UAS require control mechanisms in coordination with national and international legislation or laws.

With no appropriate international regulations and controls in place with regard to unmanned aircraft systems (unarmed or armed), security threats will remain the order of the day. In the words of President Barack Obama, “I think in creating a legal structure, processes, with oversight checks on how we use unmanned weapons is going to be a challenge for me and for my successors for some time to come” (Bowden, 2013). This situation under the Presidency of Trump has hardly bettered. On the contrary, it became more muddled, more complex and unpredictable.

In Chapter 4, the South African perspective on Defence and UAS is discussed against the background of the previous chapters and in terms of the objectives of the study.

CHAPTER 4: SOUTH AFRICA

4.1 Defining national

Williams (2015) defined security as “the alleviation of threats to cherished values; especially those which left unchecked, threaten the survival of a particular referent object in the near future” (Williams, 2015: 6). For Holsti (1988), national security is encapsulated under the assumption that (foreign and defence) policy has an objective to ensure the sovereignty and independence of the home territory and to perpetuate a particular political, economic and economic system based on that territory (Holsti, 1988: 124). Paranjpe links foreign and defence policy to national security policy. He argued that “a national security policy is one that seeks to protect national security and thus take care of the national interest of the nation-state” (Paranjpe, 2013: 3).

Whichever definition of national security is accepted by an individual, the context of this study regarding the use of unmanned aircraft and their effects on national security, whether domestic, regional or international, should be carefully considered as the world is a set of interrelated systems. “Security is an all-encompassing condition in which individual citizens live in freedom, peace and safety; participate fully in the process of governance; enjoy the protection of fundamental rights; have access to resources and the basic necessities of life; and inhabit an environment which is not detrimental to their health and well-being” (RSA, 2015b: 1-2).

For the purposes of this paper, the researcher defines national security as freedom from violence, threats of interference, a nation’s ability to pursue its values, cultures, economic, political and social development in pursuit of its own unique sovereignty and independence, without fear of internal and external incursions/invasion from intelligence, surveillance and reconnaissance (ISR) mechanisms/systems, terrorism, espionage and/or from any new form of 21st century warfare.

The fact that the international security environment has changed so radically and that we are living in a progressively unstable and complex world, should be taken into account when discussing the use of unmanned aircraft systems (armed or unarmed) in a regional, national and international security context. Factors such as, for example, the increased risks due to acts of terror, cyber threats, international crime and proliferation of weapons of mass destruction serve as examples of the unstable world we are living in. Add inadequate political governance, economic unpredictability, poverty, weak and failing states, large states in search of global hegemony, competition over scarce resources, poor human security and maritime insecurity and we are faced with deeply vexed (and in cases unpredictable) challenges.

The Defence Review states that since 1998, the international security context has changed quite considerably, and the world has become more complex and unstable, with increased security risks to international and domestic security. “South Africa’s national security is centered on the advancement of its sovereignty, democracy, national values and freedoms, and its political and economic independence. To this end it is clear that there is both a domestic (i.e. sovereignty and the

related priorities of territorial integrity) and a regional (i.e. stability, unity and prosperity of the Southern African region, and the African continent) dimension to national security" (RSA, 2015b: iii-iv).

4.2 Civil-military relations

The national security and national interests of a country cannot be discussed in this study, without addressing a critical element such as the civil military relations between the military and the state, which go hand in hand, and add another dimension to the total national security context. According to Liebenberg and Potgieter (2012: 125), the "first democratic elections in April 1994 contributed to significant change in civil-military relations; between elected civilians in parliament and the military institutions" in South Africa. With this merging of the previous opposing armed militaries, new civil-military culture and relations developed, where human security and state security principles would feature prominently in all new policy documentation. Civil-military relations (CMR) in the newly elected democratic SA were indicative of a country with new values incorporating, "not only military, but political, economic, social, technological and environmental dimensions. It also included aspects affecting the quality of life of people, freedom, justice, prosperity and development for all South Africans" (Liebenberg and Potgieter, 2012: 128, 130 and 131).

The following narrative serves as example, when assessing the role and impact which UAS could have on CMR in an African context. "Nongovernmental organizations operating in and around Goma for example, have voiced strong concerns that peacekeeping drones are blurring the line between military and humanitarian action, and that because communities have not been sufficiently informed about why drones are being used, they assume that the drones are being deployed for military purposes" (World Vision, 2014 cited in Sandvik, 2015: 87). Sandvik (2015) is thus of the opinion, that as per the above example, "peacekeeping drones can also impact civilian-military relations, as well as the relationships between peacekeeping missions and local populations" (Sandvik, 2015: 87).

The "revolution in military affairs" (RMA) has resulted in military forces around the world thinking entirely differently about warfare. Innovation in civilian technology has enhanced military capabilities and old and new concepts of war are being merged. Non-military systems are being attacked, as well as countries' communication and critical infrastructures by means of cyberwarfare. This paradigm shift, with warfare being fought in an "information and digitised" environment, requires balance, negotiation and collaboration between the military and civilian authority to address future national security challenges and threats (Peoples and Vaughan-Williams, 2015: 185-199).

As indicated above, the global environment is constantly undergoing profound changes, so too will the relationships between militaries and civilians across the world. With the "revolution in military affairs," the proliferation of new technologies like unmanned aircraft (armed or unarmed), 3D technologies, artificial intelligence and the future merging of digital, undergo continual changes. So too, will the combining of the digital, physical and biological worlds with the coming of the 4th industrial

revolution, necessitates that the relationships between the military and the civilians be addressed and improved.

Adedeji Ebo defined CMR as follows: “Civil-military relations refer to the web of relations between the military and the society within which it operates, and of which it is necessarily a part. Such relations encompass all aspects of the role of the military (as a professional, political, social and economic institution) in the entire ambit of national life. Civil-military relations involve issues of the attitude of the military towards the civilian society’s perception of, and attitudes to the military, and the role of the armed forces in relation to the state” (Ngoma, 2006: 1).

The literature study has indicated that there is a definite overlap between the military and civilian society when discussing technological advances such as unmanned aircraft systems, autonomous weapons, unarmed and armed UAS. Whether the technology is used by the military, as with armed weapons, or unarmed and merely for intelligence, surveillance and reconnaissance (ISR), or whether civilians are using the technology for agriculture, for medical deliveries in remote areas, or for mapping of terrains, the implication is that there will frequently be an overlap in terms of the uses and reasons for their employment within a military or civilian sphere. Where there is a civil-military relations gap (i.e. some civilians view the state, specially the defence force, with suspicion), one has to be careful to ensure that civilians understand the use of UAS by the military – which in SA is specifically the SANDF and the SAAF. Civilians may also complain that surveillance by drones, like any other surveillance, interfere with their human rights and their rights to privacy as was mentioned in this study. These reasons are normally used by member of the public, as counter arguments, by those opposed to the use of drones.

This study indicated that there is space for civilian-military cooperation to save costs. If civil-military relations are good and open, civilian contractors may be chosen (with great circumspection) to assist the military with development projects. Post-Apartheid SA serves as such an example, where the SA military had to be downscaled and rationalised and its offensive posture be transformed to a more cost-effective and defensive posture. This is unlike the pre-Apartheid era, where arms could be obtained during sanctions, with unexpected hidden costs and subsequent unintentional consequences, such as unforeseen escalating costs (Liebenberg and Potgieter, 2012: 128, 130 and 131).

It is precisely within this arena that collaboration and negotiation between the military and their civilian counterparts be conducted in order to address future security challenges within rapidly evolving technologies for warfare, as is the case with UAS which are taking a greater stage on international and national news channels, day by day.

4.3 Civil-military partnerships

When discussing CMR, one needs to discuss the importance of the cooperation and collaboration between the military and various Defence industries or defence partnerships. In South Africa,

companies such as Denel, Paramount and Milkor (Pty) Ltd have healthy defence industry relations with the SA National Defence Force, especially with regard to the latest development in UAS (armed and unarmed). As stated in the 2015 SA Defence Review, the Defence Force must develop its own UAS capabilities (RSA, 2015b: 15-22), and the researcher strongly supports this view, based on much literature research. With global advancements in UAS technologies (armed and unarmed), SA and the SAAF need to ensure that the UAS capabilities are developed in accordance with global standards, as far as it is feasible and cost-effective.

As indicated by Rango, Laliberte and Browning (2010: 608-611), internationally "civilian applications of Unmanned Aerial Vehicles (UAV) have been expanding rapidly. Thanks to military development many civil UAVs come via the defense sector. Although numerous UAVs can perform civilian tasks, the regulations imposed by FAA in the national airspace system and military equivalent agencies in restricted airspace need to be closely considered and followed in order to make progress in civilian applications. Personnel at the Jornada Experimental Range have developed approaches to abide by FAA and military regulations. Because of this, the enormous potential of UAVs for rangeland assessment, monitoring, and management is starting to be realized".

SA companies like CSIR, ATE and Milkor (Pty) Ltd have all developed South African military unmanned aerial vehicle concepts, ranging from hand-launched drones with intelligence, surveillance and reconnaissance (ISR) functions to larger armed unmanned aircraft. The contribution by the SA Defence industries to the SA military have assisted in maintaining an SANDF defence capability, and has assisted with growth in SA's economy. These SA defence companies' contributions will be touched on later in this study.

Added to the fast paced proliferation of new technologies, the 4th industrial revolution could add to this "grey area" between military and civilian society, specifically where militaries, due to continuous constrained budgets, will find themselves in a position where they will be required to partner with defence industries or possibly civilian companies, in order to protect the sovereignty of the country and to ensure national security.

4.4 Financial considerations: Unmanned aircraft systems

No new technological developments, interoperability, progress, cooperation or collaboration can exist between various states/countries, stakeholders, role players, governments or non-governmental organisations (NGOs) without due financial consideration. Increasingly, militaries need to think innovatively and "out of the box" to move forward from these constraints, especially in the light of diminishing defence budgets, specifically, as is the case, in South Africa.

Throughout the study, research demonstrated that more and more militaries across the world, like the UK, are constrained by restricted military budgets. In SA, based on the current and past realities, the SANDF's ever-diminishing budget allocations by National Treasury, as indicated by the Chief of the SA Air Force, is also an area of great concern. The question asked, is whether the use of

unmanned aircraft (unarmed/armed) by the SAAF could be of value and contribute to national security and be an economic benefit (cost reduction) on the SAAF's operational budget as previously mentioned. This said in light of the yearly declining budget allocations afforded to the Department of Defence, as previously mentioned when referring to the Minister of Finance's 2018/2019 Budget Vote. Other concerns are that neighbouring SADC countries' defence budgets are growing financially to build their military capacities (see Table 4.1 on p. 71), while the SA defence budget is being reduced (defenceWeb, 2018a; SIPRI, 2020). Could this not become a possible threat for SA?

Other profound and urgent alarms regarding the defence budget, and specifically the SA Air Force Budget, was raised by Chief of the Air Force (CAF), Lieutenant General Msimang, at the Parliamentary Joint Standing Committee (JSCD) on Defence on the 12 September 2019, who stated that "the South African Air Force (SAAF) is in dire straits and operating in survival mode" (Wingrin, 2019).

Further concerns that were raised by the CAF were the fact that reduced flying hours would impact negatively on air and ground crews' competencies, and especially on aviation safety. Besides the negative impacts on the SAAF itself, other unintended consequences are equally affecting the domestic defence industries. Aggravating this devastating situation further, is the impact that the National Treasury and Cabinet budget cuts have had on the SAAF.

Wingrin (2019) quoted the CAF who passionately stated, that "unless urgent intervention is initiated at the national strategic level, taking account of a complex operating environment in an unpredictable international system and the decline of capabilities is not arrested," he said, answering a Committee question, "this country will have no Air Force, but an Air Wing in the near future". Right now, we are surviving on the integrity, the patriotism of the men and women in uniform". "We are doing everything possible within our limited scope to fulfil our mandate and that is the mandate of our people" (Wingrin, 2019).

This problem is not unique to South Africa, or unique to the SAAF, but it is more acute in our case, as is with many other smaller powers and their defence environments as stated by Namufohamba (2019). Internationally, world military spending has been cut. For example, the UK has also pleaded for additional military funding. From an economic and cost-effective perspective, the question arises whether unmanned aircraft can be utilised as a more cost-effective option than the current conventional capabilities of the SA Air Force? The full financial considerations for the application/use of such advanced technologies and improved systems, based on the existing devastating and diminishing budget allocations to the SAAF, will require further in depth research as a study on its own.

A final question for consideration is that despite the costs required to get sophisticated UAS capabilities in place in South Africa, what would the eventual opportunity costs, and unintended consequences be to the SAAF and the SANDF, if it does not have the requisite technologies in

place? And if and when it has to face adversaries, whether external or internal, who does have the correct technologies, as was alluded to in Chapter 2, in terms of the international context?

In an era of diminishing defence budgets, this study has revealed that governments and militaries across the globe should determine what their future force concepts would look like.

Table 4.1: Military expenditure by country as percentage of gross domestic product (GDP)

EXPENDITURE					
	2016	**2017**	**2018**	**2019**	
NORTH AFRICA					
Algeria	6.4	6.0	5.5	**6.0**	
SUB-SUHARAN					
Angola	2.7	2.4	1.8	1.6	
Botswana	3.3	3.0	2.7	**2.8**	
Cote d'Ivoire	1.7	1.3	1.3	1.1	
Eritrea	0	0	0	0	
Kenya	1.3	1.3	1.3	1.2	
Lesotho	1.8	2.0	1.8	1.5	
Mauritania	2.9	2.9	3.0	**2.8**	
Namibia	3.8	3.4	3.2	**3.0**	
Senegal	1.6	1.5	1.6	1.5	
South Africa	1.1	1.0	1.0	**1.0**	
South Sudan	4.6	2.4	3.7	**3.4**	
Swaziland	2.0	1.9	1.9	1.8	
Uganda	1.3	1.3	1.4	**2.1**	
Zimbabwe	1.7	1.5	1.2	0.7	
MIDDLE EAST					
Egypt	1.7	1.4	1.2	1.2	

Courtesy SIPRI (2020)

In summary, it is vital that the military and civilian institutions cooperate and collaborate with regards our national security and human security. As a military and a nation we need to think systematically to understand this phenomenon as a whole. “However, system thinking is a very interrelated term to strategic thinking since we cannot have a strategy without first understanding the system, yet we cannot have a system without first developing a strategy” (Pearl, 2017 cited in Sixbert, 2017: 3).

4.5 The mandate of the SANDF in South Africa

The Constitution of South Africa acts as a foundation document when evaluating the role of unmanned aircraft systems in South Africa. The Constitution stipulates that the SANDF is to be structured and managed as a disciplined military force. Its primary role is to defend and protect the RSA, its people, and its territorial integrity against external aggression, by regulating the use of force in accordance with the Constitution and the principles of international law (Republic of South Africa, 1996: 12). “The SA Constitution also refers to political responsibilities making provision for the SANDF to be employed in fulfilment of international obligations” (Liebenberg and Potgieter, 2012: 130). The Mission of the SANDF is to “provide, manage, prepare and employ defence capabilities commensurate with the needs of South Africa as regulated by the Constitution, National Legislation and Parliamentary and Executive direction, which are in line with the domestic and global needs of South Africa”, as stated in the DOD Annual Report (2017: 14).

4.6 SA defence and policy

After the democratic elections in 1994, the defence and policy environments had to be restored to gain legitimacy and trust from the SA population. The White Paper on Defence (1996) and the Defence Review highlighted the fact that “South Africa is an important economic and military power in the region and could play an important security role within the Southern African Development Community (SADC)” and that security in Africa and the Southern African region is seen as essential (Liebenberg and Potgieter, 2012: 281).

In terms of its mandate and policy, the “Defence Force will assume full responsibility for land, air and maritime border safeguarding” (RSA, 2015b: 6-1), by a collaborative approach. It is further stated that border safeguarding entails state authority been enforced by means of land, sea and air efforts (RSA, 2015b: 6-2). In other words, maritime security and border security form an integral part of South Africa’s national security. With new global threats emerging by states, non-state actors and other actors, it is vital that South Africa, the SAAF, the SAN and the South African Army protect our vast borders and maritime zones. By integrating sophisticated UAS within the maritime, or border domain, it can provide critical technological ‘force multipliers’ and ensure fewer ‘military boots on the ground or sea. This type of technology, viz. UAS, could also be a future ‘game changer’ for the SAAF, the SAN and the SA Army and ensure national, and hopefully international security, from international terrorism, as mentioned in the media since 2018, with regards to ISIS threats in Mozambique. In this regard, Dikmen et al. (2016: 164, 165 and 168) are of the opinion that “unmanned aerial systems (UAS), with their many key advantages, increasingly fill in a very important gap in military operations requirements”. From a wider security perspective, UAS can assist in terms of economic, maritime, environmental and human security levels.

Human trafficking and drug trafficking are occurring at growing rates globally and along South Africa’s borders, which necessitates applicable intervention by the SAAF, the SAN and the SA Army.

The growing international acknowledgement is that from a human security perspective, “whether universally popular or not, the protection of human security, including human rights and human dignity, must be one of the fundamental objectives of modern international institutions” (Peoples and Vaughan-Williams, 2015: 161). In this regard, the “commitment to the idea of human security will (or should), on occasion, necessitate military intervention in support of that ideal” (Peoples and Vaughan-Williams, 2015: 161), and UAS can fulfil this role in support of human security and national security.

4.7 The SA Air Force

The SA Air Force (SAAF) was established in 1920, after the First World War and the Peace of Versailles (1919). The SAAF “started off with an ‘Imperial Gift’ of numerous aircraft no longer needed by Britain. This Imperial Gift was to form the nucleus of the future SAAF. In rather patriotic terms, the origin and growth of the SAAF can perhaps as such be described as “From bi-planes to the jet era”; “From fledgling to Eagle”; “Defender of the Nation” (Liebenberg, 2014: 4).

Aviation history in South Africa however dates back to 1899 when air balloons were used for reconnaissance by the British. In 1907 the first aircraft was built in South Africa, and the first flight in South Africa took place in 1909. Liebenberg cited Maxwell (1970: 9) by stating that an SA Aviation Corps, as part of a Citizen Force, was established in 1912 (Liebenberg, 2014: 5). In 1913, the first training commenced in Kimberly, with a mere 10 candidates. During this time, Brigadier-General Beyers was also quoted as saying: “There is no doubt that aircraft are going to play a very important part in warfare in the future” (Liebenberg, 2014: 5). In 1919, Sir Pierre van Ryneveld was called to London and instructed to start an Air Force in South Africa. And on the 1st of February 1920, this accomplished pilot was “appointed as Director of Air Services by the Union Defence Force” (Liebenberg, 2014: 6). The SAAF, as established in 1920, was a conventional and externally directed offensive Air Force, with manned aircraft received from the British government. During the Second World War, South Africa did not develop or use unmanned aircraft. Nearly fifty years later the first unmanned flight took place in South Africa during 1977.

4.8 Background to UAS in the SAAF

The first ever small light weight surveillance UAV in South Africa, named Champion, first flew in 1977. It was built in the mid-1970 by Kentron (now called Denel Dynamics) and the Council for Scientific and Industrial Research (CSIR) in Pretoria. Four were built and some of these UAVs were used by Rhodesia for surveillance during their civil war.

In 1976, Israel started with the Scout UAVs project. The first Scout prototype was flown in 1978. In 1980, the SA Air Force (SAAF) acquired more than 12 Israeli Aircraft Industries Scout UAVs for the developing war in Angola. In 1986, 10 Squadron were re-structured to operate these aircraft. During this extensive combat in the southern African theatre, many UAVs were shot down by enemy fire. Despite these financially painful losses, the SAAF was very excited, as no lives were lost and they

had proved that light and slow surveillance aircraft (UAVs) could withstand surface to missile attacks. In 1987, the Seeker I (named Seeker 2B) system was designed with a ground control station (GCS) which was a refinement of the Champion UAV model. A Seeker 2B was shot down by Angolan Forces in 1987, after having survived approximately 17 SA-8 missile attacks. These UAVs were used by 10 Squadron for spotting missions (artillery) and for tactical surveillance. The Seeker II, built by Kentron (which was then part of Denel and still is – now called Denel Dynamics) in 1990, had a 250km range, an endurance flight of up to 10 hours, 6 hours over a target at 250km, with an operational ceiling of 18 000 foot (Denel Dynamics, 2020). The Seeker II was easily deployable with a C-130B Hercules. It could be set up within 4 hours. The huge success of these models resulted in sales to the United Arab Emirates and to Algeria, amongst others (Olivier, 2014). During 1987 and 1991, 10 Squadron operated five different types of Seekers, with better engine performance and improved quality of on-board cameras. When the Angolan war ended, 10 Squadron was closed down and the SAAF's Seekers were transferred to Kentron, who was contracted to the SAAF to operate its UAVs and its Seekers' successors. A private development continued, despite the SAAF not operating or owning UAVs' anymore. During the late 1980s and the early 1990s, development in the local industry developed at a very fast pace.

In response to the SAAF's High Speed Reconnaissance Drone (HRD) Technology Demonstrator Programme, and developments into new stealth ventures, a Flowchart 2 was designed. This was followed by the remarkable Seraph design, which was designed between 1996 and 1998, and was ahead of its time. This stealth UAV could carry a 80kg payload, fly at 40 000 foot and fly at a speed of Mach 0.83 for 1 300km. (The Flowchart and the Seraph were experimental stealth high speed reconnaissance drones). Severe SA Defence budget cuts in 1997 destroyed the SAAF's HRD programme and the Seraph's final development plans. During the mid-2000's, this concept was briefly revived, with the Seraph II Unmanned Combat Aerial Vehicle (UCAV) design, but the design stage was never completed.

In the 1990s, Advanced Technologies and Engineering (ATE) was established and they developed the Vulture UAS launcher system, for the SA Army artillery, for fire control and target acquisition. It was an automated system for which no external pilot was required.

Since this development, ATE became Paramount Advanced Technologies (with the Paramount Group). Small micro-UAVs, such as the 3.5kg Civet and the larger Sentinel and Mwari, were developed by ATE. (An unnamed Asian country purchased Civet's for use by their special forces). Denel developed other projects, but again, as with the Seraph, the SA government did not provide the SANDF with the required funding. During approximately 2008/2009, Denel used its own company finances, together with a contract from the SANDF, and developed the Seeker 400. The Seeker 400 had a 10 hour loitering time, automated flight operations (including take-off and landing), as an option, which was not integrated into the local SANDF version. It could carry an 80kg payload capability, and had underwing hard points for carrying air–to-surface-missiles. However, the RSA

version did not have a weapons management system, and therefore could not carry actual fire weapons.

4.9 Current uses of UAS in the SA Military

The SANDF and the SAAF use a variety of specialised and local military UAVs, such as the Seeker 400 and the Civet, developed by our local Defence Industry partners, like Paramount Advanced Technologies, and Denel. Specialised internationally developed military UAVs, such as the Black Hornet PD 100 military Prox Dynamics products, and/or local commercial-off-the-shelf (COTS) drones, such as the commercial DJI Matrice 600 product, are used for various military tasks (Schröder, 2018).

The SANDF primarily use UAS for surveillance, reconnaissance, battlefield damage assessment (BDA), military site inspections, ground targeting assistance, anti-aircraft artillery (AAA) training (target drone), test and evaluation of air-launched weapons (target drone), media support (i.e. SANDF TV), security (base perimeter inspections), border patrol (surveillance), anti-poaching support (surveillance), CSAR support (surveillance) and intelligence gathering (reconnaissance). The SANDF and/or the SA Air Force do not have any unmanned combat aerial vehicles (UCAV) or signals intelligence (SIGINT) / communications intelligence (COMINT) / electronic intelligence (ELINT) / electronic warfare (EW) yet. According to research, the technology does exist in South Africa, where the larger UAVs, such as the MA 380 and the MA 80 do have electro-optic or infrared sensors and can carry electronic intelligence, or communications, or signals and synthetic aperture radar (SAR) payloads, besides their normal weapon payloads and mission equipment (Schröder, 2018).

Different Air Force departments use UAVs for various tasks, such as crash site investigations, to test runway navigational aids, for working at heights, for mast and tower inspections, for new installation inspections, navigation aid testing and calibration, base layout and GIS (i.e. site planning and deployment planning), drone journalism. The SA Air Force uses the DJ Phantom 4 and Inspire UAVs for site planning and deployment planning. The SAAF also has Public Private Partnerships with Denel Dynamics, with their Seeker II, Skua, and Seeker 400, as well as with Denel Mechatronics with regard to their target drone.

4.10 Rules and regulations regarding UAS in the military airspace

The section merely comprise a brief description of military airspace rules and regulations. “South Africa was the first country in the world to initiate regulations for the training and issuing of Remote Pilot Licences (RPLs), [or UAS as titled in this study], which are accredited by the International Civil Aviation Organisation (ICAO) on the 1st of July 2015” (Stopforth, 2017: 149). Despite the questioning for the necessity for RPLs, the reasoning behind these regulations are sound as they allow for the safety of unmanned flights and manned flights, responsible pilot actions, understanding of the vulnerability of radio links between the RPAS [or UAS] and the pilot/operator, and for the safe

integration into the civilian air space, as discussed in this thesis (Stopforth, 2017: 149, 151, 154 and 155).

According to Helfrich (who cites Meredith), the SAAF's Senior Air Certification Staff Officer, "the use of unmanned aerial vehicles (UAVs), also known as UAS (unmanned aerial systems) in both the military and civilian aviation environment does not present insurmountable problems" (Helfrich, 2014: 1). Where the civilian or commercial Sector in South Africa takes guidelines from ICAO's international regulatory framework, through standards and recommended practices, and the SA CAA, Part 101, the military follow a different regulatory process. The civilian/commercial process to obtain an authority to fly a civil drone (under 20kg) in SA, namely the rules of conduct, differ from the military process. The SANDF does not comply with this process. The DOD and the SAAF are self-regulatory and not bound by the Aviation Act, but by the Occupational Health and Safety Act (OHS). The Chief of the Air Force (CAF) is appointed as the overall airworthiness authority. Delegated responsibility is given to the Director Systems Integrity (DSI) and Director Aviation Safety (DAS) to ensure acceptable levels of aviation safety in the Air Force (Helfrich, 2014: 1). As indicated in Chapter 2, the integration of UAS into the National Air Space is gaining momentum, yet, it remains a challenge.

As stated by the SAAF Directorate Systems Integrity (DSI), the fundamental principles for airspace and military operations is that military aircraft must comply with the airspace operating rules and regulations. In the SAAF's case, compliance to the SA CAA for the use of military aircraft or UAS in civil airspace. When operating outside military segregated airspace and civilian controlled airspace, compliance with civil air traffic procedures are not required. When military aircraft operate in military segregated airspace, civilian rules and procedures do not apply. Currently there are no regulations or policies in place (Rules of the Air) for both military and civilian unmanned aircraft systems operating in civil airspace across the world – a challenge which is concerning (Meredith, 2014: 12).

In the civilian aviation environment in South Africa, existing SA CAA rules and procedures will apply, as they will in other countries, where their local Aviation Authorities apply, for example Civil Aviation Safety Authority (CASA) in Australia or Namibian Civil Aviation Authority (NCAA) in Namibia. The UAV/UAS operator is required to follow the existing Aviation Authority procedures, make an application to use the airspace, request temporary segregation or closure of a specific portion of the national airspace, and provide full intended flight details. Once this is authorized, a "Notice-to Airmen" (NOTAM) will be issued to caution and notify other airspace users of the requested flight. A temporary permit will be provided to the operator for that specific flight only. With each and every flight requested, the operator will go through this same process again. These procedures will remain in place until UAS regulations are drafted, accepted and promulgated.

As indicated by the SAAF Directorate Systems Integrity (DSI), the operation of military UAS in military airspace is directed and controlled by the military doctrine and operational guidelines for the operation of military aircraft within military airspace. In summary, however, there are no formal

military UAS regulations currently in place but regulations are in the process of being drafted. UAS are flown under the control of the ATC, a ‘spotter(s)’ and all flights are recorded in a log book.

4.11 Safety of Flight: Military UAS

The SAAF currently uses three methods to assess and approve military UAS for flight, firstly, a Certificate for Flight Trials [CFT] (for experimental / in-development / unqualified UAS), and secondly a Flight Permit [FP] (for qualified or ‘flight-worthy’ operational UAS that have not been Type Certified), and thirdly, a Military Type Certificate [MTC] (for qualified operational UAS that have been Type Certified). Currently, only the Denel Dynamics Seeker 400 UAS (as operated by one of the SANDF Divisions) has been subjected to a Type Certification Program, and is therefore the only SANDF UAS operating under a MTC. All others operate either under authority of a CFT or an FP.

The main advantage of Type Certification is that it yields a much more robust design and a much more reliable product, which, in the case of a UAS, means that it can be flown above large crowds or dense cities, or in congested/controlled airspace. But Type Certification is expensive, resource-heavy and time-consuming (for example, the Seeker 400 program is testament to this). One can therefore question, where and how do Military and Civilian UAS overlap or co-exist in South African air space? As mentioned, the greatest overlap will be the way in which the SANDF use their UAS in civil airspace. In answer to this question, civilians would for example want to use the airspace for huge sporting events. During an important event like the State of the Nation Address (SONA), the SANDF will control such an important event.

The use of military UAS in civilian airspace is strictly controlled. The concern, however, is quite the opposite as the question arises, will and do civilians, non-state actors and extremist groups adhere to similar regulations, or should these uncertainties be considered as a possible threat to South Africa and for the SAAF?

4.12 Integration of UAS into civil airspace

With regard to developments in 2019, the concerns raised with the proliferation of UAS in the global air space have resulted in Aviation Authorities revisiting the Air Traffic Navigation Systems (ATNS). As this has more dire consequences for the civilian and commercial markets, the civilian integration debate centres around two major issues. Firstly, whether effort should be made to integrate drones into the various airspaces, or, whether to exclude them and to invest in anti-drone technology in key areas.

The problem with the integration into civilian airspace is that only a fraction of users are educated, competent and disciplined enough to safely integrate. Consumer-off-the-shelf drone operators (COTS) will not be aware of the detailed and rigorous systems and procedures that are in place for to obtain flight authorities. The other argument is whether UAVs should fall under an Unmanned Aerial Vehicle Traffic Management system or whether it should be linked directly between the operator and the Air Traffic Management System.

In a pure conflict zone, the use of drones is less complicated as separation is only provided between own forces and coalition forces. In peacekeeping situations, safety issues could arise as both civilian entities and NGOs will be operating in the same airspace. These flights will need to be de-conflicted. Problematic issues arise when the SAAF/SANDF conduct operations in peace time and are required to operate between civilian and other military aircraft. The military and civilian entities therefore need to understand de-confliction methodologies (Meredith, 2015). For the readers' understanding, confliction in the air space is when UAVS would interfere with manned aircraft. De-confliction is a process used to ensure that there is no conflict in the airspace, and thus no possibility of a mid-air collision.

Secondly, another concern is uncontrolled or partially restricted airspace. In such cases, neighbouring countries usually need to be advised of intended border operations. Both regions/countries ATCs would then be required to continually be in contact with one another, to ensure the safety and security of the airspace along and around the border area. These examples are merely latest developments that are being brought to the fore and for which global aviation authorities will require solutions.

4.13 The RSA aerospace/aviation industry and defence

In terms of military aircraft, South Africa started with a limited and proto-aircraft industry. After the "Imperial Gift" by Britain of some surplus World War I aircraft (Liebenberg, 2014: 4), South Africa had to replace and in a few cases upgrade these aircraft that became obsolete. During the 1930s, the Union of South Africa imported some newer aircraft from the UK and even assembled and built some here. The M'pala aircraft built for the SAAF during the 1930s was one example. However the Union still lagged behind Britain as their aircraft were advancing into the era of the Hurricane fighter with the Spitfire in its design stage. The Second World War actually kick started South Africa's military industry and the production of arms served a role to propel South Africa into an industrial take-off era (De Wet and Liebenberg, 2012: 243-245).

In 1940, with the appointment of the Advisory Committee on Defence Force Requirements, South Africa's local arms industry was revitalised and drastically expanded in contrast to its former rather weak platforms that saw its proto-beginnings during the 1930s. This committee was established to analyse South Africa's military industrial potential. Six factories were established to produce weapons during the Second World War and a number of private companies also assisted with weapons productions. In the late 1940s, these weapons factories were dismantled, and in 1945 the government established the Council for Scientific and Industrial Research (CSIR). This council was required to study South Africa's total industrial possibilities and seek military research and development capabilities over the long term.

In 1949 the Board of Defence resources was established, and in 1951 the Munitions Production Office was established to oversee policy planning regarding armaments. In 1954 the National

Institute for Defence Research (NIDR) was established to expand the growing defence industry. In 1960 the National Party raised the level for development of arms for the armed forces, pursued new foreign weapon sources and acquired new military technological systems. In 1963, the government intensified these efforts when the United Nations Security Council (UNSC) restricted the sale of military vehicles, ammunition and armaments to South Africa. In 1964, the armaments Act No 87 established an Armaments Production Board to manage a state owned munitions factory to coordinate ammunition procurement between the military, private organisations and government. In 1968, the Armaments Development and Production Cooperation (Armscor), a state owned business, was established by the Armaments Development and Production Act (No 57) to “consolidate and manage public and private arms manufacturing” (Gerryts, Naidoo and Barker, 2004: 1).

In the mid-1970s, South Africa achieved a level of self-reliance in the production of military equipment, due to Armscor’s performance. Armscor was restructured, assumed larger control over the arms industry, and controlled most of the research and development conducted by the NIDR. The South African aerospace sector was established by the South African government in 1970 with the intention that it would become self-sufficient. Investments by the government to this sector would take place according to DOD expenditure (Gerryts et al., 2004: 5).

The aerospace industry in the country was imposed on South Africa as a result of the UN Arms Embargo on South Africa during 1977 to 1994. The aerospace industry was required to be a strategic self-sufficient asset to the country, with flight testing capabilities. The then existing Atlas Flight Test Centre provided only Production Testing Acceptance, resulting in the SAAF taking ownership in supporting the local defence industry with the required flight testing infrastructure.

Challenges with regard to possible security violations due to outsourcing of system modifications to Original Equipment Manufacturers (OEMs), long lead times and high costs, required that the SAAF establish their own test flight capability. Furthermore the higher demand for modifications and development flight testing, resulted in the establishment of the SAAF Test Flight and Development Centre (TFDC) at Air Force Base (AFB) Overberg, Bredasdorp.

For a relatively small country (a medium power, yet the strongest in Southern Africa), with such a small air force such as South Africa, the unique establishment of such a sophisticated and aerospace research and development capability, was quite exceptional. This was a first for a small developing country like South Africa, compared to the major first world countries like the Australia, India, France, Russia, USA, Canada, UK, who possessed their own independent research and development aerospace centres.

Research has indicated that the aerospace industry is a very competitive, prestigious environment, and of concern to the national security of a country, especially where the developments over the years have changed the aerospace industry to a proliferated ‘high tech’ driven business, where everyone can be a role player.

Over the years, the aerospace industry has been involved in an array of high tech innovation, ranging from support, research and development, maintenance, conversions, processes, upgrades, components, design testing and development, satellites, weapon systems, air traffic control systems and increasingly advanced and sophisticated unmanned aircraft systems. It is within this aerospace environment that the various unmanned aerial vehicles provide researchers with the ideal opportunities to integrate technologies before programmes are developed. In this regard, CSIR has developed numerous UAVs of different sizes which are able to carry different kinds of payloads, making them experts in their field of aeronautical research. The CSIR has collaborated with other industries such as Denel and ATE to assist them with a wide range of development, from mini UAVs to technology demonstrators, as is depicted in the diagrams below, when discussing the contributions made by South African companies.

As discussed in Chapter 2, South Africa has been part of the international Controls during its aeronautical development years and SA Defence Industries have had to adhere to these arrangements. According to Kellerman (2019), South Africa is a member of both the WA (2006) and the MTCR, as discussed previously. The controls in SA of the WA Munitions List are implemented through the National Conventional Arms Control Act No 41 of 2002 by the National Conventional Arms Control Committee (NCACC). The controls of the MTCR are implemented through the Non-Proliferation of Weapons of Mass Destruction Act by the South African Council for the Non-Proliferation of Weapons of Mass Destruction. Kellerman (2019) is of the opinion that “industries internationally and nationally need to strictly adhere to these controls when importing and exporting UAS/drones” (Kellerman, 2019). The concern raised here, is that if these controls are not adhered to by all countries across the globe, it could negatively affect the safety and security of SA and the neighbouring states.

In 2018, a Defence Industry Fund (DIF) was launched to enable the South African defence industry to grow. The intent was that small and medium initiatives could develop into international competitive businesses who could complete locally and supply the South African National Defence Force (SANDF) with equipment. The focus was also to increase industrial strategic imperatives for broad-based black economic empowerment (BBBEE).

4.14 Domestic Developments: UAS in South Africa

In the following sections, the study reflects on the contributions made to the aerospace industry by specific local/domestic South African companies/defence industries. In South Africa, there are numerous defence industries that are contributing to the increasing proliferation of unmanned systems, and are supporting the Defence Force of South Africa, in different roles/degrees. The various Defence Industries indicated below, are used to illustrate their contributions.

4.14.1 Council for Scientific and Industrial Research (CSIR)

During the early 1980s, when the Council for Scientific and Industrial Research (CSIR) in South Africa first started developing an airframe for the Seeker prototype, the future of unmanned aircraft systems (UAS) in SA was still uncertain. However, across the globe today, a clear indication exists of the importance of UAVs. The DOD of the United States of America for example, speaks of their unmanned aircraft systems roadmap from 2005 to 2030, where the use of their UAS has expanded rapidly in their operations with their “War on Terror”. The USA mention that the current military battle space has been transformed by UAS (USA Office of the Secretary of Defense, 2005).

The South African industry, similarly, as in the case with the CSIR, have their own unique road maps for UAV development in SA, as depicted in the UAV diagrams in this study. Currently the CSIR has expanded and developed a UAS integration laboratory where UAVs can be tested to demonstrate their range.

As indicated in this study, both Armscor and CSIR have been involved in the defence industry and continue to contribute to the development of our national strategic capabilities. The CSIR remains “the biggest research council in Africa and its activities are supported by a variety of expert facilities and infrastructure, laboratories, virtual platforms and instrumentation for testing and evaluation, design and technology experimentation” (CSIR, 2016: 3).

In 2003, the CSIR’s Aeronautical Systems Competency department re-examined its role with regard to UAV-related technology. During discussions between the CSIR, academia, the military, and industry, it was acknowledged that the CSIR “could add the most value to the local UAV industry in the design, optimisation, characterisation and simulation of UAV airframes” (Monk, 2008: 9). With the development of the mini UAV hand-launched Indiza, in 2005, an optimising capability was established. “This would aid with the understanding of UAV autopilot systems and flight control” (Monk, 2008: 5).

During this time, various universities, such as, the University of Stellenbosch, the University of Pretoria and the University of Johannesburg became involved with different aspects of research and development. Areas focused on were for example, non-linear control of the airframe, with flight up to and beyond stall, the ability to determine UAV behaviour in-flight, a re-configurable autopilot for control of damaged UAV, lightweight sensors, like radar, electro-optic and other for sense and avoid research and training for UAV Flight Test Techniques (Monk, 2008: 9).

CSIR was and is currently involved with flight testing, systems integration, designing of new and/or novel UAV airframes, structural and inertia testing, analysis of UAVs in a wind tunnel, performance, control and stability predictions, building of pre-production or prototype airframes and the development of test rigs, to analyse UAV capabilities or to improve designs (Monk, 2008).

The images below depict the historical research and development (or the roadmap in South Africa) where the CSIR was involved in, in this “high-tech” aeronautical field.

Year	Aircraft/Air Vehicle	Description
Early 1980s		Seeker UAV prototype. During the early 1980s, the CSIR developed the Seeker UAV prototype. Test flights were conducted with the Seeker prototype at the St Lucia test range. This product was then further developed by Kentron (i.e. Denel Dynamics).

Image 4.1: Courtesy CSIR Presentation 1
Source: Monk, 2008

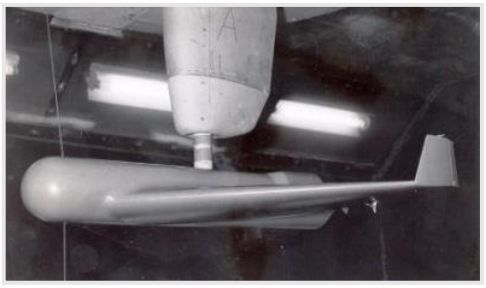
Year	Aircraft/Air Vehicle	Description
1988		1988 Delta Wing UAV technology demonstrator Two airframes were built as demonstrators for this optimised aerodynamic design.

Image 4.2: Courtesy CSIR Presentation 2
Source: Monk, 2008 and https://www.secretprojects.co.uk

Year	Aircraft/Air Vehicle	Description
1990		Skyfly target drone prototype In the early 1990s, the Skyfly target drone prototype was developed. The Skyfly was built and flown with an undercarriage, and its wing design copied a previously validated wing design code. This drone was wing tunnel tested (i.e. flown in-house) in order to determine the level of control of the drone was equipped with.

Image 4.3: Courtesy CSIR Presentation 3
Source: Monk, 2008 and https://www.secretprojects.co.uk

Year	Aircraft/Air Vehicle	Description
1992		‘Keen – eye” RPV The Keen-eye RPV had a 4m span It was built as a demonstrator for the UAOS programme bid with ATE It had a potential flight range of over 500 km The design used the data acquired from previous UAV designs –validated wing design and stability prediction codes It was flown only under remote control

Image 4.4: Courtesy CSIR Presentation 4
Source: Monk, 2008 and https://www.secretprojects.co.uk

Year	Aircraft/Air Vehicle	Description
1993		Hummingbird 2-seater observation aircraft prototype All autoclave cured, composite construction Built to an SA Army specification Exhibited at the Paris Airshow Re-engined in 1994 with Lycoming Tested by the CSIR in-house

Image 4.5: Courtesy CSIR Presentation 5
Source: Monk, 2008 and https://www.secretprojects.co.uk

Year	Aircraft/Air Vehicle	Description
2005	 (Image: Courtesy CSIR)	2005 Indiza – a mini hand launched UAS CSIR-developed airframes Indiza I – mini research UAV Wind tunnel characterised to add to the data acquired on small UAVs
2005	 (Image: Courtesy CSIR)	Small propeller performance data was not available 2005 Indiza – a mini hand launched UAS

Image 4.6: Courtesy CSIR Presentation 6
Source: Monk, 2008 and https://www.secretprojects.co.uk

Year	Aircraft/Air Vehicle	Description
2007		2007 Sekwa – Mini -unstable, tailless UAS Designed by multi-disciplinary optimiser Six spanwise aerofoils optimised Overall geometry optimised for performance while maintaining certain flying qualities Longitudinal stability is variable in flight Clean start design - all aerodynamic data was derived, the design and optimisation became a lengthy process Wing tunnel tested and characterised

Image 4.7: Courtesy CSIR Presentation 7
Source: Monk, 2008, CSIR Presentation and https://www.secretprojects.co.uk

Year	Aircraft/Air Vehicle	Description
2010		The Modular UAS The Modular UAS was designed to be a reliable UAS research platform with a 10 kg payload capability Developed over a period of less than six months with DST funding Wind tunnel tested Supported a number of related research areas from within the CSIR and universities Novel configurations are being developed

Image 4.8: Courtesy CSIR Presentation 8
Source: Monk, 2008, CSIR Presentation and https://www.secretprojects.co.uk

Year	Aircraft/Air Vehicle	Description
2013		Indiza II and III mini UAS Indiza UAS modified for border safeguarding exercises Three camera modules demonstrated: Dual camera system (wide angle and telephoto) on pan-and-tilt system HD video GoPro camera with VGA live feed Cellular 3G controlled Android camera system Flown at four border posts - obtained operational data from a realistic environment Indiza developments Hand or bungee launched Low cost, open source autopilot and data links Three piece Kevlar® wing Ground based tracking antenna system Data link and video antennas co-located Independent of the ground station Video and location transmitted to operations HQ

Image 4.9: Courtesy CSIR Presentation 9
Source: Monk, 2008 and CSIR Presentation and https://www.secretprojects.co.uk

4.14.2 Denel Dynamics (formerly Kentron)

Denel SOC Ltd is a state-owned commercially-driven company and strategic partner for innovative defence, security, aerospace and related technology solutions. Over the years Denel has built a reputation as a reliable supplier to its many international clients. Denel also has a number of equity

partnerships, joint ventures and cooperation agreements with renowned international players in the defence industry. Denel SOC Ltd is the largest manufacturer of defence equipment in South Africa and operates in the military aerospace and landward defence environment since 1992. Denel is a key domestic supplier and an important defence contractor in its domestic market and a key supplier to the South African National Defence Force (SANDF), both as original equipment manufacturer (OEM) and for the overhaul, maintenance, repair, refurbishment and upgrade of equipment in the SANDFs arsenal" (Engelbrecht, 2010).

"The unmanned aerial vehicles (UAVs) market is highly competitive, yet Denel Dynamics has been able to make this arm of the Denel Group a profitable one. The company expects its new products, the Hungwe small UAV and the Seeker 400 armed surveillance UAV, to further consolidate its position as Africa's only supplier of short, medium to long range tactical UAVs" (defenceWeb/Aerospace, 2012).

In 1979, Denel's UAV technology development began with the development of a metal airframe. In 1982, the first composite airframe in the world was developed which allowed for the first flight beyond visual Line of Sight (BVLOS) with the development of the first Seeker system. The Seeker 1 system was developed in 1986 and was delivered to the SAAF for use as a Medium Altitude Long Endurance (MALE) aerial vehicle. Since 1992, Denel Dynamics has operated the Skua in support of the South African Defence Force (SANDF). The Skua is a "high-speed target drone, designed to simulate high-speed attack aircraft during land, sea and air combat training exercises and weapon development" (Engelbrecht, 2010).

Image 4.10: Skua "high-speed target drone
Courtesy Denel Dynamics

In 1994, the RSA's first democratic elections were monitored with a Seeker 1 in civilian airspace. From 1995, the Seeker was used for security support all over South Africa in an operational support role. In 1997 the Seeker II system was developed, which was the first glass-cockpit Ground Control Station (GCS) in the world.

Image 4.11: Seeker 400
Courtesy DENEL

The South African National Defence Force (SANDF) was the first customer to take delivery of the Seeker 400 in 2015, although operational testing and evaluation were still taking place to grant the Seeker 400 full military type certification. The Seeker 400 can carry two sensor payloads of 50 kg each “such as an optronic sensor turret like the Argos II and a synthetic aperture radar or electronic intelligence package” (*defenceWeb*, 2019b). When The Seeker 400 carries two payloads, it is branded as the Enhanced Seeker 400. “The Seeker 400 can be used for a wide range of military and civilian missions, including maritime surveillance and disaster reconnaissance. It has up to 16 hours endurance at altitudes up to 18 000 feet. At typical operating altitudes of between 4 500 and 9 000 feet, it is not visible from the ground by the human eye and is effectively inaudible. The UAV’s line-of-sight range is 250 km from its ground station, but this can be doubled by using a forward ground station with deployed forces. The Seeker 400 can be armed, including with lightweight Impi and Impi-S missiles or the P2. The Impi series is based on the laser-guided Mokopa, but scaled down for lightweight platforms like UAVs” (*defenceWeb*, 2019b). The unmanned aerial vehicles (UAVs) market is highly competitive, yet Denel Dynamics has been able to make this arm of the Denel Group a profitable one. The company expects its new products, the Hungwe small UAV and the Seeker 400 armed surveillance UAV, to further consolidate its position as Africa’s only supplier of short, medium to long range tactical UAVs (*defenceWeb*, 2019b).

Denel Dynamic’s flagship project in 2014 was the Hungwe UAS. Funding was made available to Denel Dynamics to demonstrate a rapid response anti-rhino poaching system and a border safe-guarding system. “Denel manufactured and integrated the systems into the technology demonstrator airframe” (Milkor) and used validated COTS software to characterise the design. As mentioned, SA industries support one another, and thus CSIR tools were used to further optimise Denel Dynamics Hungwe’s airframe design.

Image 4.12: Hungwe UAS
Courtesy Denel Dynamics

4.14.3 Milkor (Pty) Ltd

Milkor as an industry in South Africa has been in existence for over 40 years supplying the international market with grenade launchers. However, over the past years, it has moved more into the UAV environment. At South Africa's Africa Aerospace and Defence (AAD) exhibition at Waterkloof Pretoria last year, Milkor clearly stood out as one of the few leading companies in the world to produce armed UAVs. Milkor dominated the exhibition, with its new South African research and development initiatives into an elite defence industry environment. Milkor's vision is to be one of the largest defence and security companies in South Africa and they are keen to boost South Africa's economy, benefit the SANDF and develop the local defence industry. Most of its components are locally resourced.

With Milkor's international status, it aims to create a firm reputation in the future with the design and manufacturing of cyber security products and UAVs, among others, and has "been successfully expanding into the aerospace, maritime and land systems markets. Within the space of a year, Milkor has designed, engineered and manufactured three unmanned aerial vehicles, a naval system and a 4×4 armoured personnel carrier. This makes Milkor's UAVs more attractive to defence and security customers. Milkor's products are ITAR free, making them attractive to a large number of markets" (Milkor, 2019).

It is conjectured that Milkor will in the near future, embrace a strategic agreement with Denel, to assist Denel to recover its international status, similarly to uplift South Africa's dire skills deficiencies. As Milkor has skilled engineers with decades of experience among them, it is possible that Milkor could ensure that the defence industry could once again make a noteworthy impact in South Africa's economy. With Milkor's agile and flexible approach, it is hoping to work alongside major SA defence companies like Denel to ensure that South Africa's defence industries regain their global status and become the prime choice for defence technology in the world.

Milkor has developed three UAVs, the MA 380, the MA 80 and the MA18. The MA 380 and the MA 80 are able to carry laser guided bombs. Milkor's first UAV weapon which it developed is the small diameter laser guided bomb. The MA 380 UAV with a 12 meter wingspan can carry two of these

weapons. The small MA 80 UAV can carry only one laser guided bomb. The MA 18, is a hand-launched UAV, which is unarmed and built for tactical surveillance missions.

Image 4.13: Milkor – MA 380 UAV

Image 4.14: Milkor– MA 80 UAV

Image 4.15: Milkor – MA 18 UAV

The Surveillance UAS for reconnaissance and situational awareness is Milkor's pioneering system. It is a brand new innovative long range and long endurance product which incorporates a substantial payload capacity. This UAS can carry the best optical imagery equipment in the world.

4.14.4 Paramount Advanced Technologies (PAT)

The South African company, Paramount Advanced Technologies (Paramount), which was formed in 1994, has become a global defence and aerospace industry. Paramount was initially established with a vision of defending African governments against possible threats. It is one of the fastest growing defence enterprises in the world, and offers ground breaking air defence, sea and land

solutions. The company prides itself as being uniquely solution–driven, an approach which has resulted in their global success. Their interests stretch across five continents, with capabilities to manufacture products in Africa, Asia and the Middle East. Paramount's main aim is to evaluate security and defence challenges which independent governments and/or agencies face across the continent, while other companies merely manufacture products to be sold on the market. They have the capability, knowledge and vast experience to supply a diverse market with products and technology and to advise each specific entity with unique solutions required for their unique challenges. The organisation conforms to international conventions regarding defence, peacekeeping, and internal security. Paramount adheres to their own internal regulations, South African national conventions, African Union conventions and the United Nations international regulatory frameworks.

Paramount is well known in the military and civilian global markets for their competitive supplies of defence, peacekeeping and security packages. Support to the military market include light intervention aircraft and UAVs, while civilian markets can be supported with, among others, coastal patrol, border surveillance, environmental safeguarding, disaster and organised events evaluations. The Paramount Group is one of the strongest contributors in the aerospace industry and advanced command and control systems. It offers prime and world class capabilities, among others, in research and development, UAVs and system integration, avionics, mission sensors and systems. They can for example, extend an unmanned aircraft system's lifespan and mission performance by integrating advanced systems into the UAV. This highly cost effective alternative can be followed, instead of purchasing very expensive equipment.

With Paramount's depth of knowledge, capabilities, air, sea and land based leading-edge solutions, and flexible financing plans, they can advise on international peacekeeping, national defence, internal security programmes. Their support to peacekeeping missions has provided Paramount with insight to political, economic, and security needs of countries, and the modern day challenges faced by today's militaries. They can confront national and internal security challenges by providing total logistical support, the establishment of an air force base, assist with equipment and services, such as aircraft, intelligent sensors, counter terrorism, border control, disaster management and electronic communication systems where public order is required (Paramount Group, 2019).

Paramount Advanced Technologies (PAT) was previously known as Advanced Technologies and Engineering (ATE). ATE supplied the SA Army with a 135kg UAV named the Vulture for artillery spotting.

Year	Model	Description
1995		SA Army Vulture prototype Two prototype airframes were built for ATE (now Paramount Advanced Technologies) It was further developed into the Vulture product The aerodynamic design was based on data and methods validated from the Keen-eye Airframe data.

Image 4.16: Courtesy Paramount Advanced Technologies – Vulture

In 2016, PAT unveiled its tethered UAV. It displayed the tethered quad-copter UAV at the 2016 Africa Aerospace and Defence exhibition, where it was mentioned that the prototype had flown demonstration flights. The Drone has an unlimited operational time, is secured to the ground by a cable, has no requirement for a qualified flight operator, and can hover at approximately 100 meters above ground. Possible payloads that could be attached to it were optronics and communications payloads, such as thermal imagers and cameras. The tethered UAV was developed for, among others, battlefield surveillance, anti-poaching, border control and surveillance, area security, building and crowd surveillance, and gas and chemical detection.

Image 4.17: PAT – Persistent Surveillance Tethered Drone
defenceWeb

Image 4.18: PAT – The Civet UAV System
Photo Army Recognition

This UAV is a short range mini UAV system. “The man portable UAV is the perfect aircraft for mobile observation, short range intelligence missions and tactical awareness, border patrol, infrastructure and site surveillance, aerial photography and surveying, disaster image gathering, game observation and the transport and delivery of light cargo” (Army Recognition, 2019).

Image 4.19: The Mwemwe
Photo Army Recognition

“The Mwemwe is a fully automated Medium Range Small UAV System. This UAV weighs less than 25 kgs and is powered by a petrol engine. With a 40 km operational range, the Mwewe is the ideal platform for tasks such as mobile observation, medium-range intelligence missions and tactical awareness, border patrol, infrastructure and site surveillance, aerial photography, disaster image gathering, game observation and coastal surveillance” (Army Recognition, 2019).

Image 4.20: The Mwemwe UAV System
Paramount Group, 2019

Image 4.21: The Roadrunner high speed UAV System
Photo: Army Recognition

“The Roadrunner is a high speed UAV system developed to perform various operations, including path clearance, mobile observation, pursuit of moving vehicles, short range intelligence missions and tactical awareness, border patrol, infrastructure and site surveillance, disaster image gathering, game observation, transport and delivery of light cargo, coastal surveillance and ship borne applications” (Army Recognition, 2019; Paramount Group, 2019).

4.14.5 Tellumat

Year	Model	Description
2014		Tellumat UAV CSIR developed a new airframe for Tellumat Concept and aerodynamic design Performance predictions and engine/propeller selection Stability and control predictions Structural design and prototype manufacture

2018		Tellumat ASTUS UAS "ASTUS UAS is a medium-size, medium-range tactical surveillance UAV system, suitable for lengthy missions needing real-time surveillance data collection and delivery for missions including border and coastal security, environmental protection and peacekeeping. It can also be used for training UAS pilots in beyond line of sight operations of larger UAV's" (*defenceWeb*, 2019b)

Image 4.22: Courtesy Tellumat

4.14.6 Summary of domestic/local Industries

All the above-mentioned are locally manufactured UAS with military or (potential) military applications. The companies mentioned above are only a few of the many more local developers of civilian unmanned aircraft systems and drones. Universities, as mentioned above, and Technical Colleges are also developing experimental UAS, for example the UP AREND anti-poaching UAS.

The fact that so many local South African companies can, and are, manufacturing UAVs/UAS, and also exporting and importing them internationally, seems to provide evidence of the researcher's initial observations during the research process, that the proliferation of unmanned aerial vehicles/drones is becoming an increasing challenge, and as alluded to by Sayler, Kreps and the Armaments Research Centre. These technologically advanced and sophisticated aerial vehicles, both armed and unarmed, are becoming accessible to more and more countries, and the question remains, could the proliferation of these aerial vehicles and aerial systems become a threat to governments around the world, and to South Africa and our neighbouring states?

4.15 Current UAS Trends in South Africa

In South Africa, the employment of UAS between the SANDF and defence industries receives considerable publicity. UAS are used for research and development projects have also been used for public order policing (Martin, 2014), as was the case with the Soccer World Cup in 2010 in South Africa (Engelbrecht, 2010). Martin (2019), for example, has stated that for the first time, a hand-launched UAS, manufactured by the CSIR, will be deployed to the DRC for the use by the SANDF peacekeeping forces. This follows the stringent tests and evaluations done on the Indiza over the past few years, in the Kruger National Park. Martin (2019) mentioned the UAS that were also used by the SANDF to combat rhino poaching in the Kruger National Park. Martin (2014) verified that the Indiza is used for border management. They indicated that the SA Army is using the Indiza for peacekeeping missions, surveillance and border safeguarding. It was also mentioned that the SA Army conducted surveillance trials with small multi-rotor UAS (*defenceWeb*, 2020). Furthermore, the SANDF is using UAS for security missions as well (*defenceWeb*, 2020). Martin (2019) mentioned

that the SANDF started using UAS to reduce costs due to South Africa's huge coastline which needs protection.

In 2016, Reuters published an article, wherein the SA National Defence Force stated that it was not currently operating unmanned aircraft systems. Following the SAAF indicating in 2016 that it was reactivating its former UAS squadron, the SANDF spokesperson said that there was no intention to reactivate the squadron which had closed more than a decade ago (Reuters, 2016).

On the civilian side, Airborne Drones SA stated that autonomous drones were ready to monitor crime hotspots, city streets, and do border patrols and more (African Aerospace, 2017). The SA-based international manufacturer of enterprise-grade UAS is of the opinion that security cluster departments will soon realise the efficiency and cost savings involved with using UAS. Airborne Drones SA stated that "drones provide the ideal solution to the problems and limitations faced by other surveillance methods such as GPS tracking, CCTV camera observation, biometric surveillance and ground patrols" (as cited by African Aerospace, 2017). Specialised security drones can enter narrow and confined spaces, produce minimal noise, and can be equipped with night vision cameras and thermal sensors, allowing them to provide imagery that the human eye is unable to detect. In addition, these UAVs can quickly cover large and difficult-to-reach areas, reducing staff numbers and costs, and do not require much space for their operators. Autonomous, long-range security drones are at the vanguard of new policing methods" (African Aerospace, 2017).

Other impending uses for UAS in SA, according to Cloete (2019), is that the City of Cape Town "plans to use drone technology in its fight against crime" (Cloete, 2019). This announcement was made following the recent deployments of troops to Cape Town, where the SANDF deployment was not successful in reaching the required end results in the gangster ridden Cape Flats (Cloete, 2019).

Throughout the literature study, the common themes that seem to be associated with the utilisation of UAS globally are that they can execute and undertake various roles and functions. Unmanned aircraft, however, originally used for military purposes are being used more and more by the civilian and commercial sector. As example, military and paramilitary uses include maritime roles: surveillance, security along the EEZ, anti-piracy, anti-poaching, intelligence gathering, reconnaissance, surveillance, strike and attacks, battlefield targeting, battlefield damage assessment, border patrol (i.e. patrolling the extensive SA borders), communications relay, aerial targets, drug trafficking, human trafficking, and logistical re-supply.

Research has shown that civilian uses include search and rescue, wildlife monitoring, power line inspections, environmental monitoring, wildlife poaching, agriculture, filming, forest fire detection, pollution detection and meteorological data assimilation. Daily, it seems that new developments and employment opportunities for unmanned aerial vehicles are arising, resulting in an increasing concern regarding the utilisation of these sophisticated technologies. Drones can also be used for

heavy lifting such as base jumping and for swarming (i.e. drones can be used to build bridges, and lately, drones are also used for drone racing).

The proliferated uses of unmanned aerial vehicles are growing at such a rapid pace that legislation and controls cannot compete. With legislation lagging behind, various challenges arise. Many local manufacturers are continually investing in developing exciting turnkey products, with various performance capabilities, for economic benefits, and for business solutions for South Africa, and the African continent. As stated in the Dossier, aerospace development is supporting strategic air power, and "the ultimate aim is to ensure that South Africa's Defence Force is configured and equipped to defend and secure is national interests and protect its people, as well as participate in peacekeeping missions and render military assistance to other nations" (CSIR, 2016: 48).

4.16 UAS threats to South Africa

The SA Minister of Defence and Military Veterans (MOD&MV) specified that although South Africa is a peaceful country that lives in harmony with its neighbours, no country can be considered immune from international threats due to the unpredictability of the strategic environment and emerging conflict trends taking place on the African continent. Aspects such as increasing cybercrimes are also threatening SA's sovereignty. Honourary Nosiviwe Mapisa-Nqakula further stated that acts of terror are difficult to counter due to the international networks that are often involved, and the ideological cause "which may be perpetrated by individuals not affiliated to a specific country or group. Terrorism poses a real danger to our region" (Martin, 2018).

Threats that SA are currently facing in the air-, maritime- and land domain, due to SA's ineffective management of its porous borders, are a "continuous inflow of illegal immigrants, the smuggling of goods, weapons and human trafficking" – The MOD&MV indicates that this leads to lawlessness and contributes to instability in the country (*defenceWeb*, 2018a). The MOD&MV further indicated that "unmanned aerial vehicles (UAVs) and privately owned small aircraft are often used for acts that threaten the safety and security of our people. We must remain vigilant in protecting and securing our airspace and maritime zones. In terms of equipment priorities, we must prioritise the acquisition of domain-awareness systems in order to deliver more effective operations" (*defenceWeb*, 2018a).

The point is whether policy makers and the government understand the implications of these threats to South Africa, the African continental borders, with the ensuing spillover effect that conflict(s) could have, between the various states. With the yearly diminishing allocated SA defence budget, and the SANDF's obsolete equipment and ammunition, will the SAAF and the SANDF be in a position to face the threats that for example are created by increasing sophisticated unmanned aircraft systems and cyber-attacks?

Of concern to the safety and security of South Africa, is the announcement made by the MOD&MV to Parliament, in that "South Africa has now reached the point where it must make a decision on the kind of Defence Force it wants and can afford. The level of ambition is not sustainable on the current

level of funding. Defence should remain mandate driven, and not budget driven as is currently the case" (*defenceWeb*, 2018a).

Threats and challenges facing South Africa, which the Secretary for Defence, Dr Sam Gulube, has spoken out on, is the "increasing political instability, predominantly on the African continent, which continues to demand the presence of international peacekeeping operations. National interests will continue to drive the involvement of major powers in Africa, specifically where vital interest are at stake. While traditional interests such as oil and strategic minerals remain important, the perceived threat posed by increases in Islamic extremism to intra-state security is becoming increasingly more predominant" (*defenceWeb*, 2018b).

In terms of more recent developments on the continent of Africa, it seems that interference of non-African actors by using, among others, unilateral UAV attacks in East Africa, especially Somalia and occasionally North Sudan, is driving some combatants that resist such unilateral interventions, towards the south as recent developments in northern Mozambique indicate. This seems to be a repetition of earlier support for RENAMO (a rebel movement against FRELIMO rule) to achieve a destabilisation effect. This approach was used in the past by Rhodesia (during the 1970s) and South Africa (1980s) to benefit their power interests in Mozambique. Current discontent seems to be furthered through support to these aggrieved communities in northern Mozambique. Similarly in West Africa, forces such as France's interventions in the affairs of other countries such as Mali is also driving up tensions. The affected people and victims in all likelihood would join any resisting movement/group or organisation. Movements that are almost always in Western discourse are glibly and uncritically classified as 'terrorist' without interrogating the elements of class, historical memories of being marginalised, conflict triggered by grievance, being dispossessed and those that have other long-held (historically) grievances. Such one-sided interventions by self-proclaimed police states or others defending and expanding their economic and political interest, are worsening the current situation and should be considered in the equation and evolving new trends. Only tentative remarks and hunches can be mentioned here. In this area there is space for more critical and fresh research that fall outside of the ambit of the study.

During her manifesto briefing on peace and security, the SA MOD&MV indicated that the government was always questioned by the public as to whether they have sufficient military personnel to protect the borders. In answer to this, she indicated that we needed to look towards technology and innovative ways to win the war against porous borders and criminal activities committed by illegal immigrants, and informed the media that South Africa may make use of unmanned aerial vehicles (drones) to protect our borders from illegal immigrants. Adding to the Minister of Defence's statement, it's a known fact within the military and in the open public that there are not sufficient troops to secure our borders and that civilian companies are assisting in this regard. The current realities of using unmanned aerial vehicles to patrol our borders could possibly provide a feasible solution.

The downside of the phenomenon of globalisation is that with it comes greater alienation, grievance and deglobalisation developments such as (violent) fragmentation (Giddens, 1993: 527ff; 532ff, 552-553). In this type of fragmentation the global scene becomes a potentially explosive environment where military and rebels meet (Giddens, 1993: 368, 371ff and 375ff). Compare also Noam Chomsky on the precarious problematics of distinction between various forms of resistance and the negative challenges brought by blankly calling all resistors “terrorists” (Chomsky, 2007: 189-191). See also Gwynne Dyer (2006). Military forces and resistance groups become increasingly involved with escalating alienation, fragmentation and violence (Dyer, 2006: 104-108).

Globalisation continues to create opportunities for transnational operating and aggressive non-state actors that make use of global cyber-, financial and transportation networks. This is especially the case when terrorist groups have a common cause of destabilising and breaking down government systems. The nodal points such as seaports, airports, computer servers, and banking systems form the centres of their operations with the ultimate end-state to bring about national and regional political instability (*defenceWeb*, 2018b). With urbanisation and a growing world population, more people will migrate across borders, where crime syndicates and transnational terrorists will carry out their illicit activities across the borders. During international peace support operations, the SANDF could face hybrid threats (international conflicts mixed with local conflicts) as well as the increased use of improvised explosive devices (IEDs). In essence, South Africa could be drawn into international military crises, with the character of conflict and war that is ever evolving, and as a result of existing treaty obligations with African states (*defenceWeb*, 2018b).

In the fight against the “war on terror”, the US have lowered their standards on who and where their drone strikes could take place. With the new adopted Principles, Standards and Procedures (PSP) for UAS strikes, the US president can “take military action against any alleged terrorist groups, and those in Africa. This includes groups which have not directly attacked the US homeland, like al-Shabaab and the Islamic State” (Donnenfeld, 2019). A rising concern, therefore, is the number of drone strikes that have increased in Somalia on the African continent. ISS Africa stated that “Trump has exponentially increased the pace of drone strikes in Somalia. In just two years, Trump (83 strikes) has more than doubled the number of attacks that took place under Barack Obama (31 strikes) and George Bush (10 strikes)” (Donnenfeld, 2019). This relates to the USA exporting violence to Africa (and elsewhere, i.e. Pakistan), ignoring territorial sovereignty of countries and/or destroying the lives of citizens of other countries and property. The USA sees itself as above (international law), even the International Criminal Court (ICC). In short, as Noam Chomsky (2007) and Gwynne Dyer (2006) argued, the USA in its so-called “war on terror” has itself become a net exporter of violence through the military projection of its armed forces, including drones.

“The continued use of drones leaves a huge footprint on the theatre of war, and an unsettling reality is that this technology is a feature of conflicts waged, not in the first world where it is developed, but in developing countries in Africa, Asia and the Middle East, where it is exported. The most important

debate revolves around the impact such uses have on populations desperate for peace" (Tsabora, 2015: 462). The point here is that sceptics feel that drones have a negative connotation in conflict ridden areas, and should not be used for peacekeeping missions. A point of much debate.

In another article, Donnefeld (2019) stated that policy changes in the US are adding to the risks already facing the Horn and the Sahel. Trump's latest sanctions could also create tensions and increasing threats across the world. The fact that "President Trump wants to reshape America's policy in Africa, by challenging the continent's leaders to make a strategic choice to align themselves with America instead of Russia or China" (Nissenbaum, 2018), is indicative of international tensions in Africa, which South Africa could be drawn into. While the US is of the opinion that Russia and China are security threats in Africa, they are also concerned about the "growing threat from militant groups across Africa" (Nissenbaum, 2018).

Hamilton, Bax and Sayed (2018) are of the opinion that in Africa, violent extremism has spread outside its epicentres to previously low risk countries such as Mozambique and potentially South Africa. With the latest escalating violent extremist attacks by ISIS in Mozambique, Hamilton et al. (2018) indicated that "this specific type of threat is only one porous border away from South Africa". Countries most at risk by extremist groups, following the spread away from its epicentres in Somalia, are East Africa, West Africa and the Sahel. Similarly, al-Shabaab has infiltrated Kenia and Tanzania and following the violent extremist attacks in Tanzania, extremist training camps were set up along the Mozambique border. Of considerable concern, is the fact that Mozambique can act as "a possible corridor for international jihadists going to South Africa and beyond" (Hamilton et al., 2018).

Hennigan (2018) stated that "it is the widespread availability of commercial drones that poses the largest threat". He provides a few examples of the threats that drones can pose to national security. For example, ISIS militants have used fleets of small drones which could carry grenades and miniaturised explosives in wars or conflict zones against the US. In other words, ISIS could carry out such threats anywhere, irrespective of geography. Mini quad copters that are relatively cheap have been used by criminals to drop drugs in prisons, and drug smugglers have used them for surveillance during borders patrols. Drones can even be used to deliver harmful substances. Existing radar systems were designed to detect large surfaces, and since most commercial drones are made from plastic, and do not have transponders, they are much more difficult to detect (Hennigan, 2018).

Franke (as cited by McKay, 2019) stated that millions of personal hobbyist drones are sold globally, and that non-state actors have used them to their advantage, whether for attacks, ISR or propaganda. Franke said that the "Islamic State has been particularly interested in drones, investing some effort into its drone training and development programme, and using drones as flying IEDs" (as cited by McKay, 2019). She added that terrorists enjoy using UAS (drones) because of the fear they can spread through air attacks, and because they can be used to attack high value targets such

as high level, usually inaccessible, politicians. Her biggest concern currently is that terrorist groups could attack commercial airplanes (McKay, 2019).

Friese et al. (2016: 10) stated that they have found that “there has been a significant increase in the quantity, variety, and capability of COTS small UAVs employed by non-state actors, and that COTS small UAVs can offer non-state actors capabilities that may not otherwise be readily available to them” (Friese et al., 2016: 10). COTS small UAVs are ideal for modern asymmetric conflicts or warfare because they do not require complex support systems or networks. They are cheap, flexible, and lightweight, are very portable and offer non-state actors with a variety of advanced UAV capabilities, such as offensive capabilities and intelligence gathering operations (i.e. ISTAR). She further stated that COTS small UAV technologies are not limited by ideology or geography, and can therefore be used by a diverse range of non-state actors (Friese et al., 2016: 10).

Pomerleau (2016) is of the opinion that “it’s no secret that the military is beginning to take seriously the threat that commercial unmanned aerial systems pose to personnel and military interests”. Pomerleau (2016) also indicated that ground and maritime-based unmanned systems are similarly a threat, and not only aerial drones. Another concern is that inexpensive drones can be used as expendable one-directional bombs. “From individuals to terrorist groups, the threat is metastasizing, despite the monopoly the US military has maintained on unmanned technology. Although there is still a large gap between the capabilities of the military and civilian drones, commercially available drones are giving hobbyists, companies and hostile groups, access to capabilities previously only available to the military” (Pomerleau, 2016). He further stated that terrorist groups such as ISIS are using drones to a greater degree, including using a remotely controlled car loaded with explosives. He added that they are also using them for ISR, a capability previously unavailable to terrorists that did not possess expensive aerial assets” (Pomerleau, 2016). The question that comes to mind here is whether these global commercial capabilities are not becoming an increasing threat to South Africa, with our diminishing defence budget and our diminishing military capabilities?

Research has indicated that the greatest threats facing SA are human security, crime, borderless borders which allow international terrorists to enter a country, illegal use of drugs, urban warfare, cyberwarfare, cybercrime, radio frequency jamming, asymmetrical threats, dissidents, and anarchist and anti-government agents. Commercial off-the-shelf drones (COTS), which are easily purchased, and customised to fit the operator’s needs, are an increasing threat to society. Drones operated during sensitive events or military operations can cause air collisions. Illegal surveillance are also seen as a threat, and a contravention of human rights. Drones flying to close, and invading airliners airspace, is a serious threat.

4.17 UAS counter-measures

Friese et al. (2016: 10) quoted Sweetman (2015) by stating that “numerous systems have been developed to counter the threat posed by the operation of the dangerous, threatening, or illegal use

of UAV systems. Numerous militaries have already introduced technologies which are suitable for tracking, identifying, and engaging unmanned systems" (Friese et al., 2016: 10). Military forces mostly developed counter-measures based on previously encountered threats from, for example, guided missiles, manned aircraft, and projectiles, or rockets.

White (2017) stated that "with the proliferation of COTS UAVs employed by violent extremist organisations in the Middle East, the defence and security sector continues to ramp up capabilities to not only, detect such threats before they have even occurred, but effectively counter them" (White, 2017: 35). It is not only violent extremist organisations that are using UAS against countries/states, governments or populations, it is similarly 'lone wolves' (individuals) with malicious intents, insurgent groups, terrorist groups, organised crime groups, activist groups and even corporations wishing to gain sensitive information on competing companies, as indicated by Pomerleau (2016), that pose a security threat to a greater or lesser degree.

With everything been interconnected and interrelated, as expressed by White (2017: 37), it is possible for terrorist groups to cooperate with one another.

Hammes (2016) quoted Franke, who believes that "cheap commercial drones flying today can and, in the near future likely will, dramatically change the character of conflict between state and non-state actors" (Hammes, 2016). Tilenni (2016) is of the opinion that small UAS weighing less than 150kg (known as NATO Class 1 in the military environment) will pose the greatest threat because they are easily accessible, affordable, can be used for various scenarios, and different purposes, due to their small size. These small UAS could target high value targets such as government buildings, military facilities, critical infrastructures (i.e. airports, nuclear power plants, and bridges), large open-air events, tourism sites or even public figures or community members (Friese et al., 2016: 55 and Tilenni, 2016). For such scenarios, Friese et al. (2016: 55) are of the opinion that to prevent or reduce collateral damage in such circumstances, it would be advisable to adjust tactics or even weapons systems, and allow private authorities or law enforcement agencies to execute counter-UAS operations.

Franke (as cited by Hammes, 2016) believes that "flying IEDs" will pose a threat to lines of communication centres and military bases, fuel trucks, aircraft wings, or ammunition dumps or troop movements. This could raise the cost for protecting forces, because to counter the threat, some targets will need to be "hardened", or air defences will have to be provided for critical facilities. In other words, soft targets such as living quarters, command posts, fuel dumps, satellite dishes, large stationary aircraft and communication towers, will have to be hardened. Friese et al. (2016: 55) likewise believe that the cost disparities between these counter-measure capabilities and the target, "calls into question the long term sustainability of such systems, particularly when the payload or intent of a COTS small UAV can be difficult to determine" (Friese et al., 2016: 55).

Franke (as cited by Hammes, 2016) stated that “defending against drones is very difficult. They have very low signatures and widely varying flight characteristics” (Hammes, 2016). Friese et al. (2016: 54) indicated that many counter-UAV systems would need to include specialised radar, as conventional radars cannot easily detect small COTS UAVs. To improve counter-measures against small UAS, it may be necessary to apply software modifications to existing radar, so that they can more accurately track their small targets. As example, Friese et al. (2016: 54) mentioned that SAAB has updated its “Giraffe series radar with an ‘enhanced low, slow and small’ function for identification and tracking of UAVs” (Tilenni, 2016 and Friese et al., 2016: 54). White (2017: 36) supported Friese et al.’s (2016: 54) viewpoint concerning the Anti-UAV Defence System (AUDS) (a joint venture by Blighter Surveillance Systems, Chess Dynamics and Enterprise Control Systems). This Blighter AUDS can detect, disrupt and neutralise hostile UAV threats from as far as 10km.

Image 4.23: SAAB’s Giraffe

Image 4.24: Blighter Surveillance Systems) – The Blighter Anti-UAV Defence System or AUDS

Lockheed Martin’s ICARUS is another example of cyberwarfare capabilities. Jean (2015 as quoted by Friese et al., 2016: 54) stated that their system can “disable the UAV's onboard cameras, knock the system out of the sky, or confiscate control of the vehicle and land it in a safe zone”. This happened by allowing the pilot or operator to identify, track, and engage any UAS threats, with electronic and cyberwarfare capabilities (Friese et al., 2016: 54).

On the other hand, White (2016) referred to major cyber security threats, the so-called “man in the middle” attacks, where a hacker could “intercept or change commands being given to a UAV with regards to flight information and target tracking, from a tactical control station” (White, 2017: 62). An example of such an attack, is one where it was claimed that an Iranian cyberwarfare specialist unit hacked and took control of a United States Air Force (USAF) RQ-170 UAS, approximately 220km form the Afghanistan border. Such an attack by the Iranian forces present serious concerns for modern day warfare.

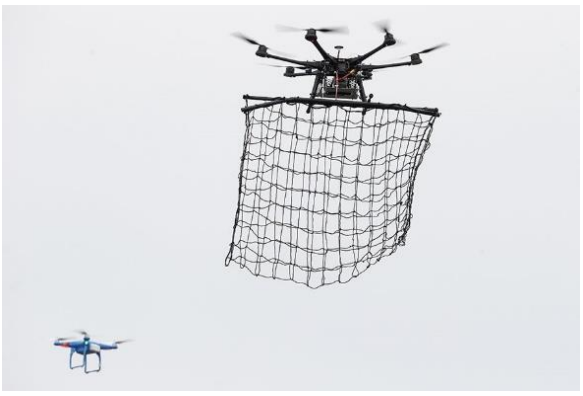
Another international counter-measure that is used is the Boeing's Compact Laser Weapon System. As illustration, Boeing UK has announced that it has developed a new Compact Laser Weapon System (CLWS), with the proven ability, to counter unmanned aerial system (UAS) threats. It was confirmed that the Boeing compact laser weapon system hit 19 out of 19 mobile targets. The CLWS is a portable laser system and can stand alone or pair with weapon platforms on vehicles or ships. Silent, invisible and precise – CLWS harnesses directed energy on its targets.

Image 4.25: Boeing's Compact Laser Weapon System
Source: Boeing Defense

As indicated, different systems have been developed and are in development internationally to counter UAS. Systems such as high power lasers, drone nets, trained hawks (birds), signal jamming/hacking and spoofing and shotguns, and microwave guns for shooting down drones exist (Schröder, 2018 and Friese et al., 2016: 54-56).

A woman test shoots the anti-drone gun known as the Drone Defender.

Image 4.26: Courtesy Battelle



A drone interceptor with a net, prepares to catch a DJI Phantom drone during a demonstration flight in Paris, France.

Image 4.27: Courtesy Francois Mori

Image 4.28: Airspacemag.com

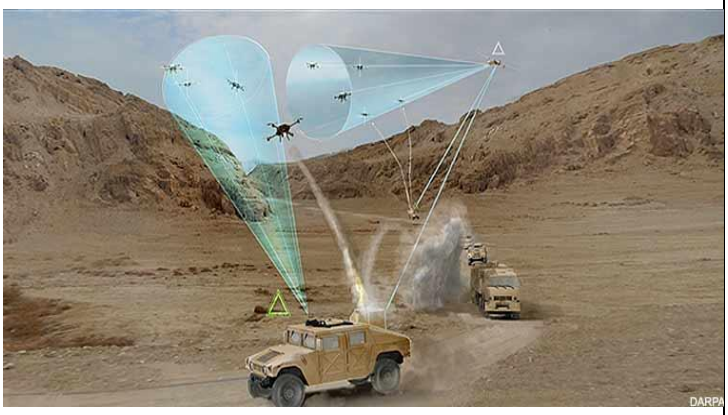


Image 4.29: DARPA (Defensesystems.com)

Kanowitz (2019) mentioned a newer development, essentially known as an ‘anti-drone buggy. Finally, with computing power increasing and the ability of carbon 3-D printing technology been available to produce between 25–100 UAS a day, and by adding an “app” for the UAs to fly autonomously, could this capability be added to the list of terrorist and insurgents threats (Hammes, 2016) or could this 3-D capability be used by the military for swarms of UAS in a conflict situation?

Within South Africa, various defence companies such as the CSIR, Reutech and Indra are developing and have developed UAS counter-measures for South Africa. Open source information in South Africa in this regard has however been rather restrictive. This part of the study has combined both SA and international availability of counter-UAS measures. With global defence partnerships in place across the world and as indicated in this study, the assumption is made that SA will be in a position to procure these technologies, if so required.

The CSIR is currently (2019) researching the types of UAV counter-measures which are required in the country. The CSIR is currently characterising the threat levels expected for South Africa and for the various types of UAS. Furthermore, they are researching the most appropriate types of counter-measures that can be used to counter those threat levels. The type of counter-measures will differ, depending on the “threat-level” involved. Abbott, Clarke, Hathorn and Hickie (2016), from the CSIR is of the opinion that “the best defence against the hostile use of drones is to employ a hierarchy of counter-measures encompassing regulatory counter-measures, passive counter-measures and active counter-measures” (Abbott et al., 2016: 1). Regulatory counter-measures he believes can assist policymakers to pass very strict laws to prevent hostile individuals and groups from acquiring and flying drones, especially ones with payload capabilities, which they could use for example, for dropping IEDS. With the use of passive counter-measures, security can be alerted to any drone which, for example, has infringed a defensive perimeter around a structure or a no-fly zone. Active counter-measures, such as radar, electro-optical, infra-red systems, radio frequency jamming, lasers and raptor (birds), can be used in addition to passive counter-measures if drones continue to be a

threat. However, there are challenges and consequences involved, should a threat be neutralised in a civilian environment. Additionally, he is concerned that “active countermeasures currently available for use in non-military settings are limited” (Abbott et al., 2016: 1). To point out, these will be the many challenges SA, as a peaceful nation, will face while analysing and developing UAS counter-measures in the SA context. Furthermore, “modular UAS are used for research and development resulting in new uses for UAS almost on a daily basis. Unpiloted aircraft is therefore permanently changing the face of warfare and peacekeeping” (CSIR, 2012: 36-37).

Martin (2019) indicated that “Reutech is developing a counter-unmanned aerial vehicle (UAV) system in response to the growing threat from UAVs” (Martin, 2019). He further quoted Carl Kies, who announced at the 2019 Aerospace, Maritime and Defence Conference that “autonomous weapons are posing an increasing threat, with non-state actors able to have an air force and a navy, primarily through the acquisition of autonomous weapons” (Martin, 2019). In referring to the strikes on the Saudi Arabia oil facilities, Kies (as cited by Martin, 2019) stated that threats posed by UAS are getting very serious, specifically if these new types of UAS targets can breach traditional Saudi air defence systems such as the Patriot, Skyguard system and the Shaheen (Martin, 2019). This new threat indicated here refers to the small hobby and commercial UAS, which have very small infrared footprint and a small radar cross section. These kinds of threats are very difficult to detect or destroy as they can fly very low and slow and do not require GPS which can be jammed. Currently, spoofing and GPS jamming are often used to neutralise UAVs, but Reutech has successfully tested another system to take out smaller targets. A remotely operated automatic grenade launcher with 40mm airburst rounds can be used very effectively as a counter-measure for small UAS (Martin, 2019).

As previously mentioned by Franke (2014), Kies (as cited by Martin, 2019), also warned against flying IEDs, which can be assembled for about R10 000. The fear of small commercial and hobby UAS is that they are becoming increasingly sophisticated, cheaper and are able to carry larger payloads than previously. In this instance, an example is provided of DJI Phantoms and other small UAVs, with 40 mm grenades, that were successfully used by the Islamic State against targets in Iraq (Martin, 2019).

Kies (as cited by Martin, 2019), said “South Africa has a number of possible counter-UAV solutions. For detection, this includes the RSR 906 gap filler radar to detect difficult targets at 20 kilometres, jammers and direction finders (such as those supplied by GEW) to target UAV communications and navigation, 23 mm anti-aircraft guns, Starstreak or Umkhonto missiles and Reutech optronic radar trackers for missile and gun fire control. Cannon and missiles would typically be used on larger UAVs. Reutech previously developed the RSR 150 radar for rapidly tracking multiple incoming projectiles, which is also ideal for tracking small UAVs” (Martin, 2019).

Indra, a global consulting and technology company operating in Africa and South Africa, have developed a counter-UAV system to protect airports as well as other zones against unauthorised drones. *defenceWeb* (2019a) states that the Indra Anti RPAS Multi-sensor System (ARMS) can detect a UAS kilometres from the space or area it wishes to invade. It has the capability to detect the type of UAS model as well, subsequently being able to neutralise it via the model's inherent weaknesses. Apparently, "the solution is so effective that it can be used in a precise manner to disable a single drone, in a 'surgical' intervention, or a whole swarm of drones, applying more aggressive measures. If an invasion occurs from different points simultaneously, it activates a full protection dome" (*defenceWeb*, 2019a).

This system is unique in the market as it has the ability to regulate an appropriated response, specifically within an airport sector, without any interference to the electronic equipment of any aircraft in the area. The Indra's ARMS system can integrate with air traffic control centres to exchange information on any unauthorised flights near the airport. The system also has infrared cameras, radar and electronic warfare sensors to determine the navigation system and radio spectrum which the drone uses. The jamming equipment of this system can use spoofing or deception techniques to take over the control of the UAS and land it where required. The jamming can also cut off the communication system between the drone and the pilot. The entire operation can be supervised from one control site by the pilot or operator. A great advantage of this Indra's ARMS system, according to *defenceWeb* (2019a), is that it has advanced artificial intelligence embedded in its system, allowing for more precision the longer it is used, and can therefore identify an area where a rogue drone operator is operating from, and enable an arrest.

Image 4.30: Indra's counter-UAV system

The Indra's counter-UAV system can use both soft- and hard kill methods to neutralise enemy drones. Soft-kill methods are usually used in a civilian environment to neutralise a drone, whereas hard-kill techniques are used to shoot down an enemy drone, as in a military operation. However, many existential risks can result from this, as it can be difficult to stop small drones that suddenly appear out of nowhere, resulting in very limited reaction times. Buildings, nuclear plants, sport stadiums, infrastructure and public facilities could therefore be at risk (*defenceWeb*, 2019a).

Developing an effective solution for drone counter-measures requires extensive knowledge in various areas such as command and control, radar technology, communications and electronic defence mechanisms as indicated in the article (*defenceWeb*, 2019a). Referring to the above-mentioned information, governments, policy holders and security advisors should realise that in developing UAS counter-measures, it would take many years of extensive effort and expertise to be positioned for future utilisation and the protection of our sovereignty.

The SANDF is looking into austerity measures, but apparently no investments have been made in this regard yet. Apparently the South African Police Services (SAPS) and the some Army Forces do have drone counter-measures and the necessary equipment. Obtaining information in this regard within the SANDF and the security clusters has not be easy, as it relates to National Security and such highly classified sources could not be used in this study.

A limitation to this section has been access to sufficient open source counter-measure information in South Africa, and the military. For national security reasons, it is however apparent that such information will not be readily available in an open forum. With the difficulty experienced to obtain information on South African counter-measures, a huge GAP has been identified in SA national safety and security context. The possibility exists that the SAAF and the SANDF together with industry partners, could have possible solutions, yet due to national security reasons, will not be divulged in any open source documents.

Gonçalves (2019) indicated that “rogue drones are not an “overseas” problem. South Africa has a specific risk profile which may be different from other countries. There is no single stakeholder that can deal alone with the rogue drone problem as it extends beyond the mandate of a single government department” (Gonçalves, 2019: Slide 20). He further stated that strategic interventions, preparedness, understanding, a mix of relevant capabilities and mature technologies are required to address rogue drone problems. Gonçalves (2019) is of the opinion that “an increase in counter-measures will lead to a response from adversaries resulting in an escalation and unpredictability of drone counter-measures effectiveness” (Gonçalves, 2019: Slide 20).

Franke (2014) and Tilenni (2016), supporting Gonçalves (2019), reckoned that “the future of counter-UAV technology seems to be closely connected to future developments in the UAV market” (Tilenni, 2016). Franke (as cited by Hammes, 2016), stated that “in the longer term, drones may actually carry lasers and use them to defeat air-defense lasers. She states that this will be part of the ongoing action – reaction – counter – reactions that have marked conflict throughout recorded history” (Hammes, 2016). Tilenni (2016) further stated that “as long as the UAV market continues to expand, the counter-UAV sector will follow accordingly – unless a ‘silver bullet’ is found, at least” (Tilenni, 2016).

Kanowitz (2019) supported this statement by saying that “though, many of the existing solutions represent huge technological advancements from where we were just five years ago and show a

tremendous amount of potential, the technology has not quite caught up with the need and a 'silver bullet' solution to the small drone problem remains elusive" (Kanowitz, 2019).

4.18 Conclusion

Drone technology is expanding and arguably bound to proliferate globally. This phenomenon impacts societies, including South Africa. This chapter explored this phenomenon and provided pointers to the effects thereof. The South African context is relevant here.

Unmanned aircraft systems have given us a new reality – the elimination of a war target with clinical precision and minimal collateral damage from a control room far away from the conflict zone. New sophisticated technologies are proliferating, yet many countries' military defence force budgets are facing declining deficits, and forcing governments to decide which kind of military structure they would want in future.

In 2012 it was stated in the Defence Review that "developments in technology have greatly enhanced the effectiveness and lethality of air power and will play an even more vital role in future warfare" (RSA, 2012: 171). Seven years later, and technology in the form of cyber threats, unmanned aircraft systems, artificial intelligence, robotics and the 4th industrial revolution is continuing to enhance the challenges and lethality of our existence. In 2016, it was stated in the CSIR Dossier of Science and Technology, that "Air Forces globally agree that going 'high-tech' in air defence is tempting, can be cost effective, and certainly provides a competitive edge" (CSIR, 2016: 48). In 2016, it was also stated that "smaller air forces that argue against the cost of new technologies are in danger of finding themselves outmanoeuvred by better equipped opponents" (GlobalSecurity.org, 2017). Where does South Africa, the SA Air Force and the African continent lie in addressing these proliferating technological challenges?

Even though SA is seen as a peaceful country, with a defensive posture, the ever present threat of 21st century technology remains, together with the threat of such systems falling into the wrong hands and those of extremist groups. Would it therefore not be advisable, based on the uncertainty of the future, that we as South Africa question ourselves as to whether South Africa has sufficient counter-measures in place against UAS that could possibly pose a threat?

Consequently, it is believed that governments and militaries across the globe would be ill advised were they not preparing for additional national security measures and counter-measures, based on the increasing proliferation of sophisticated UAS and the possible threats to our societies.

No development in the world of increased high-tech observation methods and by extension the offensive use of these systems, stands apart from political aims and objectives, human rights and international law. This chapter also touched on these complexities internationally, regionally and for South Africa. Both ethical considerations and the perceptions of global and local civil-society are at stake. This in turns call up questions about the quality of civil-military relations and the civil-military gap (the area on which civilians (the citizenry) or civil society, defence leadership and the incumbent

government arrived at a mutual consensus about a specific issue – in this case the use of UAVs). Given current developments, potential for proliferation and the phenomenon of aggressive use of these devices over borders and a more vibrant civil society, as well as debate on international law, numerous challenges await. More so in a global world where large disparities (asymmetric military power) between countries mark the international scene. In this chapter the researcher also touched on these issues as part of the broader picture.

The following chapter deals in more detail with the research methodology used in the course of this study.

CHAPTER 5: RESEARCH METHODOLOGY AND INTERVIEWS

5.1 Introduction

In this qualitative study there are two crucial complementary elements. The one is the extensive review of scholarly literature. The literature review was augmented with a qualitative approach to add to the harvesting of data and to provide insights on the chosen topic. Two interviewing methods were utilised. These were (1) face-to-face interviews with selected participants who are experts in the field or hold positions where they were exposed to the area under study (expert practitioners); (2) A focus group interview to augment the knowledge gained from the literature and the face-to-face interviews. By means of an exploratory approach with qualitative elements as much information as possible was accessed. The interviews included selected participants such as aviation members, expert practitioners and subject matter experts (SMEs). This focus group assisted greatly to obtain credible and valid information as well as feedback from those closely involved within the selected topic under study, namely “The South African Air Force (SAAF), Unmanned Aircraft Systems and National Security: An Exploratory Study”.

5.2 Research methodology

5.2.1 Central theoretical statement

The employment of unmanned aircraft systems (UAS) internationally and their use by the South African Air Force to assist with national security formed the basis for the researcher’s central theoretical approach. The study analysed the use of UAS primarily in international military roles and looked, where applicable, at the commercial side of drones that could possibly contribute to the security threats of a country. Attention was given to the various employment/uses of UAS as an extension of the capabilities of a defence force, which could contribute to the greater security of South Africa and its neighbours. In terms of the employment of UAS in SA, the concept of national security was explored. In view of the past, current and intensified use of these systems in future, the reader was as part of the background and current setting introduced to legal matters. Issues locally and internationally were addressed as part of the setting, concluding that much is still to be done in this respect, opening space for dedicated studies on the international and national ramifications in relation to human rights, rights to privacy, unilateral attacks on other countries and the setting of rules and legal parameters that are enforceable.

The role of UAS in the SANDF was then explored in terms of various employment capabilities and SA’s national security. Current budget constraints were mentioned and the potential of UAS platforms to undertake various tasks more cost-effectively.

With defence matters in mind, the relations between a state and other states (especially where [large] states pose a threat) is of great importance. The defence force of a country is the instrument employed to support foreign policy and to ensure security and play a role in defence diplomacy,

when required (defence diplomacy is linked closely with foreign policy and the way in which defence forces are used in support of a country's foreign policy, projection of power and peacemaking). As states are the main role players here, the theoretical assumption of this study was based on the theory of realism (D'Anieri, 2013: 65-66; Blanton and Kegley, 2017). It was assumed in this study that state power plays a central role in world and regional politics (D'Anieri, 2013: 61, 65-66; Dye, 2002: 352ff). Morgenthau suggested that "International Politics, like all politics, is a struggle for power …power is always the immediate aim … but (Statesmen, governments and people) in international politics strive to realize their goals through international (and regional – my insertion) context … they are striving for power" (cited in Dye, 2002: 352). Issues such as an asymmetry of power between states also play a role (D'Anieri, 2013; Dye, 2002). But it is not only the incumbents of a state that utilise the defence forces (in this case UAS). Contenders to a state or a regime (those excluded from the state an in opposition against the regime) are likewise tempted to make use of such tools for observation or offensive purposes in the current high-tech era. The same applies to criminal groups or syndicates.

In the world of politics and international relations, realism is one of the "most common theoretical perspectives policy makers use to interpret international relations" (Blanton and Kegley, 2017: 23). "Realism, as applied to contemporary international politics, views the state as the most important actor on the world stage because it answers to no higher political authority" (Blanton and Kegley, 2017: 24). These views are shared by D'Anieri (2013: 65-66) and Morgenthau (as cited in Dye, 2002: 352), as is indicated in this study. "States are sovereign: they have supreme power over their territory and populace, and no other actor stands above them to wield legitimacy and coercive capability and govern the global system" (Blanton and Kegley, 2017: 24).

Realists view world politics as a continuous struggle for power where each state is responsible for its own national security, whether it builds alliances with other states, or whether it increases its military power (Blanton and Kegley, 2017: 24). Realism critics tend to state that if one country wishes to increase its military power, another country, or its neighbour, would feel threatened, and similarly would want to increase its own military power (Blanton and Kegley, 2017: 28). The researcher is of the opinion that "world politics is a struggle for power" (Blanton and Kegley, 2017: 25), and that a stronger nation would always want to dominate a weaker nation. The reason for using realism as the theoretical foundation for this study is because it has been clear during the research on this topic, that if one country possesses, i.e. armed drones, other countries similarly want to possess armed drones. It has been apparent throughout the research, that the more powerful the state is, the more sophisticated military capabilities its desires. In the words of Blanton and Kegley (2017: 25), "international anarchy and a lack of trust perpetuate the principle of self-help and can give rise to the security dilemma" (Blanton and Kegley, 2017: 25) and a race for arms. What is implied here is that, if one state increases it power for self-protection, another state would be inclined to do the same, even if a state merely wanted to arm itself for defensive purposes (Blanton and Kegley, 2017: 25).

“Despite realism’s shortcomings, many people continue to think about world politics in the language constructed by realists, especially in times of global tensions” (Blanton and Kegley, 2017: 28). Generally, this view is supported by the fact that states feel they have a right to protect and defend themselves (Blanton and Kegley, 2017: 28). Realism can be summarized in the worlds of President Obama, “I face the world as it is, and cannot stand idle in the face of threats to the American people”.

The researcher aimed to remain critical and open-minded throughout. People, including the experts interviewed, come from various backgrounds and as human subjects, the research participants were expected to bring new perspectives to the fore to enrich the knowledge already gained from the review of scholarly literature. The author Wilfred Desan (1987) referred to people as beings that view the world from different viewpoints, or as he calls it, “angular optics” (Desan, 1987: 49ff). Such viewpoints grounded in the experiences of research participants could enrich a study such as this one.

Dudovskiy (2018, e-book) stated that “critical realists, appreciate the importance of multi-level study. Specifically, as a researcher following critical realism research philosophy, you have to appreciate the influence and interrelationship between the individual, the group and the organisation. There is a consensus among researchers that critical realist is more popular and appropriate, than direct realist approach due to its ability to capture the fuller picture when studying a phenomenon” (Dudovskiy, 2018, e-book). This was the position taken by the researcher during this study, to gain a complete and realistic picture of the world around us regarding UAS and national security issues.

“Critical realists thus retain an ontological realism (there is a real world that exists independently of our perceptions, theories, and constructions) while accepting a form of epistemological constructivism and relativism (our *understanding* of this world is inevitably a construction from our own perspectives and standpoint). The different forms of realism, agree that there is no possibility of attaining a single, ‘correct’ understanding of the world, which Putnam (1999) describes as a “God’s eye view” that is independent of any particular viewpoint. A realist perspective can provide new and useful ways of approaching problems and can generate important insights into social phenomena” (Maxwell, 2012: 5).

5.2.2. Execution of the research process

In changing circumstances and fluid conditions, SA and the SAAF should view the world with new eyes, from a new paradigm, due to the increasingly complex global environment we are living in; a context which is creating more and more challenges and threats on a daily basis to our society, and to the quintet of our national security. The context within which we operate is consistently evolving and the researcher kept this in mind.

According to Breakfast et al. (2015: 224-225), there are two methodological approaches, namely qualitative and quantitative methodologies. When using both methods (mixed-methods) the triangulation can be used to complement each method’s weaknesses and strengths. The study

mainly made use of the qualitative research approach; however, the researcher included very basic quantitative information in order to complement some of the qualitative information obtained. The methodology used by the researcher was descriptive, qualitative and exploratory.

In terms of the qualitative component, namely the face-to-face interviews and the focus group(s), the study was a low risk project due to the fact that the intention was not to divulge any information under any circumstances that could be of a sensitive or confidential nature. Consequently, the researcher and interviewees (participants to the study) were in agreement that no sensitive or confidential information would appear in the public domain. Much of the information regarding military aspects related to UAS was openly available on various websites in the public domain. Open sources provided the backbone of the study and strict confidentiality was maintained following the interviews, according to the agreement with the research participants.

The researcher interviewed SMEs in both the military and the civilian fields of aviation. The members are experts in their fields, theorists and expert practitioners and do not belong to a vulnerable group. The SMEs identified for the study were known to the researcher as SMEs, based on her career in the SAAF. In mentioning her field of study to other fellow aviation specialists, professors and guest speakers on the SDSP 05/19 programme, referrals started to snowball as names of other aviation experts were shared with the researcher. This information was utilised to gain access to those interviewed. A trust-relationship, access, position and proximity to interviewees were also considered. Due to limitations to the research budget the need to interview people had to be balanced by getting access to interviewees in the same region.

Subject matter experts in the aerospace domain were identified to participate in the study, as their insights can contribute to the improvement and establishment of new policies in the SAAF environment. This is in addition to improvements in aviation capabilities and aviation safety.

Members were informed beforehand that consent from participants and their companies were required. This detail was explained to the interviewee before the interviews were conducted and forms were completed and signed accordingly. Participant’s confidentiality was guaranteed and maintained. The majority of the participants were interviewed face to face, while some participants were interviewed telephonically as they were out of the immediate geographic location or out of the country at the time scheduled for the required interview. Mostly open-ended questions were asked. A recorder was used with the permission of the participants in the event that the researcher needed to review her notes and discussions from the interview at a later stage. Due to the SDSP 05/19 block programme, all interviews were scheduled for the afternoons. Some interviews took place in the late afternoons, or on weekends, as per the specific participant’s availability. Participants were contacted directly by researcher, even after being referred to her by other members, so as to ensure clarity and integrity of the required research study and process.

Purposive sampling was chosen in the execution of this research project as the researcher wanted to interview knowledgeable people/experts/expert practitioners in the field. For this reason the researcher identified and selected such persons (Babbie, 2010: 193).

According to Neuman (2006: 196), “qualitative researchers consider a range of data sources and employ multiple measurement methods” to give fair, honest and balanced accounts by engaging different authors’ opinions on the research topic in order to ensure the data is truthful, valid, authentic and not biased. The researcher attempted to create a close comparison between her ideas, understanding and the statements made by various authors and what is occurring in the social world by means of deductive reasoning.

Mouton (2005: 117) stated that deductive reasoning in science can take the form of conceptual explication where literary work is analysed to reveal its meaning. The researcher used inductive reasoning for this study. As Neuman (2006: 60) stated, “to theorise in an inductive direction, you begin with observing the empirical world and then reflect on what is taking place, thinking in increasing more abstract ways, moving towards theoretical concepts and propositions.” The researcher conducted this study based on “observations on the ground” (Neuman, 2006: 60) and in terms of global occurrences concerning unmanned (unarmed and armed) aircraft systems (UAS).

The data, which was gathered was divided into main themes, which are discussed before recommendations and conclusions are made in Chapter 7.

The researcher attempted to interpret the data that was collected as indicated in the research methods by means of an exploratory approach and described challenges and or threats which emerged. Neuman (2006: 160) mentioned that a “qualitative researcher gives data meaning, translates them or makes them understandable”. Neuman (2006) stated that qualitative research focuses on real events. First, second or third order interpretations were used to assign significance to the researcher theory. The researcher followed a qualitative approach, collected as much relevant data as possible, interpreted it and gave meaning to it. As stated by Mouton, qualitative studies “aim to provide an in-depth description of a group of people or community. Such descriptions are embedded in the life-worlds of the actors being studied” (Mouton, 2005: 148). Research participants in a qualitative approach through sharing their views as persons embedded in the environment of the study, provide “a slice” of life, and yet add value to the study by stating their own views and sharing unique experiences.

Basic fundamental research was used to build onto and expand the knowledge base regarding UAS. Literature research, documents or textual data, and personal interviews were used to obtain the required information. Maree (2018: 88) stated that “when you use documents (textual data) as a data gathering technique, you will focus on all types of written communications that may shed light on the phenomenon that you are investigating”. In this case, it applies to UAS as a phenomenon during this

research project. Illustrations, graphs, figures and tables were used to elaborate on points for clarification purposes.

Mouton (2005: 55) stated that “a research design is a plan or blueprint of how you intend conducting the research”. Creswell (2009: 3) similarly mentioned that designs are plans for a study and how the researcher’s project must be planned. Lategan et al. (2011: 64) stated that the “research design refers to how one will approach the research project informed by the research problem and based on the existing research methodologies” or tools required to do the research. Babbie and Mouton (2001: 74-75) similarly asserted that a “research design is a blueprint of how you intend conducting the research” (Breakfast et al., 2015: 224).

In terms of literature consulted, the researcher started off with extensive reading in the broader context, i.e. the international or global arena. When a saturation point in the broad consultation of scholarly literature was reached, the researcher tapered the reading down to the specific South African case. By starting reading widely a background was created within which the chosen case could be studied and further explored. The qualitative approach (interviewing as complimentary sources of knowledge) added to the data gathered where there was an absence of material within the local study. The potential to mine deeper into the knowledge environment was thereby broadened.

5.2.3. Data collection

The focus of this research, as an exploratory study, was based on relevant and credible literature studies. Information obtained from the different literature sources was compared for similarities and contrasts. Information for the literature came from research and literature consultation. Open source academic material and reputable internet and library sources were used, for example the Institute for Security Studies and other recognised think-tanks and research platforms. Sources used were published books, chapters to books, e-books, and various open source government publications, accredited articles in subject related journals, reviews, published peer review articles, reports and unofficial documentation (where available and in the public domain). Newspaper articles, open defence journals and open credible websites and publications on the status of UAS and their uses were used for illustrative purposes. No classified documents were used or will be submitted. This study was restricted to the above material so access to this material could be used for future studies, if so required at a later stage.

Data that was collected was analysed by the researcher. The researcher consulted an array of sources to identify specific themes during the course of the reading and research process. The themes which were identified were used to answer the research questions and obtain the goals of the study as was set out earlier. According to Mouton (2005), “analysis involves ‘breaking up’ the data into manageable themes, patterns, trends and relationships” (Mouton, 2005: 108). The themes that the researcher explored were the employment in terms of national security; financial/budget

constraints; legislation, mechanisms and controls; threats; counter-measures; international laws; global, South African and SAAF employment of UAS; (i.e. military and civilian/commercial uses of UAS); and defence partnerships and other general aspects.

5.2.4. Population sampling

The information used came from open sources and credible websites, and from SME published articles in the SANDF and in civil society. Indications were that there was almost an equal number of SMEs inside and outside the SANDF, with varying degrees of expertise. However, as this study continued, it seemed that more expertise lay outside the military, as financial resources were more readily available for research and development in the “civilian” or market-orientated realm. Civilian members’ knowledge was used to add to the data required in many specialist areas where it could be lacking, i.e. in the military such as in the specialised CSIR areas.

Specialist focus groups were used for this study due to time constraints with regard to the SDSP 05/19 course. Interviews (and informal discussions) were planned, scheduled and conducted with the following entities/members:

- South African Air Force members
- Air Force Command Post (AFCP) members
- Directorate Command and Control (DC&C)
- Directorate Aviation Safety (DAS)
- Directorate Systems Integrity (DSI)
- SAAF members working with UAS
- SANDF Joint Operations member
- Former Joint Air Reconnaissance and Intelligence Centre (JARIC) Officer Commanding
- The SA Navy (Naval Operations)
- Civil Aviation Authority (CAA)
- Paramount Advanced Technologies
- Denel Dynamics
- The Council for Scientific and Industrial Research (CSIR)
- Milkor (Pty) Ltd
- Department of International Relations and Cooperation (DIRCO).

Various discussions with guest speakers who presented to the SDSP 05/19 learners, and interviews with SMEs regarding my field of study, steered to interviews with other reputable subject matter experts. The positive aspect to this was that more validity and internal reliability could be obtained with regard to this study, which in turn meant the more reliable and trustworthy the study would be. The disadvantage the researcher was cautious of, was the time available during the SDSP 05/19

programme to do further interviews, based on the required SDSP 05/19 programme's study commitments.

To prevent bias, the researcher continually strived to get different perspectives from various individuals with diverse expertise, different viewpoints and experiences. This it was trusted would add intersubjectivity and internal validity to the process and to the end product.

5.2.5. Considerations

Considerations in terms of the topic, the literature and the answers required for this study were based on the fact that UAS are seen as a new developing phenomenon, despite UAS dating back to the Second World War. The researcher considered that with the increasing new forms of warfare, asymmetrical and transnational threats, and new developments such as artificial intelligence, the Internet of Things, the 4th and 5th industrial revolution, cyberwarfare, and the latest sophisticated and proliferated developments of UAS, information and knowledge regarding this phenomenon could be expanded upon. Thus, the researcher attempted to add new knowledge to UAS in terms of SA's national security, to add value to the area or UAS, which, according to the researcher's current knowledge, was not researched in detail in the past, in terms of the South African and African continental military context.

The study is expectantly adding to the existing body of knowledge in a new growing vibrant field of study. It is an exploratory study to expand on current information and knowledge. In doing the study, the main aim was to generate new knowledge where possible, but also point out areas for future research (see following chapter). As added value it is trusted that the study may lead to some pointers that are relevant for policy making and regulatory measures in the future.

The researcher's central argument was that UAS are not a well-known phenomenon, though UAS have been in existence since World War II. Over recent years, this phenomenon has come to the fore. All over the world, sufficient or virtuous regulations for UAS are not in place, and the global arena is grappling with, in the researcher's opinion, "what to do with this phenomenon"? People either fear UAS (drones), want to ban them, would like to use them for commercial purposes, i.e. agriculture, or for military purposes, such as the USA did in Afghanistan, Somalia and Iraq. Others, non-state actors and extremist groups would want to use them to their advantage in acts of terrorism and for other nefarious purposes. Criminal syndicates likewise can/will exploit such technology where accessible.

The greatest concern throughout the literature studies was that there are no "fixed" or defined global/international rules and regulations, or controls and mechanisms that govern the use of UAS. Each country/state has their own regulations, with many overlapping areas or "rules of the air" in most countries. These regulations and controls are not adhered to by all who have readily available access to drones. This creates a huge threat to many societies and to international stability, peace

and order. Important aspects, such as the integration of UAS into the national airspace (NAS) likewise remains an ongoing debate.

The researcher intended to use questions and interviews, scheduled with experts, to verify information in terms of new available sophisticated technologies, controls, or lack of controls, and future developments and applications of UAS, as was found in the study. In addition, any new important contributions which could be provided by SMEs, was acknowledged. Gaps and additional insights were similarly pursued during interviews. An important aspect which was addressed, was "what should inform SA national security policy in terms of UAS" given the countries security and defence needs and interests.

5.3. Ethical considerations

Before this study was undertaken, the researcher's intent to embark on this study was discussed with her employer (i.e. The Chief of the SA Air Force, Lieutenant General Zakes Msimang) to obtain his views on the proposed field of study. Thereafter a request for authority to continue with the study was forwarded to Chief Defence Intelligence in March 2019, in order that permission be granted for the study. Ethical clearance for interviews with research participants was applied for at Stellenbosch University, at the Departmental/Faculty Ethics Screening Committee (DESC/FESC) before the researcher could proceed with the interviews.

Throughout the study, the researcher continually strived to adhere to the norms of the international scientific community and no individuals or institutions were harmed or hurt during the study.

The privacy of individuals was not violated, and anonymity/confidentiality was maintained as required. Participants were granted the freedom, if they so indicated, to withdraw from the project at any given time.

When individuals were approached, they were informed that their contributions to this study would be acknowledged, if they so required.

During the research, only open (publicly available) sources were used as reading material. The information for the literature came from research and literature consultation on open sources, published peer review articles, journals, published books, chapters to books, edited works and open and credible websites. Where applicable, government or defence reports were used on proviso that they are in the public domain. No classified documents were used. This study was restricted to the above material so access to this material could be obtained for future studies, if so required at a later stage.

A confidentiality agreement as well as informed consent for the use the data for publication was signed by all participants. Participants were informed that they could join the process on a completely voluntary basis.

Participants were informed that data will be safely stored for five years (safekeeping of data), whereafter it would be destroyed and that data would be recorded in an appropriate and honest manner. During the study and the reporting of the findings all ethical considerations were adhered to and plagiarism was avoided.

With regard to the face-to-face interviews and the focus group interview, while creating an amicable atmosphere, the researcher also strengthened an interviewer and interviewee trust-relationship. The researcher refrained from asking leading questions or steering the discussion in a subjective or partisan direction. In doing so, the researcher as emphatic listener kept an appropriate 'distance' and ensured that no emotional involvement formed part of the process. Doing so consciously ensured that what Lawrence Neuman, a qualitative research expert, calls "disinterestedness" as a characteristic of the norms of the scientific community. (The interviewer needs to be neutral, impartial and open to new perspectives or ideas during exposure to data and in the generation of knowledge (Neuman, 2006: 9).

Neuman (2006) pointed out that *honesty* is demanded from the researcher and should be reflected in the research process and the end result (Neuman, 2006: 9). Simultaneously, the researcher regarded Neuman's further advice seriously, that is not to take everything on face-value, but also keep in mind the value of organised scepticism and reflect on both reading and interviews afterwards. Reflectiveness remained important both in consultation of sources and the interview process.

The researcher strived to be objective and report findings as objectively as possible. Integrity was maintained throughout the research and findings were reported in a truthful and unbiased manner. Doing so ensured internal reliability and trustworthiness of the study.

5.4. Limitations

There are limited publications available on the South African case. Research publications available in South Africa with regards to a unique perspective and challenges within the South African context are still lacking, a gap worth further exploration. Research on this topic is a relatively new phenomenon in South Africa and allows for much more (future-directed) research.

Excessive costs are involved in registering and obtaining credible sources of information from international books, journals and media houses.

UAS documentation and development are often classified. Therefore, no classified documents could be used. Classified documents would have enriched the study, but for obvious reasons could not be exploited. Instead, only open source information available in the public domain was used.

Language - The researcher is competent in English and Afrikaans. Very important research is being done in this field in various countries such as Brasilia, China, Iran, Israel, Turkey, Russia, Japan, Pakistan, Germany and France, but frequently these research findings were not published in English and therefore unfortunately not accessible.

Within the military and defence industry environment, information on sensitive UAS projects, which could have been extremely educational, could not be used as one would expect – for national security reasons.

The majority of the 2019 Masters in Military Science (M-Mil) students experienced severe time constraints regarding the completion of their thesis, due to the simultaneous attendance of the Security and Defence Studies Programme (SDSP) 05/19, with its modular assessments and outcomes, as well as all the additional unplanned commitments, i.e. such as unplanned seminars and impromptu regional experiential study visits, which were not initially incorporated into the SDSP 05/19 programme. These impacted on the time that could be spent on this study.

This study may also indicate its “passé” by the time of publication, due to the rapid and proliferated rate of advances in these sophisticated unmanned aircraft systems technologies throughout the world.

5.5. Interviews and themes

The envisaged semi-structured interviews with specialists and SMEs took place, following receipt of Stellenbosch University (SU) ethic’s clearance. Interviews were conducted as SDSP 05/19 programme activities allowed, and as per the restrictions placed on the researcher’s planned and scheduled interviews by the SDSP 05/19 programme.

Due to the busy schedules of the SMEs and other aviation members regarding their national and international commitments, some appointments had to be rescheduled. The availability of the interviewers was thus scheduled around their diaries and that of the researcher’s. Not in all cases, but to a large degree, this study was challenged by external factors and many forms of time constraints.

During interviews care was taken to record the candidate’s answers correctly and to ensure that data was not fabricated or manipulated during the interview or study process.

5.6. Conclusion

The methodology for this qualitative study consisted of an extensive review of scholarly literature, followed by (1) face-to-face interviews with selected participants who are experts in the field, and (2) a focus group interview. Interviews were held with experts to obtain credible and valid information on the dimensions, or variables, as stated in the researcher’s topic, namely “The South African Air Force (SAAF), Unmanned Aircraft Systems and National Security: An Exploratory Study”. The interviews which were conducted assisted with primary data and confirmed or refuted various opinions from the literature research.

It is expectantly envisaged that this study could add to the existing body of knowledge in a new vibrant field of study. It was an exploratory study to expand on current information and gain new knowledge.

The following chapter presents the interviews and focus group sessions that were conducted with the various subject matter experts in the aviation field.

CHAPTER 6: CONSOLIDATION OF FINDINGS

6.1 Introduction

This chapter will focus on the interviews conducted with the subject matter experts (SMEs) with reference, where required, to the findings in the literature studies. The respected SMEs approached during this study were from various disciplines in the military and from various companies within the civilian defence industry itself. In this regard, opportunity was created to harvest as much data from the participants' knowledge, perspectives and experience. This would enrich the mining of qualitative data and would help to ensure validity, objectivity and reliability.

The majority of the exploration, research and interviews during this study focused on the main research question, namely "How can the use of unmanned aircraft systems (unarmed and armed) by the South African Air Force (SAAF) contribute to South Africa's national security?" Based on the main research problem, research objectives, and considerations from numerous literature readings, both locally and internationally, the researcher identified common themes which presented themselves recurrently throughout this study. The research sought to explore how UAS are used internationally and nationally within a defence role, what impact the utilisation of UAS could have on SA's national security and whether sufficient international laws and controls are in place regarding UAS employment. The global proliferation of UAS that pose national security threats or challenges for a country such as South Africa were touched upon. Secondly, the question was to determine whether, if required, the capability does exist within the SANDF and SAAF to counter such potential UAS threats. Financial factors regarding the production/manufacturing and/or acquisition of UAS were also explored, as well as the implications should governments wish to integrate UAS into international and national airspaces.

Based on the literature studies, discussions and interactions with the SMEs and other respected aviation colleagues, it is clear that UAS are here to stay and will continue to escalate in importance, proliferation, sophistication, versatility and utilisation by various role players from individuals and military forces to extremists. This situation was highlighted by Sayler (2015: 5) and Kreps (2016: 160) in Chapter 1 of this study. SMEs that were interviewed, were in agreement with Villasenor's (2011) statement, that in the hands of a responsible military, an armed UAS capability can be a force multiplier and a game-changing asset. In the hands of a rogue group, it can be a chilling threat.

A concern shared by many interviewees was the battles and conflicts constantly erupting on the African continent, where global powers such as the US, China and Russia are involved. One example was the US's stance on the "war on terror" and the US's increased capacity for interference in Africa (Donnenfeld, 2019; *defenceWeb*, 2019d). Another concern was that the development of drones could increase the global arms trade around the world. As stated by Tsabora (2015), "it is the global arms trade that has fuelled African conflicts for the past fifty years, with African states as a primary destination for weapon sales from powerful states, such as the United States, China and

Russia" (Tsabora, 2015: 464, 465). According to Gouré (2018), Russia has recently re-entered the Egyptian market by selling combat helicopters to Egypt (Gouré, 2018). *defenceWeb* (2019c) likewise mentioned that Russia was sending troops and delivering military hardware to Mozambique (Southern Africa) to assist and neutralise the attacks in the Cabo Delgado area.

Of further concern was that the more UAS (drones) are proliferating around the globe, the more the interest and necessity to own UAS is increasing among various populations, as indicated in Section 6.4.2. "Although the United States has been the most prolific user of combat drones, several other countries have employed them as well, including Iraq, Israel, Nigeria, Pakistan, France and the United Kingdom. Almost a dozen states, including China, Iran, and Saudi Arabia, reportedly now possess armed drones, and many others—including India—are racing to acquire them" (Horowitz et al., 2016: 7-42).

The same has been said regarding the increased UAS (drone) strikes around the globe. Specialists agreed that the more UAS strikes there were, the greater the demand was among countries to increase their counter-strike capabilities. And the greater the risk would remain to civilian populations. As Donnenfeld (2019) and *defenceWeb* (2019b) pointed out, "leaders on the continent need to balance genuine security concerns with policies that promote human development as a viable alternative to violence and extremism" (Donnenfeld, 2019 and *defenceWeb*, 2019b).

Currently, people are becoming more conscious of the realities of life in a volatile, uncertain, complex and ambiguous (VUCA) world, where one aspect impacts on another and where nothing can be viewed in isolation. Aspects such as continental, regional and border security remain an ongoing concern for many countries across the globe, and very much so, SA as a maritime country. The possibility of security threats, i.e. piracy, drug- and human trafficking, spilling over onto South African soil, via neighbouring countries, has also been much debated. The impact and implications of extremists using UAS to target 'referent objects' such as a countries' environmental security, economic, financial, cyber security, energy, natural resources and human security remain a concerning reality (Bester and O'Neil, 2019).

During an interview session, while discussing security threats spilling across borders, Respondent 4 mentioned, that "the price of oil just went up as drones blew up the Saudi oil fields causing extensive damage to oil wells" (Respondent 4, 2019). Rightly stated, as this type of nefarious activity had a huge economic impact on many countries who depended on oil from the Saudi oil fields, and not only on the Saudi region itself. Saudi's energy security, natural resources and their environment were also devastated by the drones blowing up the oil fields.

The interviews conducted with the SMEs greatly enriched the study, by allowing the researcher to bring the real-life experiences, expertise and knowledge regarding UAS from a piece of paper to a visible, audible and tangible product ('bring it to life'). The fact that the majority of the SMEs identified with and understood the international and national security environments added significant diverse

opinions, validity, objectivity and (internal) reliability to this study. Interview findings are addressed next.

6.2 The employment and contribution of UAS by the South African Air Force (SAAF) to South Africa's National Security

6.2.1. Unarmed UAS and national security

Based on the main research question, all of the respondents were of the opinion that unarmed UAS can be used by the South African military (the SANDF and the SAAF) to contribute to national security. In an unarmed role, UAS can, according to Respondents 3, 5 and 9, be utilised in terms of intelligence, surveillance and reconnaissance (ISR), electronic warfare (EW), electronic intelligence (ELINT), remote sensing, and Telstar (communication relays) capabilities. Respondent 5 added uses such as electronic warfare (electronic countermeasure (ECM) and electronic counter-countermeasures (ECCM) or electronic protective measures (EPM)), for which UAS could be used to contribute to national security. An ECM device is used to deceive enemy radars, sonars or infrared systems by allowing the real target to move around, disappear or suddenly appear, making it safe and undetectable. Jamming, which confuses enemy communications or their radars, is an example of EPM.

Besides using UAS for real-time intelligence, surveillance and reconnaissance (ISR) tasks, Respondent 7 stated that UAS can be used for border surveillance during key events. Respondent 1 was in agreement that UAS can be used during important events such as national or local government elections, or international sporting events. Respondent 1 mentioned that UAS can be used to monitor events from a safe distance to provide the Commander on the ground with real-time intelligence pictures or video surveillance for effectively managing a situation or an event. Respondent 9 stated that "the SAAF (as per doctrine and planning) control and utilise UAVs mainly for ISR and the provisioning of a real-time or near real-time intelligence picture to the Commander on the ground". Respondent 8 stated that unarmed UAS can be used as an "eye in the sky" when carrying a multitude of sensors to increase the information and thus the decision making capability of personnel on the ground.

Despite the normal ISR tasks, Respondent 5 stated that real-time ISR can be used in all domains of border safeguarding such as happened during Op CORONA, Op COPPER, Op PROSPER, Op ARABELLA and Op CHARIOT. In terms of border security, Respondent 7 stated that UAS can be used for border surveillance, while Respondent 4 similarly stated that UAS can be used to counter activities such as drug-trade, for border patrols (especially at known crossing points), for the monitoring of illegal immigrants, especially at night and for internal strike action recording of individuals.

Respondent 6 mentioned that "using drones to monitor the electronic spectrum and to provide surveillance in urban hotspots will greatly enhance the ability to respond to internal security threats"

(Respondent 6, 2019). Besides border surveillance, it was noted that Respondent 7 stated that UAS can also be used for exclusive economic zone (EEZ) patrols and anti-poaching patrols. Respondent 4 stated that UAS can be used to alleviate the immense pressure placed on limited resources, and that UAS can be used for medical support, especially in the field, although this may also be utilised in other areas too. Respondent 5 added that UAS can be used for supply support (i.e. delivery of critical supplies).

Respondent 9 indicated that “UAVs can be used in controlling South African borders or specific parts of our border (both land and maritime) by providing a clear picture of what is going on in any specific identified area of operation. UAVs can also be used to monitor humanitarian disasters, such as flooding or fires. They can also be used to monitor National Key Points and provide protection thereof. These systems would be tactically deployable by the SAAF” (Respondent 9).

Respondent 9 further mentioned that there are numerous uses for UAS in the military, and that the SA Air Force, the SA Army and the SA Special Forces utilise UAS. The Respondent stated that “the Army (specifically the Artillery) utilise UAS for target identification, targeting and damage assessment. Special Forces uses will not be mentioned in this study. Today UAS and even localised drones could be used in conjunction with other Government departments when deploying along our land and sea borders or in areas of conflict or crime fighting” (Respondent 9).

Subject matter experts (Respondents 1 and Respondent 5) mentioned that UAS could also be used during national emergencies, such as floods, fires, droughts, and during search and rescue (S&R) operations.

6.2.2. Armed UAS and national security

Based on the main research question as mentioned above, the respondents offered varying opinions regarding the use or non-use of armed UAS by the South African military (the SANDF and the SAAF) to contribute to national security.

Respondent 1 was of the opinion that “once armed UAVs are permitted in the SAAF, such drones can be used to neutralize targets without endangering the operators” (Respondent 1). Respondent 4 stated that “in an armed role, my personal opinion is that the SAAF is not ready for armed drone capabilities, but this should be considered in terms of defence industry development - a requirement for the Defence Force to support local industry” (Respondent 4). He further stated that “remember, this is not restricted to conventional weapons - electronic interference, laser and other forms, play a major role as armed capabilities” (Respondent 4).

Respondent 5 pointed out that “whereas the Constitution does not allow the SANDF to apply deadly force to South African Nationals as well as migrants, the availability of armed drones will definitely have a positive impact as deterrence during Op CORONA, Op COPPER and Op PROSPER. During conflict situations and peace enforcement operations armed drones can assist the military effort with any of the above-mentioned (unarmed) applications” (Respondent 5). Respondent 8 was of the

opinion that “in our current situation with extreme budget cuts and limited expenditure we can deploy armed drones in place of fighter aircraft with limited funding” (Respondent 8). This was similar to the answer from Respondent 3 who stated that armed UAS can be used for “unmanned, air delivered loitering munitions for precision strike” (Respondent 3).

Respondent 7 stated that “UAS can be used as a “credible source (“show of force”) to deter attacks on the mainland; for a long range strike platform (Africa is a huge continent, so long-range is key); for close air support to our troops; an armed combat search and rescue (CSAR) platform to support search and rescue (SAR) operations; armed EEZ patrol to deter piracy; and armed anti-poaching to deter poaching. It is however important to note that the SANDF do not own any armed UAVs” (Respondent 7). Respondent 6 believes that UAS “has limited application in the current political and legal climate. Expending ordnance from a drone to respond to internal security threats or a border security situation is unlikely to receive authority. Should relationships deteriorate with neighbouring countries this may change” (Respondent 6).

Respondent 9 stated that “armed UAVs and the use thereof are directly related to the type of warfare that a military is involved in at the time. Armed UAVs are mission specific and need to be controlled at all times, especially prior to delivering the armaments on board. These systems are currently mainly used by the larger more complex defence forces of the world and comprise high-end technologies. Armed UAVs will be utilised to a limited degree by the SAAF, as this is not part of our actual doctrine and regulations would have to change accordingly” (Respondent 9).

6.2.3. Aerospace, maritime and border security

During the researcher’s interactions and interviews with the subject matter experts, she posed open-ended questions to the respondents to obtain more clarification and validity on the issues of national security. Respondents were requested to provide their opinions on how UAS could be used by the South African military (specifically the SAAF) to contribute to aerospace, maritime and border security.

Respondent 1 was of the opinion that “UAVs can be effectively used in maritime and border security roles by replacing mundane tasks carried out by manned aircraft with UAVs. In my view UAVs cannot be used in aerospace security because of the limited field of view (FOV) of the UAVs camera systems. Although manned aircraft can and are used for these roles, currently there is shortage of both personnel and equipment to conduct continuous surveillance of our land or sea borders. Because of the ability to change UAV crews during a mission without curtailing the mission, the flow of information remains continuous for the duration of the UAVs endurance (12–16 hours)” (Respondent 1).

Respondent 3 stated that UAVs can be used for borderline safeguarding through the application of ISR, EW, ELINT and weapons delivery. He further stated that UAVs can be used from centralised facilities which are located far from the area of operations. Respondent 5 indicated that as mentioned

previously, real-time intelligence, surveillance and reconnaissance could be done in all domains of border safeguarding (Op CORONA). Respondent 6 stated that these systems can play a key role in providing surveillance for border security as well as maritime security. This will allow reaction groups to respond to the area of concern without expending resources on standing patrols. Respondent 7 indicated that unarmed UAS could fulfil reconnaissance tasks, do border surveillance, EEZ patrols, and assist with anti-poaching patrols as mentioned previously.

Respondent 4 mentioned that UAS "could provide a cheaper option for future use, but it will cost money to establish and at present the SAAF would not see clear to budget for such capabilities. Other uses for unmanned aerial vehicles or –systems, are with regard to space and cyber technology, listening-in to systems, security clusters and camera or Wi-Fi-systems from a Defence Intelligence (DI) point of view" (Respondent 4). The researcher agrees that UAS could provide a cheaper option for future use as was evident throughout this study. Yet taking the SA defence budget cuts into account, the researcher believes that the SANDF or the SAAF will not presently be in a position to fund such projects without the political will of the government, or some other form of external funding or impetus. More likely, it would be opportune to generate own funding within the SANDF and the SA defence industries and not to rely on the government.

Respondent 8 emphasised that "a drone that flies using advanced autopilot navigation and is equipped with high technology digital image processing capability, can tirelessly and reliably patrol our borders and seas" (Respondent 8). In short, this will provide for immediate real-time intelligence, saving of aviation fuel and less maintenance and costs involved, than were it a manned flight. Respondent 9 supports the researcher's statement. Respondent 9 indicated that "a balanced air force must maintain the ability to gather, analyse and distribute information and intelligence in a timely manner. In an air force this function is ensconced within the ISR (Intelligence, Surveillance and Reconnaissance) capabilities and must have the minimum capacity to provide adequately analysed and highly reliable information to all who require it, at minimal time delay. The ability to provide the right information to the right person at the right time and place is a primary requirement for a balanced air force" (Respondent 9).

6.2.3.1. The greater threat to national security?

Following the respondents' answers to the contribution of UAS to aerospace, maritime and border security, the subject matter experts were asked which of the three, namely aerospace, maritime or border security did they classify as the greater threat 'area' to national security?

Based on the respondents' answers, Respondents 1, 6 and 8 appeared to be of the opinion that border security was our greatest threat. Respondent 1 stated that "as I see it, there is no real aeronautical or maritime threats from our neighbours, so the greatest threat to our national security is border security. This is not only to monitor the influx of illegal immigrants over our long land borders but includes the movement of stolen vehicles and livestock across borders and the decimation of

our natural resources through poaching" (Respondent 1). Respondent 6 agreed that "the porous borders contribute directly to a vast array of evils. Anything from potential terrorist groupings to crimes such as vehicles and human trafficking. It affects the natural environment (poaching) and the economy (undocumented migrants). It recently induced xenophobic violence, with the subsequent political fallout" (Respondent 6). Respondent 8 indicated that "our greatest threat is not currently from highly funded government agents attacking us, but the average poor African attempting to illegally enter our country to take away jobs and money from South Africans" (Respondent 8).

Respondents 3, 5 and 9 shared similar opinions. Respondent 3 felt that aerospace, maritime and border security were of equal concern to our national security. He further stated that they are of "equal importance, three interfaces to threats on sovereignty, if you don't have persistent presence in all three areas then you may as well have nothing at all" (Respondent 3). Respondent 5 mentioned that "each of the three domains of border safeguarding has its own threats to national security; however, the air and maritime domain are probably a higher threat to the economy of the RSA, whereas the landward domain is more crime related" (Respondent 5).

Respondent 9 added that in fact the land border (i.e. border security) is the greater threat area. "Taking the inputs from the DOD/SAAF Environmental Scam 2019 into account, border control or border management is the greatest threat" (Respondent 9).

Respondent 4 was of opinion that "most likely "aerospace, as it is closer linked to cyber threat. Remember every laptop/cell phone has a camera that can be tapped into. This is a complex system not just a complicated one - a complicated one can have defined boundaries, where a complex one depends on too many independent variables. Maritime and border security has purely tangible or mechanical requirements. CCTV systems or airborne platforms can be used for reconnaissance and intelligence gathering" (Respondent 4).

Lastly, Respondent 7 was of the opinion that maritime security was the most important. He stated that "the largest part of our border is marine; with easy access to the country via our relatively sparsely populated coastline (small boats can come ashore anywhere); our major "frontline air bases" (where our frontline fighters are based) are at the landward border, and there are no frontline air bases at the coast" (Respondent 7).

6.2.4 Unmanned aircraft systems as force multipliers

Based on the previous open-ended questions posed, the researcher additionally requested opinions from the subject matter experts as to whether UAS could definitely be used as a force multiplier. All the respondents indicated that unmanned systems could be used as a credible force multiplier, and added additional responses to their answers.

Respondent 1 was of the opinion that "as many of the roles of a UAVs military mission could be combined in one flight (i.e. doing surveillance / border patrol / artillery fire control / strike damage assessment all during the same mission) one UAV can easily do the work of three or four manned

aircraft thereby being a great force multiplier" (Respondent 1). Respondent 5 answered with an emphatic "yes", as can be seen in all the different roles an unmanned system can fulfil. Respondent 7 also supported this statement by highlighting the roles of UCAV, "such as its uses for ground attack, long-range strike, close air support, anti-radiation ("wild weasel" role), and armed CSAR support, armed "reconnaissance & surveillance" (Respondent 7). Respondent 6 said that these systems can "allow limited resources to be focused on critical areas due to the availability of surveillance products" (Respondent 6).

Respondent 4 was of the opinion that unmanned systems could be used as a credible force multiplier if it is utilised correctly. However, he stated "that he doubts that the SANDF is ready for implementation and without correct capability requirements being identified it would just become a white elephant project" (Respondent 4). Respondent 8 stated "most definitely, unmanned systems are able to fly further into combat zones without risk to lives and gather more information allowing for better decision making" (Respondent 8).

Respondent 9 emphasised that the use of unmanned systems, as a credible force multiplier, could definitely be used by the SANDF and that "the current uses should be maintained and be improved upon. They are an integral part of any air force and must be used in unison with other aircraft capabilities and should not be used on their own. The utilisation of said technologies should be incorporated into each Service to compliment the roles and responsibilities of each and as determined by Joint Force Employment Requirements" (Respondent 9).

Respondent 1 indicated that "UAVs should and can easily be operated in conjunction with current weapons and, or aircraft. As mentioned earlier, UAVs tend to have a longer endurance than manned aircraft. They can thus provide a continuous flow of surveillance for longer than a manned aircraft. This surveillance is in real-time and could be very effectively used in peacetime to aid ground forces to secure our land borders by being directed by the UAVs to specific areas that need attention. During wartime UAVs can be very effectively used in the forward air control role to direct fighter aircraft to specific targets as well as in artillery fire control to determine fall of shot errors and to suggest corrections to aiming points. UAVs can also be very effectively used in the search and rescue role as the camera makes identification of ground based events more accurate" (Respondent 1). Respondent 2 answered with a definite "Yes, obviously, in the systems context it is only one piece in the puzzle, not the puzzle itself" (Respondent 2). Respondent 8 similarly indicated "Yes, most definitely, a manned aircraft can have an unmanned wingman to protect him and serve as a force multiplier in combat situations without having to place more people in danger" (Respondent 8).

Both Respondents 4 and 6 categorically agreed that UAS can be used in collaboration with other current conventional weapons/aircraft, and spoke about the advantage capabilities of UAS. Respondent 4 indicated that UAS can be used "through data-link capabilities - radar/video enhanced imagery to attack aircraft or delivery platforms" and through "target designation (i.e. laser designation

or fighter weapons delivery). Additionally they can be used for Search and Rescue (S&R) coordination with real-time platforms for rescue capabilities, for maritime S&R capabilities and flood assistance to partner nations. They too can be used for natural disaster assistance from airborne platforms (i.e. Cape fires) and obviously weapons Forward Air Control (FAC) type operations" (Respondent 4). Respondent 6 said that "Yes, drones can for instance be used to pinpoint an area of interest to which a manned asset is then directed. Applicable in especially the maritime and border security roles. Drones can also be used to shape the battlefield by, for instance, eliminating enemy sensors and command and control nodes" (Respondent 6).

Respondents 5 and 7 had similar views. Respondent 5 mentioned that "it should definitely be utilised in collaboration with conventional systems. Evidence to this is the manner in which all drone operating countries are applying their drones" (Respondent 5). Respondent 7 stated, "Yes, it is being done overseas, so it should be possible in SA. One use being explored currently is an unmanned aerial tanker, where the UAS refuels a conventional manned aircraft. Other inter-operable uses could be communications relay to manned aircraft, image relay to airborne image interpreters, airborne decoys during hostile engagements (to draw fire from manned aircraft), CSAR support where the UAS does the searching and manned aircraft do the rescuing, and so on. Proper, formal standing operational procedures (SOPs) and a proper DOD Regulatory framework for UAS will be the foundations for these kinds of operations" (Respondent 7).

When comparing the answers from the subject matter experts, the researcher's opinion regarding the advantages of unmanned systems, and the literature studies, it is clear that unmanned aircraft systems (UAS) can definitely be used as a force multiplier for the military, especially in the near future.

The employment of UAS internationally has become ubiquitous and will remain so for many years to come. Though the SANDF has a defensive posture, it is possible that many lessons can be learnt from the USA military and other militaries using UAS, be it positive or negative lessons. As stated by the USA DOD UAS task team, "over the past several years, Unmanned Aircraft Systems (UAS) have become a transformational force multiplier for the Department of Defense (DOD). When UAS were introduced into the front-line DOD aircraft force structure over a decade ago, small numbers of aircraft were fulfilling niche capabilities. This is no longer the case. The numbers and roles of UAS have expanded dramatically to meet overseas demands, and in some categories, more unmanned aircraft (UA) are budgeted than manned. Operational commanders have come to rely upon robust and persistent support based on unmanned platforms to execute their core missions against hostile forces" (DOD, 2011 – UAS Task Team: 1).

6.3. International employment of UAS (unarmed/armed) in a defence role

As background to this question, readers are to note that based on the support and "backbone" provided by a military in terms of its employment of its UAS, there can be a huge difference in

employment of these unmanned aerial technologies between various countries. The manner in which UAS can be employed, can be either in a defensive role or in an offensive role. SA and the SANDF itself keep a defensive posture as outlined in the first and second Defence Reviews (1997/1998 and 2014/2015). Based on this mandate, the SANDF would not use armed force. Research has indicated that the employment of UAS is not a simple matter as one would assume. The employment of UAS goes hand in hand with "backbone" support, such as command and control, logistics, communications, and personnel (i.e. the human factor) to operate all the systems which support the UAS employment, whether it be in a defensive or an offensive role. Countries, like the United States of America, United Kingdom and China for example, that have larger military budgets than South Africa's defence force, will be able to employ unarmed and armed UAS in a greater variety of roles.

Respondent 1, stated that "currently no UAVs are employed either national or internationally in a defence role by SA or the SANDF" (Respondent 1). According to Respondent 3, "unarmed UAVs/drones can be used as unmanned, remotely controlled, airborne platform for carrying sensors and other electronic devices in a military context. Armed UAVs/drones can be used as unmanned, remotely controlled, air delivered loitering munitions for precision strike in a military context" (Respondent 3).

Respondent 8 was of the opinion that "the global leader in drone technology according to the media is America. They actively are deploying drones and advancing their capability for war time operations. Currently South Africa has a very limited capability that does not directly rest within the defence force, but belongs mostly to outside contractors" (Respondent 8). With regard to unarmed UAS, the respondent mentioned that drones can play a major role in peace support operations. In the Command and Control (C&C) context, he stated that drones assist greatly in routine maintenance, providing a very versatile platform to carry photographic and other equipment as required. Regarding armed UAS, Respondent 8 stated that "one of the aims during war time is to reduce loss of life. Using unmanned armed drones can accomplish this. As a show of force having more cost effective platforms (when compared to conventional manned aircraft) to carry weapons, can allow presence in the airspace" (Respondent 8).

Respondent 4 similarly stated that South Africa does not have any UAS employed internationally in a defence role. It is the researcher's understanding that crews are still in training, but should be capable of doing this in the near future. Furthermore, the respondent stated that UAS can be utilised for local "basic law enforcement and monitoring, (similar to what is be used at the moment), game conservation/counting from drones, anti-poaching operations and for internal crime monitoring and assistance to SAPS operations" (Respondent 4). Respondent 4 further stated that communication relays and real-time infra-red videos of the battlefield can take place both at night and during the day, due to the optic payloads that can be attached to the UAS. Decoys can be used, with EW counter-measures and jamming capabilities.

Respondent 4 said that “search and rescue operations can be conducted without risk of major losses. Airborne platforms directly in the field can assist with command and control (C&C) without which commanders would be at a serious disadvantage. UAVs in the field can monitor missions without radar signature” (Respondent 4). The respondent also mentioned that drones “can operate autonomously in for example dark rooms and tunnels, to do reconnaissance in hidden places, and thereafter return with intelligence/video”. Last but not least, the respondent mentioned that artificial intelligence, and where it is going, and the threat of airborne robots, can change the conventional approach to warfare (Respondent 4).

Further, Respondent 4 stated that unarmed UAS have a multitude of uses in the military such as close air support for resupplies in the field, or for urgent medical supply support. “There are already 911-type drones flying around with medical kits, i.e. cardiopulmonary resuscitation (CPR) kits and paddles for shocking patients back to life. In terms of urgent medical support required in the field, micro drones have already been used in living bodies to determine injuries out in the field. Basically it opens up the battlefield for almost anything required urgently without threat from enemy fire, which changes the whole situation as drones are now used extensively in the theatre” (Respondent 4).

Another use mentioned by Respondent 4 was that armed or combat UAS deliver the same weapons as fighters without the risk of lives lost. “UAVs can designate (laser) and attack targets themselves for greater accurate delivery should it be required, and for chemical and biological warfare, making it a serious threat if/when the UAS are in the wrong hands. UAS can furthermore be utilised for laser delivery or attack on optical systems and camera security systems, as these UAS have stabilised platforms for accurate delivery. Armed UAS airborne times are virtually continuous for patrols and surveillance as others can be put up to take over when energy/fuel runs out. This all at a fraction of the price of piloted aircraft” (Respondent 4).

“Airborne (missile CUAVs) become a major draw card when operated in an offensive mode, in order to shoot down enemy targets/aircraft at their own airfields. Satellite control of CUAVs gives them extensive range – literally global range” (Respondent 4). Respondent 4 indicated that ‘kamikaze-type’ capabilities can disrupt operations in the commercial sectors and micro drones can kill people. For example, “a small drone (1cm in size) carrying a few grams of explosive detonates, can hit an enemy/target’s head with a small charge, and kill him”. Lastly, Respondent 4 mentioned that from micro drones to combat UAS, they all have exceptional capabilities and that they can even plant explosives without any risk (Respondent 4).

Respondent 5 was in agreement with Respondent 4 regarding the uses of UAS employed internationally in a defence role, and as in South Africa. Similar sentiments for employment were echoed by Respondent 5, who indicated that armed UAS could be used for the same tasks (i.e. ISR, EW and Telstar (communication relays). Yet, “armed UAVs would include the use of guided missiles, anti-armour, precision strikes and force protection” (Respondent 5).

Respondent 6 stated that UAS are employed primarily as surveillance and reconnaissance platforms. UAS can be used throughout the whole spectrum from strategic reconnaissance to urban reconnaissance for Special Forces. “They can be used in threat replication and weapon development” (Respondent 6). With unarmed UAS, Respondent 6 mentioned that these systems can be used in any role where it is desirable to prevent own personnel from being captured or lost. “This includes activities where a particular high risk/low survivability is identified or activities of a clandestine nature. It can also be used where the task is of a fatiguing nature, to a level where human endurance may compromise efficiency” (Respondent 6). With regards to armed uses of UAS, the respondent said that the same general criteria as with unarmed UAS apply, but with the added requirement of direct fire options.

Respondent 7 agreed with the opinions of Respondents 4, 5 and 6 regarding the fact that UAS can be used primarily for “intelligence-gathering platforms”, i.e. reconnaissance and surveillance in an international role. Respondent 7 added that UAS can be used for “CSAR support, battlefield damage assessment (BDA), targeting assistance, anti-aircraft artillery (AAA) gunnery training, anti-ship gunnery training, test and evaluation support (“target drones”), base security, base/military site inspections, border patrol, EEZ surveillance and security during major events (a sub-set of “recon & survey”), anti-poaching assistance, for defence television (“camera drone”), decoys, and for air-to-air refuelling (“unmanned tanker”)” (Respondent 7).

6.4. Threats and challenges posed to SA’s national security by the international proliferation of UAS

When addressing the above objective, Respondents 5, 6, 7 and 8 were of the opinion that unmanned UAS technology (unarmed/armed) could pose a threat for South Africa’s national security. Respondent 5 stated that “although there is currently no known threat against the RSA, the global proliferation of drones can pose a threat in the near future. These threats do not need to be military of nature, but can even be related to extremism and organised crime” (Respondent 5). Respondent 6 emphasised that “the threat is significant. These systems (UAVs) provide a cheap and capable option to extremist groups to use as a ‘poor man’s cruise missile’. It provides options to opponents to execute offensive or reconnaissance operations against the country using non-attributable systems” (Respondent 6). Respondent 7 was of the opinion that “small drone technology, parts and 'build plans’ are easily accessible to the ‘man on the street’ and are becoming cheaper and more reliable. In the wrong hands this could pose a problem to national security” (Respondent 7). Respondent 8 stated that due to the relatively inexpensive technology that is currently available, it will enable the average person to procure and arm a drone.

This resonates with the concerns expressed by Friese et al. (2016: 10) and Hennigan (2018), who stated that it is the small commercial off-the-shelf (COTS) UAS that pose the largest threats, as used by non-state actors for ISTAR missions. Hennigan (2018) mentioned that ISIS have used mini quad

copters, which look like small aeroplanes, to “drop crude bombs on U.S. and allied forces in Iraq and Syria” (Hennigan, 2018). These UAS which are converted into improvised explosive devices (IEDs) for offensive purposes were used in countries like North Africa, Ukraine and the Middle East (Friese et al., 2016: 10). The danger of these COTS is that they are easily obtainable for a few hundred dollars, unlike costly $15 million military UAS (Hennigan, 2018).

Respondent 2 stated that “threats from UAVs are many and varied based on the type and size of the airframes. Any UAV system could be converted into a weapon system. The threats from these systems range from small commercial UAVs modified to carry guns to large systems carrying a range of weapons. The UAVs do not need be armed to pose a threat. Denial of the use of an airport by simple commercial drones can be used as a very effective commercial attack. To be realistic, what has to be considered though is the likelihood of an attack. Intelligence of an attack prior to it happening is the most important tool in this regard” (Respondent 2).

The World Economic Forum substantiates the above views, that “the proliferation of certain emerging technologies has effectively diffused power and made it available at the lowest levels. The barriers to entry have never been lower for individuals to gain access to commercial off-the-shelf technology (COTS) that can be used to lethally target individuals. Lone actors or small cells of terrorists, criminals, or insurgents can effectively harness the tactical flexibility of a small drone to wreak havoc, including potentially using a drone to take down an airliner” (World Economic Forum (WEF), 2018).

Respondent 4 mentioned that there are threats and challenges relating to defence espionage and industry espionage. The respondent stated that “although drones are not required as access to major institutions, it is not really controlled and most are easily accessible. For thirty thousand rand (R30k) you can acquire a drone that is capable of a fairly long range–reconnaissance at a fraction of the price of a conventional platform. How would you stop it from operating - you now require expensive EW capabilities to find the ‘owner’ or destroy the platform. Internationally they even train falcons to attack drones” (Respondent 4).

Respondent 3 said that “if you don’t have counter-drone capability then you are open for exploitation and/or attack” (Respondent 3). However, Respondent 1’s opinion was that “currently I do not see that the advances of this technology in terms of UAVs holds any threats to our national security in given that very few countries possess the capability to produce and operate UAVs via satellite, as the US does. As such this means that drones have a limited range and require a land or sea-bound base to operate from. The vastness of our country also prevents the use of UAVs for spying purposes due to the limited range” (Respondent 1).

Respondent 9 spoke of drones as the future of terror. Respondent 9 stated that “because the drones are commercially available, the Islamic State (IS) modified them with a centralised approach to manufacturing that brought the group’s drone program up to scale. In Syria the IS have successfully used drones to conduct surveillance and reconnaissance missions in addition to carrying out

offensive actions like dropping a grenade on an adversary's military base. Due to the possibility that the SANDF could become a victim of acts of terror during its operations, the SANDF should adjust its doctrine in line with the new trends of conflict, comprising of hybrid wars that includes use and counter use of drones. The SAAF must ensure that it remains abreast with these changes and play an integral role in the development of electronic and aerial-borne counter-measures" (Respondent 9). He further indicated that "the threat to South Africa itself, however is not high, but the use of drones by criminal elements from within the country cannot be ruled out. This poses a limited threat to National Security, but the SANDF must be prepared to counter such threats as deemed necessary and with the appropriate actions taken against perpetrators" (Respondent 9).

This resonates with current concerns of the escalating ISIS activities flaring up in Mozambique in 2020 yet again, after it was initially reported in 2017. "Since October of 2017 there have been a number of violent events in northern Mozambique attributed to Islamist elements" (Resilience, 2018). The fact that ISIS threatened SA, should SA wish to intervene in Mozambique, is indicative of the possible future realities facing SA in a national security context.

6.4.1. Countries posing the greatest threat to South Africa, the SAAF (military) and the SADC?

Based on the above-mentioned question, namely what threats and challenges does international proliferation of UAS pose for SA's national security, subject matter experts were requested to state whether they were aware of which countries, if any, that currently pose a threat to South Africa, the SAAF (military) and the SADC region?

Some of the respondents replied that they had no idea, did not know, or honestly could not say. Respondent 1 stated that "South Africa, the SANDF and the SADC currently have no countries that pose a physical threat to them. On the non-military front, only countries that have the capability to have a serious influence on the economy pose any form of threat. Such countries include the US, China, Russia and the other G7 countries" (Respondent 1). Respondent 3 indicated that he had no opinion, "as the current threat analysis appears to still show no perceived threat" (Respondent 3). A very interesting response was received from Respondent 4, who said that the question was a difficult one. He stated that "the US and China has outstanding cyber world capabilities and thus that drones are of little significance in terms of national threats. He indicated that "drones cost money as do other systems and military hardware. Threats are no longer of a reconnaissance or intelligence gathering nature, as the internet provides that information almost freely. Defence news provides daily updates and free trade in the global environment which provides access to militaries and their capabilities, to all" (Respondent 4).

Respondent 5 was of the opinion that "although there is maybe not a specific country that poses a direct threat towards the RSA, there are different role-players or actors that might in future impact on the RSA, military operations and aviation in general. The current threat is mostly one of a lack of

regulations and might pose an aviation hazard in general. The lack of methods of detection and counter measures also exacerbates the threat" (Respondent 5).

Respondent 6 indicated that "countries that have marginal control over the security situation in their own country pose the greatest threat. This provides a ready-made base for various extremist or criminal entities to project from. In regional context this includes the DRC and Uganda. Closer to home Mozambique is a problem as we can see the appearance in the northern provinces of Islamic Extremism. Even countries such as Swaziland and Lesotho can be problematical as they have some internal discord and an insufficient security cluster" (Respondent 6). Respondent 9 indicated that "from my own knowledge there is no current high level threat against the RSA from any country in Southern Africa. There may be diplomatic differences and unhappiness, especially due to xenophobia and other criminal activities" (Respondent 9).

When considering the above-mentioned responses, the researcher is of the opinion that it is evident that there are many forms of threats, not only UAS threats, currently facing us. Threats such as regional conflict, hunger, displacement, drug- and human-trafficking remain a global concern. The fact that UAS currently do not pose the greatest threat to our national security, however, does not mean that South Africa, the SANDF and the SAAF should be complacent and not prepare for future threats and contingencies.

6.4.2. Views with regards to the SAAF (SANDF) playing a greater role in safeguarding South Africa and Southern African Development Community (SADC), in terms of possible threats

Based on the above-mentioned responses, the researcher chose to probe deeper into this aspect and posed further open-ended questions to the respondents regarding their views of the SAAF (SANDF) playing a greater role in safeguarding South Africa and the Southern African Development Community (SADC) against possible threats.

Respondent 1 had an interesting opinion, namely that "it was always the responsibility of the SAAF (SANDF) in conjunction with the SAPS to secure our borders. Currently this is done with very little enthusiasm or resources. To ensure the safety and growth of our country, the SAAF (SANDF) has to play a much more significant role in border security as they have very few military roles internally and limited military roles internationally" (Respondent 1). Respondent 2 stated that "answering from the UAV aspect, I believe that if the SAAF is called on to provide a greater role in safeguarding South Africa and the SADC, reconnaissance UAVs in particular would be useful for providing information on potential threats and their movements. These airframes could range from the miniature systems that can fly into buildings providing video coverage of the contents to larger systems that fly for 8 hours or more providing coverage of larger areas. As with any unmanned aerial system, the choice of an air vehicle and its sensors will be decided on based on the identified concept of operations (CONOPS)" (Respondent 2).

Respondent 3 indicated that “if correctly staffed, funded, trained and equipped then it could play a role. It is currently not succeeding in the first step as described in the Defence Review “Arrest the Decline” and as a result the question is moot” (Respondent 3). Respondents 6 and 7 had similar views. Respondent 6 was of the opinion that “focus should be placed on South African borders at the expense of regional security. I am familiar with the modern views on regional security but the diluted resources make a significant regional impact unlikely. Basic military principle is to fall back if your resources contract” (Respondent 6). Respondent 7 stated that safeguarding our own borders against possible threats, including our maritime borders, was undoubtedly important (Respondent 7). Respondent 8 indicated that “it is our duty as one of the stronger countries within Africa to assist as and when we can, in securing and if needed, enforcing peace within SADC countries and within our own (country) too” (Respondent 8).

Respondent 4 had a different opinion, stating that “we could benefit here, but what really exists in terms of the African Standby Force (ASF) and commitment from all the host nations? Drones and UAVs would probably pose more of a threat to other nations who did not have such capabilities, when they hear that we have such capabilities. Africa/Southern Africa does not have major requirements for drones, as cyber technology and leaks (political and military) in a global insecure environment provide intelligence literally as and when required… why buy drones when you can hack into cyber/internet networks online? If SA made it aware that we had such capabilities, remember over-night other sponsoring nations would supply alias nations with such capabilities to spy on us too” (Respondent 4).

Respondent 5 stated that “whereas it is a national imperative to pursue the political, economic and military integration of the SADC, it is evident that the SANDF should play a greater role in safeguarding the RSA and SADC in terms of possible threats. The absence of an operational standby force is currently seen as a high threat to the continent, and the RSA should therefor pursue a continental force. Currently the RSA is contributing to the regional grouping – African Capacity for Immediate Response to Crisis (ACIRC) and also to the SADC Standby Force. My personal opinion is that the SANDF cannot currently provide for the RSA requirement and should refrain from trying to be Africa’s Big Brother until we can solve our Constitutional obligations” (Respondent 5).

Respondent 9 stated that, “to meet political objectives in Africa, the SANDF has expanded its military operations into Africa mostly in the peacekeeping role/environment. The decreasing requirement for conventional warfare has led to defence spending being cut drastically as a percentage of Gross Domestic Product (GDP). The decline in conventional warfare requirements of the SANDF and the focus on core force structures with Peace Support Operations in mind, has unfortunately led to the demise in application and requirement of UAS. If need be, the DOD must reconsider the feasibility of UAS and its application within the SANDF, the organisation needs to overcome financial constraints and also understand the Theatre of Operations (TOO)” (Respondent 9).

Respondent 9 further emphasised that “South African foreign policy is focused on diplomacy as well as the development and maintenance of trust within the SADC region. It is thus imperative that South Africa places its focus on Socio Economic issues rather than pure military development and acquisition. As the SANDF is severely underfunded, its focus is on survival rather than expansion. Sadly, with both financial pressures and existing airborne sensor capabilities being available, the requirement will be postponed or denied. A further constraint is the short supply/low number of aircrew for manned aircraft. It is common fact that pilots prefer to be in the cockpit of an aircraft, rather than being inside a ground station to remotely control an ISR asset. The possibility exists to overcome all constraints, however, the true requirement and use of UAS need to be determined” (Respondent 9).

The opinions stated above seem to favour the fact that SA and the SAAF should first look internally at the protection of our own borders and our own national security. What is however lacking to a certain degree, is the fact that the researcher could not, due to time restrictions for this study, pose the above-mentioned questions to Defence Intelligence members or to members at National Intelligence, as should have been the case. The researcher is consequently of the opinion that this specific area of the study would require deeper research which, due to the short time frame and the specific focus of this study, was not possible. To an extent, it has created a degree of limitation to the outcomes of this important topic with regards to SA’s national security.

6.5. SA counter-measures for UAS threats

Based on literature studies, it was difficult to determine the reality of this situation for SA. It was evident that information concerning South African counter-measures for UAS was not forthcoming and/or is lacking. The contrary was true as regards the international arena. Consequently, the lack of SA UAS counter-measures raised a serious concern. The researcher trusted that the subject matter experts would be in a position to provide insight and clarity regarding this point.

Based on the above theme, Respondent 3 and Respondent 6 were very adamant that South Africa and the SANDF (SAAF) will not be in a position to counter possible threats. Respondent 5 and Respondent 7 said that according to their knowledge, South Africa and the SANDF (and the SAAF) do not have any suitable means of detecting or countering drones. Respondent 7 argued that “he was not convinced that we will be able to counter possible threats, as he was not sure which counter-drone policies, technologies and procedures exist in SA” (Respondent 7). Respondent 4 stated that “this is obviously a threat should foreign neighbours acquire such capabilities - politically South Africa is however a peacekeeping nation in support of the SADC region. As such I doubt we could defend against such a threat - until of course it becomes ‘a threat’ “(Respondent 4). Respondent 6 mentioned that detection and anti-drone systems are still limited in number.

Respondent 5, Respondent 8 and Respondent 9 mentioned that the CSIR and different companies in industry are busy with research and experimentation in this field. Technology does exist and is

currently being investigated to enable the SAAF to have an anti-drone capability. However, as research and experimentation are currently taking place, no details were available.

Both Respondents 1 and 9 mentioned “that though limited, the SAAF and the SANDF do have the capabilities to counter possible threats from UAVS” (Respondents 1 and 9). Respondent 9 further indicated that “the SANDF has limited capacity to counter threats. There are ways and means to do so and this can be done mainly through electronic warfare (EW) and existing capacity and capabilities are either in place or been developed. South Africa will need to acquire the necessary capacity and capability to counter any possible threats. Military airfields and most of the larger civilian airports have systems in place which are able to jam drone signals, thereby making sure they are unable to fly within a certain radius of the airfield” (Respondent 9).

Based on literature study, it was noted that countries such as America, the UK and France, as discussed in Chapter 4, possess various counter-measures for UAS attacks such as nets that can capture UAS (drones), or weapons with which UAS (drones) can be shot down. The researcher is of the opinion that the lack of sufficient counter-measures in SA and the SAAF raises serious concerns with regards our National Security. This will definitely require urgent attention and further investigation as a project on its own, as it points to a huge gap in our national and military security strategies.

6.6. International laws and controls

The issues around international laws and the possibility and capacity to enforce such restrictions are vexed and multi layered. Current and future challenges abound. When discussing the above theme with the subject matter experts, the researcher was of the opinion, as indicated in the study, that this area remains a great concern on a global scale for all aviation specialists, human rights advocates and for the man in the street. Literature studies have indicated that there is a global concern regarding international laws. Specifically, more concerns came to the fore regarding the control of commercial drones, which are so easily accessible (consumer-off-the shelf [COTS] drones) to the “man on the street”. Much more space for future research exists here.

6.6.1. Are sufficient international laws and controls currently in place regarding UAS employment?

Specialists were approached regarding their knowledge on UAS laws. Based on all the respondents’ answers, the researcher is of the opinion that there is no finite clarity regarding international laws and controls for UAS. One of the respondents stated that he unfortunately did not have sufficient personal knowledge regarding international laws and controls to answer the question. Respondents 4 and 6 were of the opinion that there are not sufficient international laws and controls currently in place regarding UAS employment. Respondent 4 similarly stated that laws were not yet in place, but that “partnering nations and institutions in the global perspective (such as ICAO) are addressing the problem” (Respondent 4). He further mentioned that “our SA CAA is also addressing the issue but

realistically, how do you control the problem? Gatwick Airport (UK) had to close down last year after Christmas day, because of the risk associated with drone activity at the airport" (Respondent 4).

Respondent 6 stated that "there are not sufficient international laws and controls currently in place regarding UAS employment" (Respondent 6). He believed that laws were probably adequate, but as always, that control measures were lacking. According to the literature studies and Respondent 6's confirmation, "high end systems are well monitored, but the use of commercial off-the-shelf systems (COTS) are not subject to adequate control" (Respondent 6). This supported the researcher's views and findings. Respondent 7 indicated that "international laws ("civil drone regulations") do exist, but that they are still very new, immature, largely untested and in most instances in some form of development or updating. I am not certain of what is in place regarding military drone regulations or laws with regard to the use of military UAS in civil airspace internationally" (Respondent 7). Respondent 8 was of the opinion, that "there are stringent laws but as with any law, if it is not enforced what is it worth? The SA CAA has a document Part 101 that governs the use of drones, but only on a commercial level" (Respondent 8).

Respondent 5 indicated that "the international perception is that there are not sufficient rules and regulations regarding the utilisation of drones, however, "these are normally the perception of that grouping that is 'anti-drone'. The reality is that this is a new concept and it is only recently that countries, defence forces and industry realised the growing capabilities of drones as a system. Whereas the initial regulations were applied so as to stop drone utilisation, it is now changed to accommodate drones in a safe aviation environment. There is a perception that the application of autonomous weapons (such as drones) are in contravention of the Law of Armed Conflict. This is however depending on perceptions, and will not necessarily have an impact on future regulations" (Respondent 5).

6.6.2. Are South Africa's current legislations and regulations regarding UAS in line with global standards?

Based on the varying answers received by the specialists on the previous question, namely whether sufficient international laws and controls are currently in place regarding UAS employment, the researcher decided to probe further into this area. Answers to the question as to whether South Africa's current legislations/regulations are in line with global standards were explored further.

Respondent 1 emphasised that "South Africa is one of a handful of nations worldwide that has enacted laws and regulations regarding the use of UAS in civilian airspace. As there are currently no UAS really operational in the military environment in South Africa, the regulations regarding the use of military UAS is presently not sufficient" (Respondent 1).

Respondent 1 was of the opinion that "the current SA CAA regulations for the operation of UAVs are at the forefront of global standards. The regulations are however not perfect as much of the regulations were based on and adapted from the regulations regarding the operation of manned

aircraft. The regulations also currently only cater for small UAVs in use in the private sector and not for larger systems that are normally used by the military" (Respondent 1). Respondents 6 and 8 agreed that SA CAA regulations are in line with ICAO guidance material. Respondent 8 was of the opinion that "we are actually ahead of many countries as great effort was put into compiling our laws and guidelines. The current drone regulations are regarded by many as too stringent as they were adapted directly from manned aircraft regulations" (Respondent 8).

Respondent 3 mentioned that unfortunately he had insufficient personal knowledge to answer the question. Respondent 4 stated that SA CAA regulations are supposed to be in line, but "that development of regulations is slow. Again even with regulation in place, how do you control the China store sales of such drones?" (Respondent 4). Respondent 5 indicated that it was his perception that the CAA's RPAS (UAS) regulations were instituted to prove that the CAA has got something in place. "It was there, but mostly focussed at preventing people from operating drones. Fortunately the "positives" of drone operations have been realised by the CAA and they are now endeavouring to change the regulations to accommodate drones; even making provision to allow drones into general aviation in future" (Respondent 5).

Respondent 9 was of the opinion that "the current legislation and regulations in the RSA is very good and can be regarded as in-line with global standards. Further updates or changes will need to be included, as necessary" (Respondent 9). Here the respondent was referring to the Regulations SA CAA – Part 101 Ninth Edition – February 2015 – Department of Transport Civil Aviation Act, 2009 (Act no. 13 of 2009) – Ninth Amendment of the Civil Aviation Regulations, 2011, as indicated previously in this study.

Respondent 9 further mentioned that this question "would need to be researched. But within the RSA there are newly adopted laws and regulations in place to control the employment of UAS. International laws are in place within most of the first world countries, but are extremely limited in the majority of other countries, especially in Africa" (Respondent 9).

Quite in contrast to the previous opinions of the above-mentioned experts, Respondent 7 emphasised that "No, even if SA CAA think they "were first" to field drone regulations, they were not. Australia was ahead of us and at the moment we are far behind the rest of the world. The rest of the civil drone world have moved ahead and we are reviewing, revising/updating and improving their older "first-order" drone regulations. At present there are no regulations or policies in place to regulate the use of military UAS in our national airspace in SA – this is in development, but is as yet, un-promulgated" (Respondent 7).

According to all the respondents' answers, the researcher is of the opinion that there is much uncertainty regarding the status of SA's national UAS laws in relation to the rest of the world. Answers as captured above, range from "the current SA CAA regulations for the operation of UAS are at the forefront of global standards, SA CAA regulations are in line with ICAO guidance material,

SA CAA regulations are supposed to be in line", but "that development of regulations is too slow, the rest of the civil drone world have moved ahead and we are reviewing, revising/updating and improving their older 'first-order" drone regulations'" (Respondents answers as stated above).

Regarding these contrasting views, the researcher believes that this is an area that will require considerable impetus as well as further research in future, both nationally and internationally.

6.6.3 In your view, which are the most important laws that should be in place globally in terms of UAS?

As varying answers were received from the SMEs, the experts were further questioned as to which UAS laws in their opinions were the most important laws that should be in place globally. Where applicable, clarifying questions were asked and the answers carefully noted.

Respondent 3 mentioned that unfortunately he had insufficient personal knowledge to answer the question. Respondent 4 indicated that "more than likely the regulation regarding usage of drones close to major Air Traffic regions/airports, was the most important. There is no way to control the sale/purchase of small drones… so there is no way to stop them either. People ignorant of the law cannot necessarily be held accountable" (Respondent 4).

Respondent 5 was of the opinion that "without making any exceptions, it will most probably be the regulations and rules regarding the allowance of drone operations into general aviation" (Respondent 5). Respondent 6 stated that "commercial systems should be subject to more rigorous import and export regulations. Systems should be subjected to something akin to RICA or FICA methodology where unique numbers are allocated and transmitted to monitoring stations. This will address illegal use and airspace violations" (Respondent 6).

Respondent 7 emphasised that there are laws governing the use of privately-operated civil drones. He further stated that "the private operators are by far the largest group of drone operators worldwide, and also by far, have the most inexperienced art aviation laws and airspace rules. I'm not saying this sector needs to be heavily regulated, but a major awareness program needs to be in place that will reach all recreational drone operators. After this, laws to govern seamless airspace integration (UAS plus manned aviation operating side-by-side, safely)" (Respondent 7). Respondent 8 was of the opinion that an international guideline similar to the Geneva Convention that governs the use of drones should be put in place. "Possibly an international watchdog to help enforce this" (Respondent 8).

Respondent 9 indicated that the he believed "the most important laws are imposing restrictions on the flying of UAS in proximity to international airports, military installations and national key points. This is by no means the only restrictions and adherence to policy will need to be policed, otherwise it is superfluous. The use of military UAS should abide by regulations, especially internally within the RSA, but if they are on a specific operation they will need to do so within the realms of the rules of engagement" (Respondent 9).

From the above-mentioned answers, it would seem that the private and commercial sector would need to be the most regulated sectors regarding UAS practices.

6.6.4 Are countries globally adhering to International Laws, the Law of Armed Conflict (LOAC), the Missile Technology Control Regime (MTCR) and Rules of the Air with regard to UAS?

Once again, various contrasting opinions were received when the above-mentioned question was posed to the various subject matter experts.

Respondent 3 mentioned that unfortunately he had insufficient personal knowledge to answer the question, and Respondent 7 stated that he was not qualified to answer the question. Respondent 1 stated that “in his view, these laws are not being adhered to, as they do not have sufficient regulations pertaining to the use of UAVs. Many countries are developing armed UAVs that remove the operation from the battlefield thereby making the operator unfeeling towards collateral damage” (Respondent 1).

Respondent 4 made an interesting statement, saying that countries are mostly not adhering to the laws, although Civil Aviation Authorities (CAAs) are urgently trying to put regulations in place. He further mentioned that “rules of the air” must be put aside, “because a drone pilot is not looking ahead at all times. A pilot in the cockpit has to lookout for his own safety while a drone flies along in one direction looking at the target below…it can easily fly into something else - or into another drone” (Respondent 4). Subsequently, the lesson learnt from this specialist is that “Rules of the Air” only apply to pilots and manned aircraft. There are as yet, no “Rules of the Air” for unmanned aircraft systems (drones) in South Africa as per current literature research and knowledge.

This aspect was subsequently investigated by the researcher to ensure better understanding of the concept. According to the highest aviation authority in the world, namely the International Civil Aviation Organization (ICAO), Annex 2 to the Convention on International Civil Aviation is an international standard for the “Rules of the Air”.

In terms of the applicability of this rule, Annex 2, Chapter 2 speaks of the territorial application of the rules of the air, the compliance required with the rules of the air, and the responsibility for compliance with rules for the air by the pilot-in-command. Annex 2, Chapter 2 states that firstly, “the rules of the air shall apply to aircraft bearing the nationality and registration marks of a Contracting State, wherever they may be, to the extent that they do not conflict with the rules published by the State having jurisdiction over the territory overflown. Secondly, the operation of an aircraft either in flight or on the movement area of an aerodrome, shall be in compliance with the general rules and in addition, when in flight, either with the visual flight rules; or with the instrument flight rules. Lastly, the pilot-in-command of an aircraft shall, whether manipulating the controls or not, be responsible for the operation of the aircraft in accordance with the rules of the air, except that the pilot-in-

command may depart from these rules in circumstances that render such departure absolutely necessary in the interests of safety" (ICAO, 2005, 2-1).

Based on research till date, and the above-mentioned Annex 2, UAS currently do not bear the nationality and registration marks of a Contracting State. They should not fly over other countries' territories (as was the case when an American drone was shot down over Iranian airspace on 20 June 2019). Secondly, UAS may not operate near any aerodrome or airport. Thirdly, drones are unmanned aircraft, so there is no pilot-in-command in the 'cockpit' of the drone.

Respondents 5, 6 and 8 agreed that in general, countries are adhering to laws. Respondent 5 stated that although countries are adhering, "however, there are many areas of conflict where these rules are neglected and even ignored. Unfortunately many countries in Africa are also not complying, posing a threat to operations and aviation in general" (Respondent 5). Respondent 6 indicated that he believed the threats were coming from non-state entities. Respondent 8 was of the opinion that "countries that initially bought in and signed the agreements are outwardly complying, but what is actually happening behind closed doors with covert research projects is unknown. Similarly there are countries that openly do not agree with the terms of these agreements and thus do not comply with them" (Respondent 8).

Respondent 9 was of the opinion that countries globally are adhering, and also not adhering, to International Laws, the Law of Armed Conflict (LOAC), the Missile Technology Control Regime (MTCR) and Rules of the Air? He stated that "Yes," the larger defence forces do adhere to laws as stated, but when it comes to countering specific terrorist threats then "No", as certain regulations may well be 'broken' (Respondent 9).

Simply stated, there was no consensus or guarantee that countries globally are adhering to International Laws, the Law of Armed Conflict (LOAC), the Missile Technology Control Regime (MTCR) and Rules of the Air with regard to UAS.

6.7 Budget/financial constraints

One final aspect which was of great importance to this study, was the aspect of budgeting and finances. The researcher thought it appropriate to request the SMEs' opinions on a few budget-related questions in accordance with the possible utilisation/employment of UAS in SA, the SAAF and the SANDF. In the event that UAS would be used for national security purposes by the SAAF, the question to be answered was whether the SAAF would be in a position to finance this capability/asset in the long term and whether it could be a credible and force multiplying asset for the SAAF in the near future.

The first question that needed to be addressed was whether SMEs thought that UAS could be of economic benefit to the SAAF, in light of the severe budget cuts by Parliament, with regards to South Africa's military operational budget.

All the SMEs'/respondents' replies to this question were very positive as they believed it would be a more cost effective utilisation or employment capability. With their vast knowledge and background, subject matter experts were able to provide enlightened motivations for their opinions. Respondent 1 was of the opinion that, "although the initial purchase of a UAV System may be expensive, the operating costs are significantly lower than that of a manned aircraft. There is also associated cost saving with regard to training the pilots and technicians for a UAVs. The training is also considerably shorter than that for personnel and pilots of a manned aircraft. Another benefit is that pilots of manned aircraft that may no longer be medically fit to fly, can be utilized as UAV pilots as the medical requirements are less stringent" (Respondent 1). Respondent 2 agreed with Respondent 1 and said that there will be "potentially lower acquisition costs and operating costs than comparable manned systems" (Respondent 2). Respondent 5 stated that "drones could in the long term be a cost effective means to do many of the required tasks, however, the initial layout to establish the capability is very expensive and the current budget can most probably not accommodate it" (Respondent 5).

Respondent 4 indicated "Yes, but initial outlay would prevent us and many similar nations from acquiring full capabilities. The Army has many systems already, and these are operated without air traffic knowledge in terms of regulation – while the whole world struggles to control the capability of UAVs and drones. It would probably be more beneficial to look at the EW/jamming capability with the Defence Industry. This would maybe provide alignment with the SAAF's requirement and industry and enhance security on bases. It would be easier to motivate national security requirements defined through such capabilities, where government would have to provide resources to maintain national security" (Respondent 4).

Respondent 7 indicated that if one were to acquire the Seeker 400 for employment, "the initial acquisition costs could be high, but keeping UAS technology local is key, as SA is one of only a handful of nations having the knowledge base to develop large and complex UAS. Operating costs could be cheaper if operated locally (than e.g. a Gripen or C130). Deployment costs will be high if the UAS is large and requires large strategic aircraft to deploy. The real benefit is not necessarily financial, but operational – persistence and reduction in risk to humans. Small UAS could, however, be cheaper to operate than e.g. a helicopter or fixed wing aircraft – for tasks like surveillance or border patrol. A proper study will show if there are any financial benefits or not" (Respondent 7). Respondent 8 stated that "simply put, the purchasing and operation of drones is far less costly than manned fighter aircraft" (Respondent 8).

Respondent 6, conversely, was of the opinion that "only in the use of small commercial type drones for activities such as perimeter security or calibration of navigation aids" would the UAS could be of economic benefit to the SAAF. The bigger military systems have an expensive and bigger footprint than manned aircraft, for example, the Seeker or Heron versus the C208 Caravan with same sensors" (Respondent 6).

Respondent 9 indicated that “a true reflection of cost can only be calculated once the missions that will be performed by the system is identified in terms of endurance, speed, altitude, sensor type payloads and integrated networks that are needed. Within any application of an UAS, it is the sensor/gimbal payload that determines the platform that must carry this sensor. In lay man terms, the smaller the sensor, the smaller the platform. Smaller platforms means less endurance, less distance away from the ground station, smaller image footprint, and thus less intelligence. The opposite is obviously true!” (Respondent 9).

From the above-mentioned answers, it was clear that all SMEs believed UAS would be of economic benefit to the SAAF in the long term. In the words of Christof Heyns (UN special rapporteur), when discussing transformational warfare in the 21st Century, “drones are revolutionary because they lower the costs of using military force” (Horowitz et al., 2016: 7-42). Experts also indicated that various factors, such as the size of the UAS being employed, its footprint and the type of mission (deployment) would determine the actual costs. Initial outlay would be expensive, but associated cost savings regarding pilot and technicians would be less. Perhaps the largest and most realistic benefits would be the operational benefits, such as saving lives and having a capability that “never gets fatigued”.

6.7.1. Is there ‘Political Will’ in South Africa to support the research and development of UAS?

A further question that needed to be addressed was what the expert’s opinions were on whether there was ‘Political Will’ in South Africa to support UAS research and development.

This question seemed to elicit contrasting answers from experts. Respondent 6 said he believed so. “The negative connotations to these systems are not well established in this country as it is in e.g. the Middle East” (Respondent 6). Respondent 1 was of the viewpoint that “the political climate in South Africa at present is focused on social needs. There is very little support or will to support continued research and development of UAVs in the country” (Respondent 1). Respondent 4 likewise said “No, as its capability is not fully understood or actually required – according to Parliamentarians. Again unfortunately the capability must firstly be defined… only then will it be motivated in Parliament. The Defence Review highlights the necessity to support local industry but this is not supported without BEE or other spin-offs” (Respondent 4).

Respondents 5 and 3 were of the opinion that there was some ‘political will’ yet lacking in certain areas. Respondent 5 stated that “although there is a definite ‘political will’ towards research and development in general, I cannot confirm that there is one towards drones. The SANDF is however very positive towards acquiring and applying drones” (Respondents 5). Respondent 3 indicated that “political will maybe, but not effective will in terms of funding. Why develop something that is not unique and easily available on the market unless you have a niche application or a need to develop and retain a strategic capability” (Respondent 3).

Finally, Respondents 7 and 8 had interesting and alternative perspectives. Respondent 7 said that the researcher's question "was a good question, but a better question would be to ask if there was "political will" to support our Aviation Industry as a whole. Currently it does not seem so. Refer to Denel's demise and the miniscule budget given to CSIR DPSS for aero research" (Respondent 7). Respondent 8 stated "personally I think the resistance to change factor will seriously make this difficult and the fear of something new and completely unconventional for us will contribute to this too" (Respondent 8).

Respondent 9 indicated that, "in terms of 'political will', the fact that we have continued to develop these technologies should be "enough" to convince the powers that be. However, the political influence and dynamic, especially over state owned enterprises is a cause for concern – Denel is a prime example" (Respondent 9).

From the above opinions, it seems that there is much disparity, and more doubt as to whether the government of the day really would have the 'political will' to support a much needed research and development in terms of UAS in South Africa.

6.8 Conclusion

Subject matter experts approached during this study were from various disciplines within the military and from various entities within the defence industry itself, and snowballing of interviews created very interesting insights for this study. It became clear from literature studies and interviews that UAS (or drones) are here to stay, and will continue to escalate in importance, proliferation, versatility and utilisation.

This chapter focused on obtaining answers for the questions arising during the study. In many cases, interviews negated or confirmed the literature findings and the researcher's discoveries, based on the various discourses regarding UAS. The wide range of experts sought was to ensure validity, objectivity and reliability.

Based on the main research question, all the respondents were of the opinion that unarmed UAS can be used by the South African military (the SANDF and the SAAF) to contribute to national security. In an unarmed role, UAS can be utilised in terms of intelligence, surveillance and reconnaissance (ISR), electronic warfare (EW, ECM and ECCM, ELINT), remote sensing, Telstar (communication relays), and during national emergencies, such as floods, fires, droughts and during search and rescue tasks.

It was stated that the SAAF does not have or utilise any armed drones, in line with the SANDF's defensive posture and its peace-making and diplomatic relationships with all other countries. The SANDF and the SAAF likewise do not currently employ any UAVs nationally or internationally in a defence role. It was also evident that UAS cannot be used for aerospace security, but can be used for intelligence collection missions and for maritime and border security. Border security was seen

as being the greatest criminal threat and the exclusive economic zone, being the greatest economic threat.

Subject matter experts were on par with “the proliferation of certain emerging technologies” (WEF, 2018) which has made the entry levels to commercial off-the-shelf (COTS) technology so easy, that COTS can be used as lethal targets, by criminals, individuals or even small extremist or terrorist groups. Concerns regarding state sponsorship of terrorist groups, which could possible increase UAS (drone) attacks, remain a focus point for SA. As stated by the WEF (2018), that “since states can provide the necessary equipment and training, terrorist attacks featuring weaponised drones is a near fait accompli in the not-so-distant future” (WEF, 2018).

It was noted that UAS can fulfil many roles, depending on their sizes and characteristics, and can be a credible force multiplier. It was similarly evident that UAS could pose a threat for South Africa’s national security. Yet, it was stated, experts did not see an immediate significant threat from other countries to South Africa. Threats such as organised crime, espionage, and other criminal elements inside the country could pose a greater threat than merely UAS.

Regarding international laws, it seems that this is a large area for improvement, not only in addressing international and humanitarian laws including issues such as privacy and the unilateral use of UAVs in terms of offensive deployment – especially by large states. With regard to counter-measures, a concerted effort would be required by SA in this regard. It would comprise a unique study on its own as this issue raised much concern. And finally, in terms of ‘political will’ and financial support from the government, regarding UAS, dedicated investigations, assessments, understanding and education of parliamentarians, in terms of military capabilities, and assets for national security will require earnest attention, without negating the importance of social, economic, and educational concerns of the country.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

It was evident from this study that the phenomenon of unmanned aircraft systems (UAS) has become a very emotive and contentious issue on many levels. Irrespective of whichever terminology is used in society, unmanned aircraft systems are here to stay and will remain in the public eye and for those that live through the consequences for many years to come. The proliferation and sophistication of unmanned aircraft technologies, whether unarmed or armed, and the ease at which military, non-state actors and individuals can acquire drone technologies are becoming an increasing threat on a global scale. South Africa, the SANDF and the SA Air Force need to take cognisance of this fact, as the threat from rogue actors, criminal elements, extremists, radical groups and even individuals internally, and externally to South Africa, could pose a severe challenge or threat, should such technologies be disregarded.

This study set out to address imminent and realistic future threats and challenges regarding the complex phenomenon of UAS. The final product reflects useful findings/discoveries and has gained insights relevant to recommendations. Specifically so that these sophisticated and weaponised technologies were not merely a threat for the future as one would think, but are very much a global concern presently. The researcher concluded that some of the findings raised serious national security concerns as is mentioned in this chapter. Lastly, should defence matters continue to be flouted by government and policy makers, South Africa and the SA Air Force would most likely face future threats, specifically if the required technologies no longer exist within our Force structure with which to defend the sovereignty and territorial integrity of the country.

Chapter 1 provided a broad background to the intention for this study with regards to UAS and the extremely fast paced proliferation of these technologies on a global scale. The problem statement indicated that South Africa could face many challenges and threats within the present and foreseeable future, from emerging technological developments in the global community, where militaries, state actors and virtually any individual would have the required access and funding to develop their own weapon systems. It was indicated that because of years of economic underperformance in SA, the most significant cuts to defence spending have affected the SA Air Force and the SA Navy. This has made it extremely challenging for the SA Air Force to maintain its existing capabilities and to fulfil its defence commitments, let alone close any strategic capabilities.

Taking the above budget restrictions and deterioration of the SAAF's capabilities into consideration, it was questioned whether the SAAF could provide prepared and supported air defence capabilities for the defence and the protection of South Africa. Similarly, it was determined that UAS could in future pose a threat to SA, since South Africa and the SAAF currently do not have the appropriate counter-measures against such threats.

In Chapter 2, the categories, employment and performance classifications of UAS, were discussed. The terminology of UAS used in this study was explained against the background of the extreme proliferation, developments and sophistication of said technologies in a complex environment.

The evolution of UAS (drones) was explored, from unmanned hot-air balloons with basic military ISR roles, to an exciting exploration of micro-drones (MAVs) and nano-drones (NAVs) for spying purposes/real-time intelligence, as could be viewed in the film “Eye in the Sky”. It was shown how the increased sophistication of these UAS systems had created a complex environment wherein autonomous systems, advanced cyber capabilities, and new digital developments such as 3-D printing have presented a transitioning for conventional military forces to an information warfare area, with definite game changing opportunities. The future developments (and with it expected proliferation) of these systems will gain increased traction in this age of the Fourth Industrial Revolution, with consequences not yet foreseen nor predictable.

The study highlighted the growing interest by international countries and South Africa, to safely integrate UAS into civilian and non-segregated airspace. With the merging of military and commercial industries and airspace restrictions slackening, it is suggested that the airspace will truly be open to all types of manned and unmanned operations which could be of commercial and economic benefit to the country. The study similarly indicated the opportunities, dangers and complexities should UAS be integrated incorrectly into civilian airspace.

Should finances not be injected into investing in essential technologies, capabilities and a future force concept, armed forces would face a great risk of lagging behind their potential adversaries. Because of the inherent unpredictability of the future, militaries need to maintain sophisticated core defence capabilities. Governments and policy makers need to be mindful of the economic and operational benefits that UAS could hold for the SAAF as a new revolutionary form of warfare. Ethical considerations regarding UAS and their use (and future deployment) continue to remain an emotive and highly controversial topic. World opinions indicate that all people involved in defence matters, from policy makers to arms manufacturers, need to be seen to behave ethically as defence forces around the world are continuously open to intense public and media scrutiny. In the current international environment, there are many dimensions to the expansion of UAS usage and deployment. Much of this also touches on international rights, human rights, territorial integrity, laws related to armed conflict (LOAC) and the conduct of war, such as the unilateral use of offensive UAS by major powers.

Chapter 3 discussed the national and international legislation regarding unmanned aircraft systems as well as the international laws and control mechanisms regarding UAS. The Chapter expanded on the above discussions and debates centred on whether sufficient international legislation and controls were in place regarding UAS employment. It was indicated that drone strikes raised human rights debates within various international laws, and similarly impacted on issues of international

peace and security, sovereignty of states and territorial integrity, as stipulated in the Geneva Conventions, LOAC and other IHLS.

The study pointed out that the complex challenges and concerns relating to UAS legislations and controls were not because of countries not acknowledging the importance for compliance and controls, but because they were questioning how such laws were applied globally to (i.e. armed) UAS use. This specifically refers to the secrecy in which some countries conducted armed UAS missions, and the manner in which arms could be transferred outside of current legislation and controls by countries not willing to adhere to prescribed legislations. Increasing COTS sales in the commercial market further lead to policies lagging way behind the realities of a proliferated UAS market.

The study likewise indicated how militaries, diplomats and even human rights organisations could not keep abreast with the unprecedented speed of these technological developments, within the Volatile, Uncertain, Complex and Ambiguous (VUCA) 21st century environment people are living in. Despite buy-in by many countries across the globe to international control mechanisms, it remains disheartening to realise that immense challenges for defence forces, human rights groups, environmentalists, society and diplomats across the globe would continue to prevail, by those not adhering to international laws and the global control measures.

The current and future uses of UAS will remain a contentious issue with regards to international peace, stability and security. “Who has what?”, and “What is to be done?” with these surveillance systems or armed “weapons” are questions that will linger far into the future and most likely will become more complex and multi-layered.

In Chapter 4, the study focused on how the term national security was defined, with the researcher’s working definition adding context to this study. People are living in a progressively unstable and complex world because over a period of time the international security environment and the threat dynamics have changed dramatically. Adding inadequate political governance, economic unpredictability, poverty, competition over scarce resources and poor human security and maritime insecurity, we are faced with deeply vexed (and in cases unpredictable) challenges. On the continent of Africa, the occurrence of weak, fragile and imploding states combined with armed rebel groups, resisting the state, further complicates the political and military setting.

Civil Military Relations was defined as being a principal component of a military security policy. With the use of UAS by military forces around the world, militaries need to think entirely differently about warfare, military doctrine and military concepts of operations. With warfare being fought in a new digitised environment, both military and civilian authorities need to address current and future security threats and challenges, within rapidly evolving warfare technologies.

The establishment of the SA Air Force was mentioned. The different uses of UAS in a military and civilian context came under scrutiny. Concerns with regard to the integration of UAS into civilian

airspace was explored. It was found that only a fraction of UAS operators were adequately trained and competent to allow for safe integration of UAS into civil airspace.

This study also questioned whether the international proliferation of UAS technologies posed threats and/or challenges for South Africa's national security. Based on qualitative analysis and feedback from expert practitioners, it was clear that SA is facing new challenges and threats. Threats such as increasing cybercrimes, acts of terror by international networks or ideological causes, illegal immigrants, the smuggling of goods, wildlife poaching, weapons and human trafficking are challenges currently facing SA, which is threatening safety and security. The increasing political instability predominantly on the African continent, the involvement of major powers in Africa, and the perceived threat posed by increases in Islamic extremism to intra-state security are compounding the threats and challenges significantly. Challenging and concerning therefore, is the fact that the latest escalating violent extremist attacks by ISIS in Mozambique are only one permeable border away from South Africa.

The yearly diminishing SA defence budget allocations, the SANDF's obsolete equipment and the ever present and increasing wars surrounding SA's porous borders and those of our neighbouring states, are all of great concern. For the moment, an increased budget for defence is highly unlikely due to numerous economic challenges and social pressures – and more so, in the period post COVID-19 which has seriously impacted an already struggling economy.

During researching this theme, and by discussing it with expert practitioners, it was concluded that South Africa and the SAAF do not have (sufficient) UAS counter-measures.

The study indicated that many different counter-measure systems have been developed internationally to counter UAS threats. Security and defence sectors continually attempt to improve technologies in order to proactively counter COTS UAS threats used by violent extremist groups, 'lone wolves', activists and organised crime groups with malicious intents. Within South Africa, various Defence companies such as the CSIR, Reutech and Indra are developing UAS countermeasures for South Africa. The CSIR are also researching the most appropriate types of countermeasures that can be used to counter different threats on various levels (the notion of threat levels are important here).

The SANDF is looking into austerity measures. Apparently, no investments have been made in this regard yet. The South African Police Services (SAPS) and some Army Forces do have drone countermeasures and equipment. Obtaining information in this regard within the SANDF and the Security clusters has not be easy, as it relates to National Security and such highly classified sources that could not be used in this study. Open source information on South Africa and the SANDF in this regard was rather restrictive. More space for future research exists here.

A concluding discovery was that rogue UAS are not only an "overseas" problem, but a global problem. Each country's risk profile will differ, therefore this should be considered by policy makers

and government when analysing UAS threats against South Africa. Critical consideration is therefore required to assess whether increased counter-measures would also lead to increased unpredictability and responses by adversaries.

Chapter 5 described the research methodology used for this study. The employment of UAS internationally and its use by the South African Air Force to assist with national security formed the basis for the researcher's central theoretical approach. In terms of the employment of UAS in SA, the concept of national security was explored, followed by the role of UAS in the SANDF, in terms of various employment capabilities which could contribute to SA's national security.

This study followed an exploratory, qualitative and descriptive approach. It included two crucial elements, namely an extensive review of scholarly/academic literature, followed by face-to-face interviews and a focus group with aviation experts and other stakeholders in this field. This was done by creating a trust-relationship with the research participants (interviewees) and creating an amicable interview atmosphere. The trust relationships that were established after gaining access to the participants enhanced the possibility for harvesting credible and valid information to enrich the study.

The researcher aimed to remain critical, realistic and open-mind throughout the study, based on the continuous changing and fluid conditions occurring in SA and in the SAAF. Experienced subject matter experts in the aerospace domain were chosen to participate in the study to contribute to the improvement of and establishment of new policies in the SAAF environment. Likewise, contributing in improving aviation capabilities and aviation safety in South Africa. This study has expectantly added to the existing body of knowledge in a new vibrant field of study, and to UAS in terms of national security in South Africa.

Research publications available in South Africa with regards to a unique perspective and challenges within the South African context still lace a lacuna worth further exploration.

Chapter 6 focused mainly on the interviews, as part of the qualitative approach conducted with the respected expert practitioners who were from various disciplines in the military and from various companies within the civilian defence industries. These interviews as well as focus groups provided a dearth of information and a deeper understanding of the phenomenon. Insight on academic work, theoretical approaches and applied knowledge in the field and the experience and reflections of participants provided valuable depth to the study. The use of UAS as a contributor to South Africa's national security, and their roles in airspace, maritime and border security were discussed. In the researcher's view, this was the most vibrant, realistic/real-life and interesting chapter of the study.

Experts were questioned concerning the use of UAS as credible force multipliers, whether South Africa employed UAS internationally in a Defence role and whether they believed that UAS posed threats to SA's National Security. Clarification was requested by experts as to which countries in their opinions posed the greatest threat to South Africa, the SAAF (military) and the SADC. In considering the responses, many diverse answers were received and the researcher concluded that

the evidence pointed to many different forms of threats, i.e. cyber threats, and not merely UAS threats.

SA counter-measures were discussed and the lack of counter-measures against UAS threats is rather concerning. SMEs' opinions on international laws and controls regarding UAS were questioned, and it was indicated that this area remains a great concern on a global scale for all, i.e. aviation specialists and human rights advocates.

Interviews also focused on whether sufficient international laws and controls were currently in place regarding UAS, and whether experts believed that South Africa's current legislations and regulations were in line with global standards. Expert practitioners' opinions were asked to determine whether they knew if countries globally were adhering to international laws and which laws in their opinions are the most important. The creation of or implementing ethic approaches, norms, enforceable laws in international, regional and local space deserves much more research.

Finally, aspects regarding financial constraints on defence budgets, and the political will of the government to support research and development of such needed technologies were deliberated with subject matter experts.

From the study it is evident that UAS could be used by South Africa to contribute to South Africa's national security.

7.2 Recommendations

South Africa does not have sufficient sophisticated counter-measures with regards to UAS. With the difficulty experienced to obtain information on South African counter-measures, this was identified as a concern in terms of SA's national safety and security.

The study indicated that with technology advancing at such a proliferated and sophisticated rate, compared to other international defence forces, it appears that the SANDF/SAAF is lagging behind. Therefore, the SAAF needs to make concerted efforts to uplift current UAS knowledge, expertise and technologies in the military.

Furthermore, the SANDF/SAAF could investigate funding by private sector, industry or government to develop these types of technologies, such as micro- and nano UAS (drones) and swarming technologies.

The SANDF (SAAF) should explore the opportunities created by sophisticated UAS.

The use of light and medium UAS should become part of the SAAF's strategic assets as a force multiplier with manned aircraft, for dull, dirty and dangerous missions. These types of UAS should be placed back on the Strategic Capital Acquisition Master Plan (SCAMP) project list for future acquisition. These systems would be a great financial benefit and support for internal operations along land and sea borders. UAS could similarly be used for external peace support operations.

In order to develop and harness the capabilities of UAS technologies, it is recommended that drone testing sites be revamped for future military research and development.

7.3 Pointers towards policy considerations

During the study, gaps in military doctrine were identified, as regulations regarding the use of military UAS are currently not sufficient. Military UAS regulations need to be promulgated in line with a proliferated civilian sector. This could ensure safer operations in both military and civilian airspace.

In terms of global UAS employment, international laws should be aligned across the globe. This points to a mammoth task, because in some countries international laws are in place. To impose these laws on stronger countries would be extremely challenging. Irrespective of the number of international laws in place, i.e. LOAC, (stronger) states still do not adhere to these. In this regard, ethics, norms and regulations including enforceable actions need to be instituted.

An extremely important area for policy consideration is the area of UAS integration into civilian airspace. Policy makers need to investigate the safe interoperability between UAS and manned aircraft, for combined missions, internally and externally to South Africa.

Policy makers should investigate how UAS could function in an integrated, synergetic and holistic manner with manned aircraft.

7.4 Suggestions for future research

Further research and investigations regarding the cost implications for acquiring and employing various sized UAS for internal and external missions, versus manned aircraft, are required.

Investigations are required into the implications of proliferated and sophisticated micro-drones, nano-drones, autonomous UAS, swarming drones and UAS possessing artificial intelligence.

Implications for the safe integration of UAS into civil airspace is another area that future research should consider.

7.5 Conclusion

Based on the fact that UAS are seen as a new developing phenomenon, the researcher recommends that with the increasing new forms of warfare, information and knowledge regarding this phenomenon should continuously be expanded upon.

The current and future uses of UAS remain a contentious issue in terms of international peace, stability and security. “Who has what?”, and “What is to be done?” with these surveillance systems or armed “weapons” are questions that will linger far into the future. This also applies to international law, human rights, law of armed conflict (LOAC) and the territorial integrity of (weaker) states.

As mentioned in the book *The Military’s Business. Designing Military Power for the Future*, the UK Ministry of Defence was taken to task for not ensuring appropriate mission material. If the SA military was in a similar situation, would the SA government support the SAAF, and “show commitment to

continuous technological innovation and the notion that technology, rather than strategy or tactics, is the key to military success and safe conduct on the battlefield, or will we continue on the path we are currently on?" (Rasmussen, 2015: 154).

"Air power theorists and strategists need to be careful about what they claim can be achieved. From a UAS perspective we are today at the cusp of unleashing a capability that has the potential to create a step-change function in the conduct of war. Sadly, our doctrine and concept development has not kept pace with the advances already brought about by technology, and have not anticipated probable future developments. If this mismatch is not addressed in a concerted manner, and without delay, I am afraid we will fail to take full advantage of this emerging air power capability. Perhaps more importantly, we will be failing to meet the expectations of future generations" (Kainikara, 2014: 7-8).

Figure 7.1: The future airspace and UAS (drone) saturation
Image by courtesy A. Meredith

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APPENDICES

APPENDIX A.1: INTERNATIONAL DRONE STATISTICS (AS AT 3 AUG 2016)

Ser No	Countries with armed drones	Countries with drones used in combat	Non state actors with Drones used in Combat	Countries developing armed drones	Countries producing Drones domestically
	a	**b**	**c**	**d**	**e**
1	China	Iran	Hamas	France	Algeria
2	Iran	Iraq	Hezbollah	Greece	Argentina
3	Iraq	Israel	Isis	India	Armenia
4	Nigeria	Nigeria	Libyan Rebels	Italy	Australia
5	Pakistan	Pakistan		Pakistan	Austria
6	Somalia	Turkey		Russia	Azerbaijan
7	South Africa	United Kingdom		Spain	Belgium
8	United Arab Emirates	United States		Sweden	Brazil
9	United Kingdom			Switzerland	Bulgaria
10	United States			Taiwan	Canada
11				Turkey	Chili
12					China
13					Columbia
14					Czech Republic
15					Denmark
16					Egypt
17					Estonia
18					Ethiopia
19					Finland
20					France
21					Georgia
22					Germany
23					Greece
24					Hungaria
25					India
26					Indonesia
27					Iran
28					Israel
29					Italy
30					Japan
31					Jordan
32					Latvia

Ser No	Countries with armed drones	Countries with drones used in combat	Non state actors with Drones used in Combat	Countries developing armed drones	Countries producing Drones domestically
33					Malaysia
34					Mexico
35					The Netherlands
36					New Zealand
37					Nigeria
38					Norway
39					Pakistan
40					Peru
41					Slovenia
42					Spain
43					Sweden
44					Switzerland
45					Taiwan
46					Tunisia
47					Turkey
48					Ukraine
49					United Arab Emirates
50					United Kingdom
51					United States
52					Uruguay
53					Venezuela
54					Vietnam

Note: Information used from the Geneva Academy, 2015

APPENDIX A.2: THE SECOND GENERATION OF ARMED DRONE OPERATORS

The Second Generation of armed drone operators						
Operator	Armed UAVS development programme	Has imported armed UAVs	Armed UAVs in service	Strikes in own territory from UAVs	Lunch strikes extra-territorially from UAVs	Exported armed UAVs
China						
Iran						
Turkey						
Pakistan						
Iraq						
Saudi Arabia						
UAE						
Egypt						
Nigeria						
"Non-state actors"						

Source: Drone Wars The Next Generation, 2018

APPENDIX B: COMPARATIVE ANALYSIS OF 19 NATIONAL UAV REGULATIONS

Applicability			Technical Requirements					Operational Limitations (Distances)						Administrative Procedures			Human Resources	Ethical Constraints	
Country Issued and/or Last Updated (Reference)	Applicable for MA/UAVs	Classifica-tion (Weight, Purpose, Area, Visibility)	Weight Limits (Max)	Special Technical Require-ments	Collision Avoidance capability	Airports /Strip	People	Congested Areas	Prohibited Areas	Additional	Max Height	VLOS/ Lateral Distance	BVLOS	Application and Operational Certificate	Need for Registra-tion	Insurance	Qualification of Pilots	Data Protec-tion	Privacy
United Kingdom 05/2002 03/2105 (73)	MA/UAV	W,P	7/20/ 150 kg		for special operations		50m	150m		N/A	122 m	500 m, EVLOS possible	need for special approval	various approval requirements for different flight operations	N/A	N/A	pilot competency	refer to Data Protec-tion Act, CCTV Code of Practice	advice to respect personal privacy
Australia 07/2002 09/2016 (74)	MA/UAV	W,P	2/25/ 150 kg	N/A	N/A	5.5km	30m			emergency situation	120 m		need for special approval	>2/25 kg	N/A	recom-mended	license > 2 kg	advice to respect personal privacy	
Malaysia 02/2008 (75)	no distinction	W,P	20 kg	Request equivalent level of compliance with rules for manned aircraft			N/A	N/A	N/A	N/A	122 m		if ATC capable	flight authoriza-tion and airworthy-ness certification	>20 kg		licence for pilot and commander	UAV operation shall comply with civil requirements	
United States 08/2008 06/2016 (76)	MA/UAV	W,P	0,25/25 /150 kg	N/A	N/A	8 km		N/A		N/A	122 m	EVLOS possible	need for special approval	>25 kg	registra-tion number	depen-ding on purpose	certificate	N/A	refer to related law
Canada 2010 05/2015 (77)	MA/UAV	W,P	2/25 kg	N/A	>25 kg	9km	150m			forest fires	90 m		N/A	>25 kg	N/A	depen-ding on weight	pilot competency	advice to respect personal privacy	
France 2012 12/2105 (78)	MA/UAV	W, A, V	2/8/ 150 kg	>2 kg	in populated areas and BVLOS		not over crow ded	N/A		emergency situation	150 m	100 m/ 200 m/ EVLOS		for specific operation procedures	dependin g on flight scenario		depending on flight scenario	commerc ial use ask for permissi on to use data	advice to respect personal privacy
The Netherlands 2012 07/2016 (79)	MA/UAV	W,P	1/4/25/ 150 kg	N/A	N/A	no fly zones	50m			moving cars	120 m	100/ 500 m	N/A	operational certificate			license	refer to related regulations	
Germany 12/2103 07/2016 (80)	UAV	W	10/ 25 kg	>10 kg	may help to get BVLOS permission		not over crow ded	N/A		emergency situation	100 m		need for special approval	general permission, single operational approval for >10-25 kg	N/A		pilot competency	emphasize that actions might be subject to other laws	
Italy 12/2013 12/2015 (81)	UAV	W,A	2/25/ 150 kg	for critical flights	N/A	5km	50m	150m		N/A	150 m	500 m/ EVLOS	in segre-gated airspace	for critical operations and/or >25 kg	plate and electronic ID		0-25 kg certificate, >25 kg license	refer to Italian Data Protec-tion Code	N/A
Austria 01/2014 08/2015 (82)	no distinction and if >500 m from pilot	W,A	5/25/ 150 kg	depen-ding on scenario	depending on scenario		not over crow ded	N/A		N/A	150 m		need for special approval	general permission, single approval for risky operations	registra-tion needed		depending on scenario	N/A	N/A

Applicability			Technical Requirements				Operational Limitations (Distances)							Administrative Procedures			Human Resources	Ethical Constraints	
Country Issued and/or Last Updated (Reference)	Applicable for MA/UAVs	Classifica-tion (Weight, Purpose, Area, Visibility)	Weight Limits (Max)	Special Technical Require-ments	Collision Avoidance capability	Airports /Strip	People	Congested Areas	Prohibited Areas	Additional	Max Height	VLOS/ Lateral Distance	BVLOS	Application and Operational Certificate	Need for Registra-tion	Insuran ce	Qualification of Pilots	Data Protec-tion	Privacy
Spain 10/2014 (83)	MA/UAV	W	2/25/ 150 kg	N/A	N/A	8/15 km	not over groups			N/A	120 m	500 m for 2-25 kg	0-2 kg or special approval	flight authoriza-tion, NOTAM notification	registra-tion and ID plate		0-25 kg certificate >25 kg license	N/A	N/A
Azerbaijan 01/2015 (84)	no distinction	W	20/ 150 kg	N/A	for BVLOS		50 m	150 m		N/A	122 m		in segre-gated airspace	for critical operations and /or >20 kg	>20 kg		pilot competency	N/A	N/A
Chile 04/2015 (85)	no distinction	W	6 kg	many special demands	N/A	2 km	30 m	N/A		>60 min	130 km	500m	N/A	flight authorizatio n		N/A	license	N/A	N/A
Colombia 07/2015 (86)		W	25 kg	many special demands	N/A	5 km				intern border	152 m	750m	N/A	flight authorizatio n			license	not allowed to violate the rights of privacy	
South Africa 09/2015 (87)	N/A	W.V	7/20 kg		N/A	10 km	50 m			N/A	122 m	EVLOS possible	need for special approval	air service license, letter of approval and operation certificate	registration marks		license	N/A	N/A
Japan 12/2015 (88)	no distinc-tion and if heavier than 200 g	N/A	N/A	N/A	N/A	no fly zone	30 m			N/A	150 m		N/A	for restricted area	N/A	N/A	N/A	N/A	N/A
Nigeria 12/2015 (89)	no distinction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	special authorization	N/A			flight authoriza-tion	N/A	N/A	manned aircraft license	license	N/A
Rwanda 05/2016 (90)	not for toy aircraft	N/A	25 kg	N/A	N/A	10 km				N/A	100 m	300 m		flight authoriza-tion, operational certificate	registration marks			license	respect privacy of others, surveil-lance of people and property without their consent is prohibit-ted
China 09/2016 (91)	no distinction	N/A	7 kg	N/A			N/A			10 km to other aircrafts	N/A		N/A	flight authoriza-tion and operational certificate	registration	N/A	certification	N/A	N/A

White cells indicate that the variable is addressed by the UAV regulations. Dark grey cells indicate that the variable is not addressed by the UAV regulations. Additional text outlines further details if applicable.

Source: Remote Sensing. Review of the Current State of UAV Regulations. Stöcker, Bennett, Nex, Gerke and Zevenbergen, 2017: 10-11

APPENDIX C: OVERVIEW OF MECHANISMS APPLICABLE TO ARMED UAV TRANSFERS AND HOLDINGS

Mechanism	Purpose	Membership/ Adherents	Relevance	Preventive measures	Transparency and reporting	Pros	Cons
UN Security Council resolution 1540 (2004)	Prevent proliferation of WMD and their means of delivery, particularly to non-state actors	**Universal**	Any technology that might be used as means of delivery for WMD	Physical protection; effective export, border and end-user controls	Initial reporting on implementation	Good reporting record; possibility to review mandate; mutual assistance; cooperation; best-practice sharing	Narrow scope
				Develop control lists National action plans; point of contacts; best practice			
Missile Technology Control Regime (MTCR), 1987	Limit risk of WMD proliferation	**35 Partner States**	Armed and unarmed UAVs; related equipment/com-ponents, and software	States exercise transfer restraints; establish certain end-user controls	None	Proven flexibility; detailed guidance and definitions for export controls	Technical thresholds increasingly under pressure; exclusive membership
Hague Code of Conduct (HCoC), 2002	Prevent and curb proliferation of WMD capable ballistic missile systems	**138 Subscribing States**	Ballistic missiles capable of delivering WMD	Maximum restraint in the development, testing; reduce national holdings	Annual declaration on policies; holdings and (test-) launch sites; system launches; pre-launch notifications	Universal norms for responsible use; transparency and confidence building measures	Limited direct relevance for armed UAVs; legitimacy concerns; lacking compliance
UN Register of Conventional Arms (UNROCA), 1991	Promote transparency for weapon transfers and holdings	**Universal**	Armed UAVs	None	Imports, holdings and exports; national legislation	Possibility for updates and improvements	Very poor reporting record
Wassenaar Arrangement, 1996	Promote greater transparency and responsibility in the conventional arms and dual-	**42 Participating States**	UAVs for military use; related equipment or components	States control the transfer of dual-use technologies and munitions depending on their sensitivity	Information exchange on conventional arms transfers; transfer denials of dual-use goods and	Comprehensive information sharing; regular meetings of Licensing Officers;	Ambiguity due to different interpretations; exclusive membership and

Mechanism	Purpose	Membership/ Adherents	Relevance	Preventive measures	Transparency and reporting	Pros	Cons
	use technology transfers		including software		technologies; risks	guidelines for implementation	information sharing
EU Community regime for the control of exports, transfer, brokering and transit of dual-use items, EC No 428/2009	Facilitate Member States' compliance with relevant international agreement	**Universal All 28 EU Member States**	Dual-use items as defined by the Wassenaar Arrangement, MTCR, the Nuclear Suppliers Group and the Chemical Weapons Convention National	National exporting and brokering service authorization	Record keeping of exports and brokering services; cooperation and information exchange between competent authorities	Designed to enhance efforts of existing mechanisms; relevant stakeholders are consulted in the review process	National authorities are responsible for export authorizations
Vienna Document of the Organization for Security and Co-Operation in Europe (OSCE), 2011	Confidence-building measures	**57 Participating States**	Armoured combat vehicles	Military cooperation e.g. joint military exercises and training; observation visits; provision of military experts Information	Information exchange on military forces; equipment; defence planning; hazardous incidents; certain military activities	Extensive information exchange; related confidence-building measures; reviews and updates have ensured its relevance	Lacking clarity about the relevance for armed UAVs
Legal Weapons. Reviews (Customary Law, codified in Art.36 of API to the 1949 Geneva Conventions)	Ensure intrinsic compatibility with IHL	**Universal**	Any new weapon, means or method of warfare that a State studies, develops, acquires or adopts States	States determine whether a new weapon, means or method of warfare can be used in compliance with international law	None	Encompasses all types of UAVs and, as a rule of customary international law, is binding upon all States	Only between 15 and 20 States are known to conduct reviews; major differences in implementation
Arms Trade Treaty (ATT), 2013	Establish the highest common standards for the	**130 signatories, 92 State Parties**	Combat aircraft and attack helicopters;	States assess transfers regarding	Reporting on exports and imports; national	Only mechanism with broad	Discretion in the design of national controls; Does not

Mechanism	Purpose	Membership/ Adherents	Relevance	Preventive measures	Transparency and reporting	Pros	Cons
	trade in conventional arms		some provisions apply to components and munitions	international law and security; adopt laws and domestic controls	control lists; designate national points of contact; status of national implementation	membership and mandatory transparency measures; States may seek assistance	cover dual-use platforms and technologies; lacks membership of major armed UAV exporters
EU Common Position defining common rules governing controls of exports of military technology and equipment (2008/944/CFSP), 2008	Prevent export of military technology which might be used for internal repression or international aggression	**All 28 EU Member States**	UAVs specially designed or modified for military use, related equipment	States assess transfers with regard to their international security risks; establish certain end-use controls	Information sharing and consultations on denied export licenses; reporting on exports of military equipment and implementation	Comprehensive export assessment criteria and interpretive guidance; involvement of EU Parliament in the development of recommendations	All aspects of policy implementation remain in the hands of State

Measures (binding and non-binding)

Source: United Nations Institute for Disarmament Research (UNIDIR), Increasing Transparency, Oversight and Accountability of Armed Unmanned Aerial Vehicles, 2017: 38-39.

APPENDIX D: INTERVIEWS

1. Anon. 2019. Interviewee 1. Date of Interview: 28/09/2019
2. Anon. 2019. Interviewee 2. Date of Interview: 08/10/2019
3. Anon. 2019. Interviewee 3. Date of interview: 11/09/2019
4. Anon. 2019. Interviewee 4. Date of interview: 25/09/2019
5. Anon. 2019. Interviewee 5. Date of interview: 08/10/2019
6. Anon. 2019. Interviewee 6. Date of interview: 07/10/2019
7. Anon. 2019. Interviewee 7. Date of interview: 04/09/2019
8. Anon. 2019. Interviewee 8. Date of interview: 02/08/2019
9. Anon. 2019. Interviewee 9. Date of interview: 03/10/2019
10. Anon. 2019. Interviewee 10. Date of interview: 09/10/2019
11. Anon. 2019. Interviewee 11. Date of interview: 09/10/2019
12. Anon. 2019. Interviewee 12. Date of interview: 09/10/2019